Situation-oriented Provision of Knowledge Services

Dissertation

zur Erlangung des Grades

Doktor der Wirtschaftswissenschaft (Dr. rer. pol.)

der Juristischen und Wirtschaftswissenschaftlichen Fakultät

der Martin-Luther-Universität Halle-Wittenberg

vorgelegt von

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Tag der Verteidigung: 17. Juni 2008

urn:nbn:de:gbv:3-000013900
[http://nbn-resolving.de/urn/resolver.pl?urn=nbn%3Ade%3Agbv%3A3-000013900]

Abstract

Knowledge management (KM) is concerned with the creation of an environment that supports knowledge work in order to improve organisational performance. The context of this work is represented by a business process-oriented approach to KM that amongst others promises a tighter link between knowledge management and the creation of customer value. The term knowledge work has been coined to denote creative work targeted at the creation of new knowledge which is characterized by solving ill-structured problems, a high degree of variety and exceptions as well as strong communication, coordination and cooperation needs. Information technology is able to support KM and knowledge work in manifold ways. Enterprise knowledge infrastructures in this relation represent the vision of an organisation-wide technical infrastructure for KM that offers integrated knowledge services for discovery and publication of documented knowledge, collaboration and communication between people as well as for facilitating learning. However, process-oriented KM lacks approaches that are able to integrate knowledge work, business processes and information technology. This work targets the development of an approach that allows process-oriented KM to systematically structure the aspects of knowledge work relevant for its goal-oriented support with knowledge services. The goals are to define and empirically explore an appropriate concept, to find ways for its inclusion within modelling approaches proposed in the context of process-oriented KM and to show how state-of-the-art technologies can be applied in order to support knowledge work.

This led to the definition of the concept of knowledge work situation. It describes a recurring situation where a knowledge worker can, should or must switch from a business-oriented function to a knowledge action which is specified by the context of the situation. Knowledge work situations are triggered by occasions to learn and to generate knowledge related to the core competencies of the organization. They integrate a process-oriented perspective on knowledge work and a learning-oriented perspective that can be structured with the help of activity theory. Based on a comprehensive review of approaches more recently proposed for the knowledge-oriented modelling of business processes, requirements are defined and a meta-model for the description of knowledge work situations is proposed. On the level of technical support, a service-oriented perspective on enterprise knowledge infrastructures is established and the application of service composition is illustrated for the context-aware and integrated support of knowledge actions.

This work includes an empirical exploration of the knowledge work situation concept and its single components. 31 semi-structured interviews with technical consultants in large organisations have been conducted that focused on a set of eight selected knowledge actions. The interviews were transcribed and the resulting substantial amount of data has been structured and analysed with the help of a qualitative content analysis approach. Amongst others, 12 variants of the initial eight knowledge actions could be identified which consist of 69 steps, are supported by 35 knowledge services and are identified to be influenced by 33 context factors. These constructs not only give a rich description of the single components of knowledge work situations but also allowed to revise the concept and to formulate hypotheses about the knowledge actions conducted and the services accessed their relation. Overall, this work contributes to process-oriented KM by offering an innovative, theoretically well-founded and empirically grounded concept for the description of knowledge work.

Preface

To date, knowledge management has been received a lot of attention within research and practice. Though the term recently has been used as a buzzword and thus might have been overstretched, the opportunities and issues addressed remain to exist. One of them is the enhancement of individual knowledge work with the help of information technologies. A fundamental challenge that knowledge management faces is the systematic integration of business processes, knowledge work and supportive technologies. In my thesis I try to make a step towards solving this challenge.

The topic of KM has accompanied me for years since my diploma thesis completed in 2001 at the University of Regensburg. In 2003, it led me to the Martin-Luther University of Halle-Wittenberg in Halle (Saale) where I received the opportunity to participate in the research and teaching activities of the Chair for Management Information Systems, Information Systems Leadership of Prof. Dr. Ronald Maier. This thesis represents one of the results achieved during this time. It involved many people. Unfortunately, I only have the space to thank some of them. First of all, I would like to thank my supervisor Ronald Maier, now at the University of Innsbruck, not only for creating an excellent infrastructure and environment for research and teaching but also for many stimulating ideas, his helpful advice and his strong commitment to all of our research projects. My thanks also go to my colleagues Florian Bayer, René Peinl, Stefan Thalmann and Mathias Trögl for many inspiring discussions, helpful remarks and not to forget a great team spirit.

This work would not have been written in English if Sid Huff and Hans Lehmann had not kindly invited me for a stay as a research fellow at the School of Information Management of the Victoria University of Wellington, New Zealand. Without the many competent researchers and PhD students there I would not have learnt half as much about a foreign academic system and another perspective on research as I did during this time. Many thanks go to Eusebio Scornavacca, Jörg Evermann, Alastair Smith, Andreas Schröder, Dan Dorner and Maria Molina. This research project was funded by the DAAD. Last but not least I wish to thank my parents, Margitta and Eberhard Hädrich, and also my sister, Christina Hädrich, who gave me the possibility to obtain a university degree, and my girlfriend, Agnes Thiemann, for her wonderful empathy.

Halle (Saale) and Hamburg, December 2007

Contents

1 Introduction

This work is dedicated to the topic of enhancing the effectiveness of individual knowledge work in the context of a systematic knowledge management approach. This chapter motivates the main research question (section 1.1), defines the goals of this thesis (section 1.2) and gives an overview of the procedure, methods and contents of this work (section 1.3).

1.1 Motivation

The *concept of knowledge* is used to explain the fundamental economic and social changes since mid-twentieth century and ultimately the transformation from an industrial to a knowledge society (Drucker 1993, 5ff; 1994; Stehr 1994, 26ff). It is closely linked with many subjects discussed in society at present, e.g., the preparation of students for future challenges, the relevance of life-long learning, the availability of skilled workers in ageing Western societies and ultimately the disappearance of organisational and also of national boundaries (UNESCO 2005). The discussion of knowledge is not new but has been the core of philosophical considerations for centuries. In the context of economics, it is reflected by the knowledge-based perspective of the firm (Grant 1996; Nonaka & Takeuchi 1995; Spender 1996) that extends the resource-based theory of the firm (Hall 1992; Wernerfelt 1984). In this view, knowledge has fundamental influence on the competitive position of an organisation.

As a consequence, the management function *knowledge management* (KM) is concerned with the regular selection, implementation and evaluation of knowledge strategies that aim at creating an environment that supports work with knowledge in order to improve organisational performance (Maier 2004, 55). Research on KM is an interdisciplinary field that spans disciplines such as economics, information systems, organisational behaviour, organisational theory, psychology, strategic management and sociology (Argote, McEvily & Reagans 2003, 571f). Several authors under the topic of *business process-oriented KM* (PKM) propose the application of principles and methods of business process reengineering (BPR) in the context of KM (Davenport, Jarvenpaa & Beers 1996; Wiig 1995, 257ff). The reason is that this does not only promise a tighter link between KM and the creation of customer value but also offers ways to bridge the gap between opposing orientations of KM (Maier & Remus 2002, 102ff; Remus 2002b, 33ff). The integration of knowledge into business processes is regarded as a very promising starting point for KM (Scholl et al. 2004, 31). More recently, a number of approaches were proposed particularly by German-speaking members of the management information systems (MIS) community that tackle some of the related challenges (Bach, Österle & Vogler 2000; Heisig 2003; Hinkelmann, Karagiannis & Telesko 2002; Remus & Schub 2003). However, PKM still lacks practical and theoretically well-founded methods and ways to overcome organisational and technical barriers. The integration of knowledge and business processes remains one of the prime challenges of KM (Scholl et al. 2004, 31).

The increased importance of the handling of information and knowledge is emphasized by the term *knowledge work* (Drucker 1969, 287ff). Knowledge workers were the fastest-growing group of the overall workforce of the United States during the last decade (Wolff 2005, 39). The term is applied to emphasize the differences to traditional blue collar work and the changes and challenges associated with its support (Maier 2004, 44). Knowledge work is targeted towards the creation of new knowledge instead of the application of existing knowledge (Kelloway & Barling 2000, 292) and amongst others is characterized by the solving of ill-structured problems in complex domains as well as strong communication, coordination and cooperation needs (Drucker 1974, 32f; 1993, 75ff; Schultze 2003, 44f). However, the characteristics of knowledge work contradict the perspective adopted by process management that traditionally focuses on the goal-oriented enhancement and control of well-structured business processes (Gaitanides, Scholz & Vrohlings 1994). To date, PKM lacks approaches that are able to integrate knowledge work and process-orientation.

The diffusion of information and communication technologies (ICT) and the growth of the Internet and of digital technologies is one of the driving forces behind the fundamental changes of the last decades (UNESCO 2005, 18f). Many KM initiatives rely on ICT as an important enabler for KM (Alavi & Leidner 2001, 114). It should be noted that the need of KM for advanced ICT sometimes is judged critically due to unfulfilled promises made by technologists and high expectations concerning the capabilities of technology (Scholl et al. 2004, 30). Nonetheless, though technology might not apply to all issues of KM, it surly may support it effectively in manifold ways (Alavi & Leidner 2001, 114). The term *enterprise knowledge infrastructure* (EKI) has been coined in order to denote the vision of an organisation-wide technical infrastructure for KM that offers integrated knowledge services for discovery and publication of documented knowledge, collaboration and communication between people as well as for facilitating learning (Maier, Hädrich & Peinl 2005, 71). It integrates functionality from a large variety of root systems such as Groupware, content management systems (CMS), e-learning platforms and business intelligence applications (Maier 2004, 231ff). Today, employees are already able to access a range of knowledge services at their workplace, e.g., Intranet search engines that offer keyword-based search services, email systems that support text-based communication or CMS that provide storage services. However, the vision of an integrated and comprehensive infrastructure is far from being achieved. Users face challenges that stem from a weak integration of the information systems (IS) involved, e.g., they are required to replicate information filed on multiple storage systems or they have to identify by themselves which one of multiple alternative systems is suited best for their task. A major challenge that organisations face thus is to offer the right services in an integrated manner, i.e. in a way that suits the user's current situation.

In order to find a good compromise between rigor and relevance, researchers are advised to look to practice in order to identify research topics (Benbasat & Zmud 1999, 8). The challenges outlined above are located at the intersection of the lively research fields business process management, KM and ICT and represent concrete problems that practice presently faces, i.e. the systematic support of knowledge work by technical services in the context of organisational KM. Consequently, they motivate the leading research question of this work which is formulated as: *"What is an approach that allows PKM to systematically structure the aspects of knowledge work relevant for its goal-oriented support with knowledge services?"* Another requirement posed to research is that authors should develop frames of reference that are intuitively meaningful to practitioners and suited to organise complex phenomena (Benbasat & Zmud 1999, 11). Consequently, this work starts out with the development of a manageable concept suited to structure and describe the relevant phenomena. A situation-oriented approach is proposed here as a foundation for such a concept as it is regarded to offer a fruitful foundation for the structuring of the aspects of knowledge work relevant for PKM.

1.2 Goals

The goals defined for this work are structured based on three basic levels of systems design: concepts, models and systems. This systematization is suited to include all aspects relevant in this context and enables to answer the leading research question comprehensively. This work also includes an empirical part whose goals will be described afterwards.

Level of concepts. A *concept* denotes an abstract or generic idea generalized from particular instances (Merriam-Webster 2003, 257). It represents the basic elements that are used for the description of reality. Examples for concepts applied in process management are organisation, business process and data entity. Goal of this work on this level is the definition of a concept that allows for a systematic integration of business processes, individual knowledge work and knowledge services. It is an explanative research goal as it requires the understanding and clarification of the aspects relevant. The concept developed below will be labelled as knowledge work situation (KWS). It targets the provision of knowledge services that fit with the needs of typical situations of knowledge work which is explicitly referred to by the headline of this thesis.

Level of models. A *model* is a goal-oriented, simplified representation of a portion of the perceived reality (Heinrich & Roithmayr 1989, 324f; Lehner, Maier & Hildebrand 1995, 27). Modelling is one of the key tasks in order to describe, analyse, simulate, optimize and document phenomena that are significant for the development of IS and thus is frequently applied in the context of process management (Gaitanides 2004, 1214; Rosenkranz 2006, 16f). Concepts amongst others determine the syntax that defines the constructs of a modelling language and the valid relations between them. Examples for models are organisation diagrams, business process models and data models. A number of knowledge-oriented business process modelling languages has been proposed in the literature on PKM. The goal associated with this level is to review and compare these languages in order to investigate the concepts of description they apply for analysis of knowledge work and the design of technical infrastructures. This represents a foundation for the discussion of how KWS can be described based on an existing or a new modelling approach.

Level of systems. The level of *systems* includes socio-technical IS that comprise human and machine components (WKWI 1994, 80). Though this work generally deals with IS in this sense, the focus is placed on *ICT* which refer to the technical components of IS, i.e. all resources available for storage, processing and communication of information (Krcmar 2005, 27). Examples for typical systems are workflow management systems, enterprise resource planning systems, application systems and database management systems. The main goal associated with this level is to point out how knowledge work based on the concept of KWS can be supported with ICT. The concept developed is not only intended as a descriptive unit but also as a framework that should guide the design of technical infrastructures. Hence, this and the former goal represent normative research goals as they involve decisions about how KWS can be applied in order to design technical infrastructures.

Empirical study. As a result of working towards the aforementioned goals, it can be expected that KWS will have been detailed conceptually. Since this inevitably has to remain on an abstract and general level, the goal is defined to conduct an empirical study suited to explore and concretise selected parts of KWS. This also includes the subsequent reflection and potential redefinition of the concept based on the empirical results. This goal can be characterized as descriptive in the sense that the study is concerned with the empirically-grounded portrayal of the KWS concept and the current state of its technical support.

1.3 Procedure, methods and overview

The research project undertaken in order to answer the leading research question and to achieve the goals defined has been organised into three phases. They are depicted in Figure 1 that also indicates the relationship of the aforementioned levels of concepts, models and systems with the work packages defined.

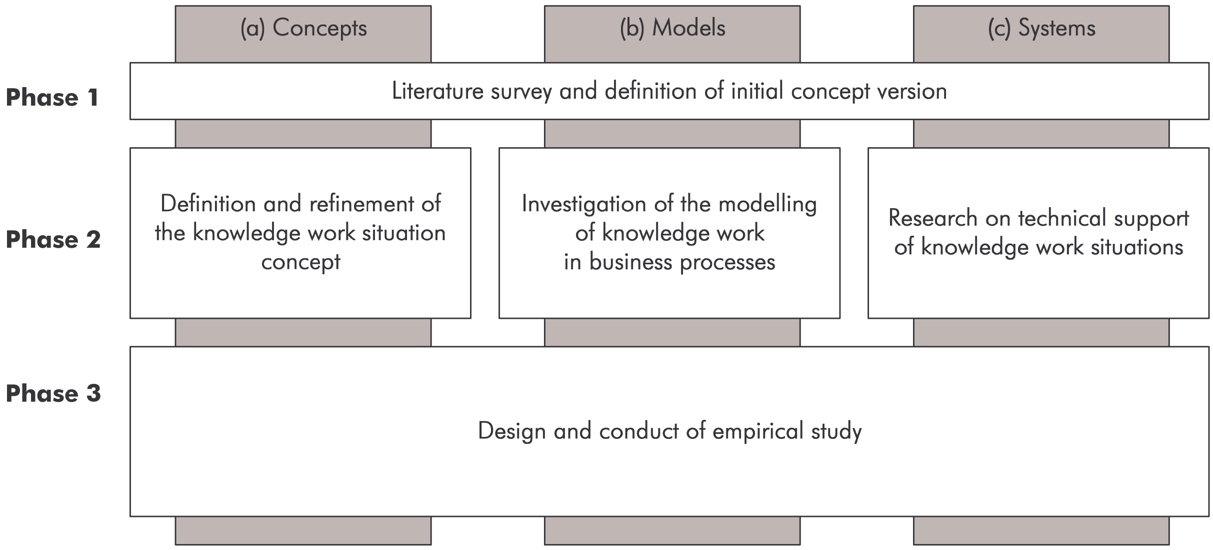

Figure 1. General procedure of this research

The *first phase* consisted of an initial literature survey in the areas process management, KM, PKM, knowledge work and ICT applied within a KM context. It turned out that new concepts of description are required which led to the formulation of an initial version of the KWS concept and the framing of three work packages dedicated towards its definition and enhancement on a conceptual, a modelling and a systems level. Consequently, the *second phase* comprised the completion of three work packages that each target at one of these three levels. All three work packages involved a comprehensive review of the relevant literature and preferably of publications in highly-ranked international journals as well as papers introduced at leading MIS conferences.

An important way to *refine the KWS concept* was the publishing and discussion of papers on leading scientific conferences, e.g., at the Multikonferenz Wirtschaftsinformatik (MKWI) 2004, Essen, Germany (Hädrich & Maier 2004), and on the European Conference on Information Systems (ECIS) 2005, Regensburg, Germany (Hädrich & Priebe 2005b). The concept and the general research design of this thesis were also presented on international doctoral consortia, e.g., associated with the Conference on Organisational Knowledge, Learning and Capabilities (OKLC 2004), Innsbruck, Austria, and related to the International Conference on KM in Asia Pacific (KMAP) 2005, Wellington, New Zealand. Concept and research design were also introduced on several local doctoral consortia such as the Inter-University Doctoral Consortium 2005 of the Universities of Leipzig, Halle-Wittenberg and Jena in Germany as well as the Doctoral Consortium on Economics in the summer term 2006 of the University of Halle-Wittenberg, Germany. As a result, many different perspectives on the concept, hints for further directions and suggestions for relevant literature or subjects could be gathered that were incorporated within the concept if this was regarded appropriate and manageable.

The *review and comparison of modelling approaches* was not only based on the analysis of related publications but particularly on the practical application of selected modelling approaches. Important occasions for this were master-level university courses at the Martin-Luther-University of Halle-Wittenberg on KM where the author was involved. In order to gather experiences, student modelling projects were conducted during the summer terms 2004 and 2005 that applied modelling approaches to various case examples and compared them with regard to advantages and disadvantages. If available, the modelling process was supported by specialized modelling tools. The investigation of the modelling approaches was accompanied by a thorough review of the literature on modelling in the context of MIS. More details on the procedure of analysis are described in section 4.4.

A fundamental framework for structuring services targeted at the *technical support of KWS* is represented by the architecture of EKI that was created based on a market-review and the amalgamation of other architectures (Maier 2002, 196; Maier 2004, 258). The author contributed to the enhancement of this architecture and its application in the context of peer-to-peer architectures (Maier & Hädrich 2004; 2006). Technologies relevant in this context are discussed in detail in a textbook created in cooperation with two other authors (Maier, Hädrich

& Peinl 2005). Insights were also gained by the introduction and administration of the system Open Text Livelink 9[1] by the author that was applied in the context of research and teaching processes of the chair of Information Systems Leadership of the University of Halle-Wittenberg. The literature review also took into account the topic of service-orientation as it offers starting points for the integrated and flexible support of KWS.

The *third phase* consisted of the design and conduct of an empirical study targeted towards the empirical exploration of KWS and their technical support. It was based on semi-structured interviews with 31 consultants employed at large firms. The interviews were recorded, transcribed and subsequently analysed based on a qualitative content analysis approach. A set of categories structuring the qualitative data was created based on a systematic coding procedure. Details of the research design and the methods applied are described separately in chapter 6. The results were used for the formulation of hypothesis about KWS as well for its revision. The study is also relevant from a methodological view as qualitative empirical studies currently are underrepresented in the German MIS community (Wilde & Hess 2007, 283). The results of this work package contributed to the former three work packages. They were used in order to revise and redefine the KWS concept, to propose an approach for the modelling of KWS and to detail the technical support of KWS.

Figure 2 gives an overview of the structure of this thesis and also includes the levels of concepts, models and systems. It directly reflects the procedure described. The *first chapter* motivates the leading research question, defines the goals of this research and gives an overview of this thesis in terms of the procedure applied, the methodology selected as well as its structure. *The second chapter* concisely summarizes the fundamentals of this work, i.e. the foundation of knowledge and knowledge work and of the fields of business process-orientation, KM and PKM. As every main chapter of this thesis, it starts out with a short overview of the contents and closes with summary.

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[1] URL: http://www.opentext.com, last accessed: 2007-12-02

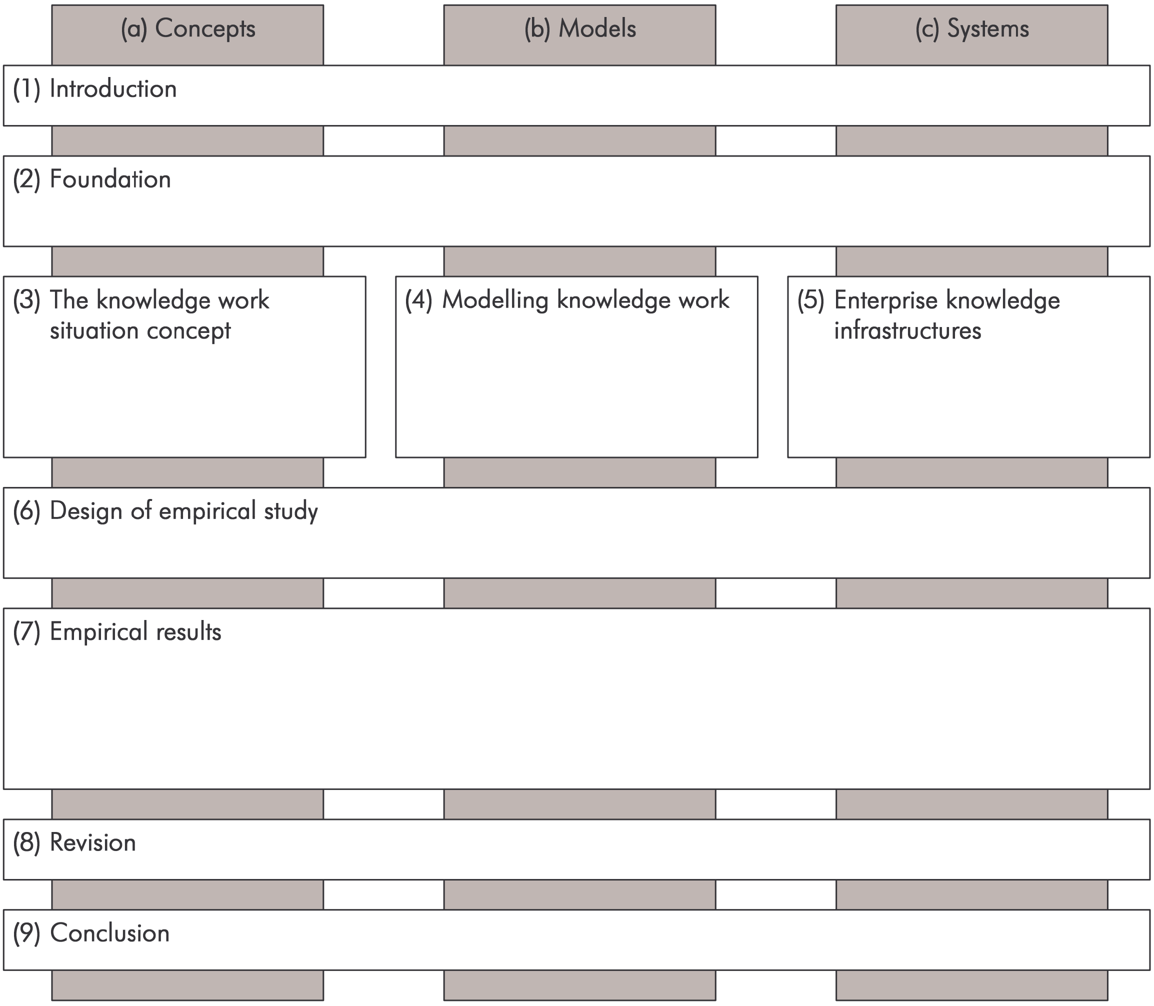

Figure 2. Overview of the structure of this thesis

The three levels of concepts, models and of systems are discussed in detail each within a separate chapter. The *third chapter* motivates the need for a new concept based on contrasting a task-oriented and learning-oriented perspective on knowledge work in business processes and presents relevant features of the situation concept that in turn inform the definition of the KWS concept. The *fourth chapter* based on the foundations of modelling in the context of the MIS discipline and KM defines a set of criteria that then are used in order to compare approaches proposed for the knowledge-oriented modelling of business processes. The *fifth chapter* introduces the principles of service-orientation and then turns to a service-oriented perspective on EKI. It pays special attention to the description of traditional and more flexible means of service composition. It summarizes the state-of-the-art of knowledge services which also represents a foundation for the empirical study.

The following two chapters are dedicated towards the description of the design and the results of the empirical study. They concern all of the three levels investigated in detail before.

The *sixth chapter* motivates the general research approach and the specific goals of the empirical part and describes semi-structured qualitative interviews, which were used for data collection. Afterwards, it outlines the approaches applied for data analysis, i.e. qualitative content analysis based on a primarily inductive coding procedure. The *seventh chapter* presents the results of the analysis of the empirical data. This comprises the description of steps and knowledge actions that are accomplished as the result of KWS, of knowledge services accessed in their context as well as of further results gained based on the data, e.g., a characterisation of the respondents' work tasks from a KM perspective and a comparison of the organisations surveyed. It also includes a reflection on the results, amongst others in terms of the similarities of and differences between knowledge actions. Finally, a set of hypotheses that is formulated that incorporate the main results of the empirical study. The *eighth chapter* revises the KWS concept based on the findings achieved. This concerns the redefinition of the KWS concept, the proposition of a meta-model for modelling KWS as well as their support by means of composite services and portals. The *ninth and last chapter* summarises the results of this work, proposes research questions that follow from it and gives a short outlook.

2 Foundation

Before the levels of systems design *concepts*, *models* and *systems* can be investigated in more detail, the most important theoretical fundamentals concerning this work are summarized. This touches all of these three levels. Goals of this chapter are to explain and define concepts referred to in the course of this work and to summarize the related key arguments, insights and current state of research. This mainly concerns the concepts knowledge and knowledge work as well as business process-oriented KM and related fields.

2.1 Overview

Figure 3 provides an overview of this chapter. As each of the figures within the overview sections of the following chapters, it focuses the structure of the chapter in question and visualizes which of the aspects *concepts*, *models* and *systems* is touched. Firstly, the concept of knowledge is defined and detailed with regard to possible classifications, media and its representation in IS (section 2.2). Then, knowledge work is described in terms of perspectives on the concept and related challenges of support (section 2.3). Afterwards, strategies, organisation, instruments and systems relevant in the context of KM are outlined (section 2.4) and the principles of business process orientation are summarized (section 2.5). Business process-oriented KM integrates ideas from both fields and is presented based on these foundations (section 2.6). Finally, the results of the chapter are summarized (section 2.7).

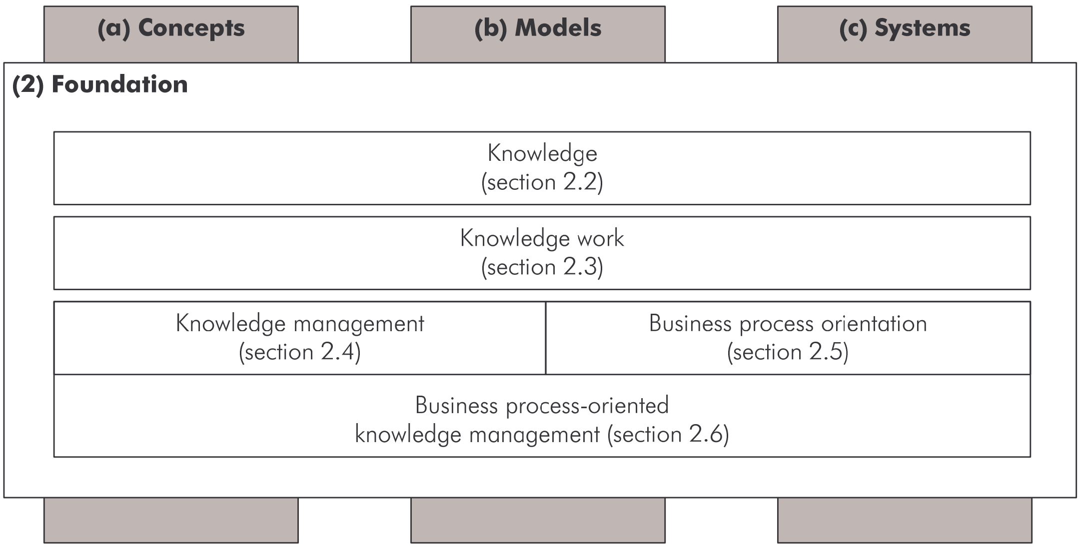

Figure 3. Overview of the chapter *Foundation*

2.2 Knowledge

Knowledge is one of the key concepts used to explain the economic and social transformations during the last century and ultimately the shift from an industrial to a knowledge society (Drucker 1993, 5ff; 1994; Stehr 1994, 26ff). Economically, this is reflected by the knowledge-based perspective of the firm in the strategic management literature (Grant 1996; Nonaka & Takeuchi 1995; Spender 1996; Zack 2003) that extends the resource-based theory of the firm (Hall 1992; Wernerfelt 1984) proposed as an alternative to a primary strategic focus on markets (Porter 1985). The main task of the firm in this view is the coordination of knowledge-based resources since they represent the major source of competitive advantages (Grant 1997, 451). Strategic management operationalises the term knowledge pragmatically by means of resource classifications, e.g., the distinction between tangible, intangible and human resources (Grant 1998, 111ff).[2]

However, when taking a closer look on this concept, its high complexity is revealed as well as the many different associated meanings and connotations. This is reflected by a multitude of terms and expressions that denote a piece or process in the scope of knowledge, e.g., ability, competence, experience, idea, know-how, understanding or wisdom (Lehner 2006, 74f; Maier 2004, 58). Defining knowledge has occupied philosophers for many centuries since the Greek era. A common understanding has not been found yet (Maier 2004, 59). An important reason is that different schools of thought exist that formulate various and partially competing perspectives on what is regarded as truth and knowledge in a society and how it is constructed. These schools of thought are reflected by different research paradigms that will be summarized very briefly in order to clarify the fundamental questions discussed and to classify the nature of this research. Afterwards, the concept of knowledge will be described in terms of classifications, media and its representation in IS.

Paradigms

A paradigm is defined as a set of "… basic beliefs … that deals with ultimates or first principles" (Guba & Lincoln 1994, 107). These represent the researcher's worldview and ultimately have to be accepted or rejected because their truth cannot be proven (ibid.). Research paradigms differ with regard to three fundamental and interrelated questions (Guba & Lincoln

[2] See Maier (2004, 92ff) for a classification that integrates common other taxonomies of intangible resources.

1994, 108): the ontological, the epistemological and the methodological question. The *ontological question* is concerned with the form and nature of reality. It is about what exists and what can be known about it. The *epistemological question* relates to the relationship between the knower and what can be known. It is constrained by the position taken with respect to the ontological question. The *methodological question* asks how the inquirer can proceed to find out what can be known and is determined by the first two questions.

Prominent paradigms are positivism, critical rationalism, pragmatism and constructivism (Guba & Lincoln 1994, 108ff; Maier 2004, 58f; Riempp 2004, 58ff): *Positivism* goes back to Comte and assumes an apprehensible reality driven by natural laws and mechanisms. Investigator and investigated object are independent entities. Questions and hypotheses are stated as propositions and are subject to empirical test. *Critical rationalism* as advanced by Popper argues that an objective reality exists but can only be imperfectly apprehended due to flawed human perception and fundamentally unobservable phenomena. Researchers are responsible to facilitate the objective apprehension of reality as closely as possible but true objectivity remains an ideal. The paradigm addresses the critique of pure positivism by collecting a larger amount of situational information, inquiring more natural settings and re-introducing discovery as an element in inquiry.

Pragmatism states that all knowledge evolves from experience which is always restricted to a local reality. Labels such as "real" and "true" cannot be understood outside the context of inquiry and thus this paradigm is not concerned with universal truth. Theories need to be abstracted from experience and in turn must be able to inform it. Amongst others, pragmatism is referred to in the context of action research. It was developed by was developed by, e.g., Pierce, James and Dewey. *Constructivism* questions the existence of an objective reality. It equates reality with multiple, intangible mental constructions of individuals or groups that are based on social relations and experiences. The investigator needs to interact with the object of investigation which in turn is influenced by him so that findings literally are "created". Methods suggested are hermeneutical techniques and dialectical interchange. It is represented, e.g., by the Erlangen school in Germany.

Table 1 summarizes these paradigms concisely and highlights their relation to the three main questions. They can be used in order to classify research approaches and strongly influence the choice of concrete research methodologies as well as the interpretation of findings. This work is based on critical rationalism represented by Popper (1969). This is reflected by the design of the empirical study and the way how the empirical data is analysed and interpreted (chapters 6 and 7).

	positivism	critical rationalism	pragmatism	constructivism
ontological question	An objective reality exists that principally can be fully apprehended by …	There is an objective reality but it can only partly be objectively observed …	Reality manifests only by its practical consequences …	Reality is socially constructed by individuals and groups, …
epistemological question	… an independent investigator …	… due to flawed human perception …	… because all human experience is restricted to a fraction of the universe …	… reconstructed and changed during investigation …
methodological question	… who needs to evaluate empirically testable hypotheses.	… which needs to be taken into account by research methods.	… so that theories need to be generalized from practice and simultaneously need to inform it.	… and can only be discovered by different forms of interaction.

Table 1. Overview of research paradigms[3]

Definition of knowledge

The general debate about paradigms and the term knowledge neither influenced the knowledge based-theory of the firm nor the management of organisational knowledge (Alavi & Leidner 2001, 109). Nevertheless, the paradigms outlined not only highlight important issues related to the concept of knowledge but also influence the selection of research methods which is also relevant for this work. Different and pragmatic views on knowledge are expressed in fields related to this research such as information technology (IT), strategic management and organisation theory. Within the IT-oriented literature, knowledge is defined by distinguishing between data, information and knowledge (McQueen 1998; Rehäuser & Krcmar 1996, 3ff) with the help of the linguistic fields syntactics, semantics and pragmatics (Krcmar 2005, 16f; Yule 2006). *Data* refers to symbols that represent an elementary description of an entity. They are ordered according to a syntax which defines the constructs of a language and valid relations between them. *Information* refers to the meaning that is assigned to data and thus is linked to the linguistic field of semantics. This field deals with the conventional meaning conveyed by the use of words, phrases and sentences (Yule 2006, 100). The distinction between information and *knowledge* is drawn by referring to the field of pragmatics, which is concerned with the meaning of language and especially the gap between literal

[3] based on Guba & Lincoln (1994, 109)

meaning, e.g., of a sentence, and the speaker meaning, i.e. the meaning that a speaker is trying to convey (Yule 2006, 112). Knowledge in this context can be defined as "personalized information" (Alavi & Leidner 2001, 109) that is the result of associating information items with other contents of individual memory.

Based on a literature review of the abovementioned fields, Maier (2004, 73f; 2005, 19f) defines knowledge as all cognitive expectancies, i.e. meaningfully organised and accumulated observations that have been embedded in a context through experience, communication or inference, that an individual or organisational actor uses to interpret situations and to generate activities, behaviour or solutions. Actors are individual persons and organisational or social entities such as groups, teams or communities. This definition implies that knowledge principally does not exist outside an actor. It is converted to information once it is articulated and represented in symbolic forms and thus needs to be reconstructed by its receiver through interpretation (Alavi & Leidner 2001, 109). Consequently, it is more appropriate to speak of knowledge reproduction than of knowledge transfer as in strict sense, knowledge cannot be transmitted objectively (Stehr 1994, 394f). Particularly relevant is the context of knowledge as it determines its processing, interpretation and thus the actions of an actor. Maier's definition highlights the close relationship between knowledge and individual or collective action. Knowledge is not only the result of interpretation and action but vice versa represents a capacity to interpret and act (Maier, Hädrich & Peinl 2005, 20; Stehr 1994, 208).

Classifications of knowledge

Numerous classifications of knowledge are described such as the distinction between embrained, embodied, encultured, embedded and encoded knowledge (Blackler 1995, 1023ff), between implicit knowledge, explicit knowledge, public knowledge and proprietary knowledge (Willke 1998, 67) or between core knowledge, advanced knowledge and innovative knowledge (Zack 1999a, 133)· These classifications can be aggregated to the following dimensions (Maier 2004, 65f, 74ff): (1) The dimension *source*, i.e. organisation-internal vs. organisation-external knowledge, maintains the organisation as focal point for distinguishing knowledge though its boundaries get increasingly blurry through project organisations, co-operations or virtual organisations. (2) *(Electronic) access*, i.e. (electronically) accessible vs. inaccessible knowledge, addresses the accessibility of documented knowledge, e.g., on the Intranet, as well as of experts holding knowledge in selected domains. (3) *Security*, i.e. secured vs. unsecured knowledge, emphasizes the fact that an increased transparency and electronic distribution of knowledge also increases the risk of unwanted knowledge distribution. (4) *Organizational level*, i.e. individual vs. collective knowledge, separates knowledge held by each individual employee from collective knowledge as targeted by many organisational learning theories represented by organisational routines, norms, values, culture and a shared understanding. (5) *Formality*, i.e. formalized and approved vs. informal and unapproved knowledge, reflects the degree of institutionalization of knowledge in an organisation in contrast to individually developed knowledge that is shared within communities. (6) *Externalization*, i.e. tacit vs. explicit knowledge, refers to the extent to which knowledge can be formally articulated. (7) *Generalization*, i.e. specific, particular, contextualized knowledge vs. abstract, general, decontextualized knowledge, indicates whether knowledge can be applied within one specific setting or across multiple cases. More recently, Maier & Schmidt (2007) add (8) *maturity*, i.e. ideas vs. established knowledge, that opposes newly, individually created knowledge with established and more broadly accepted knowledge distributed, e.g., by means of electronic training units.

The differentiation of types of knowledge based on varying degrees of externalization is very popular. The frequently-cited aphorism "… we can know more than we can tell" coined by Polanyi (1966, 4) points to the fact that there is expressible and not expressible knowledge. Nonaka (1995, 8) picks up this distinction by referring to tacit and explicit knowledge. *Tacit knowledge* is not easily visible and expressible, highly personal and hard to formalize, which makes its sharing difficult. *Explicit knowledge* on the other hand is formal and systematic. It can be expressed in words and numbers and thus is easily communicated in the form of formulae, codified procedures or general rules. The distinction can be used to oppose different conceptions of knowledge in Western and Japanese approaches to organisational KM (Nonaka & Takeuchi 1995, 8f). It also parallels conceptions of knowledge and truth of the different research paradigms, i.e. positivism tends to prefer knowledge that can be externalized and formalized whereas constructivism emphasizes personal tacit knowledge.

Turning tacit knowledge into explicit knowledge is called *externalization* and the reverse process *internalization* (Nonaka & Takeuchi 1995, 62ff). However, these processes should not be understood in the sense that all tacit knowledge can be externalized and later on internalized. As already noted, exchange of knowledge is a complex reconstruction process. Sometimes, tacit knowledge is further distinguished into implicit knowledge, i.e. knowledge that can be externalized with more or less efforts, and the residual tacit knowledge, i.e. knowledge that principally cannot be expressed. Polanyi comes to the conclusion that *every* knowledge has a tacit dimension (Polanyi 1966, 24f), i.e. some share of knowledge never can be expressed formally. This also points to the fact that all the dimensions described should be taken as continua rather than as dichotomies. The concept of knowledge is not "solid" and should not be reduced to simple classes or categorizations though this is done frequently (Alvesson 2001, 865; 2004, 47).

Knowledge media

Knowledge is described to reside on the different media product, person and process (Maier 2004, 77f; Maier, Hädrich & Peinl 2005, 23f). These will be explained in more detail as they each determine alternative perceptions of KM, different strategies for managing knowledge and a different role of IS (Alavi & Leidner 2001, 110):

Product. The view on knowledge as a product posits that a part of it can be detached from actors by means of externalization resulting in documented knowledge that can be made available for reuse. Knowledge is regarded as a thing that can be stored and manipulated (Alavi & Leidner 2001, 110; McQueen 1998, 610), basically as *information plus context* (Rehäuser & Krcmar 1996, 6) or as *content and structure* (Zack 1999b, 48). Viewing knowledge as a product principally contradicts the definitions above that strongly tie it to an actor. The products essentially are data and information that can be stored and manipulated with IS. Context information that is stored as a part of these products nevertheless offers a means to interpret the information and to reconstruct the knowledge stored. It describes the circumstances of the creation and application of a specific knowledge item (Alavi & Leidner 2001, 109). Thus, it can be rightfully stated that knowledge resides within these products that are created and used by knowledgeable actors. An implication is that systems to support knowledge may not appear fundamentally different from traditional IS but are targeted at enabling users to assign meaning to information (Alavi & Leidner 2001, 109). Typical examples are documented lessons learnt, best practices, micro articles or stories.

Process. The view on knowledge as being represented by processes in social collectives emphasizes the position that knowledge should be rather regarded as something that individuals do than as something they possess, i.e. acting knowledgeable (Blackler 1995, 1023). Blackler suggests that this should be analysed on the level of socially-distributed activity systems as described by Engeström (1987) rather than on individual level. The reason is that knowledge is not only revealed in practice, but also created out of practice (Brown & Duguid 1998, 95). As most work is a collective, cooperative venture, most dispositional knowledge is inherently collective which consequently has to be analysed on collective level (Brown & Duguid 1998, 95). Learning in this context is regarded as a non-individualistic process, an active community-based social practice which involves participation, activity and negotiation of meaning (Lave & Wenger 1991). Knowing is a dynamic and constantly reshaped activity rather than a state of mind which ultimately resolves the dichotomy between knowledge and learning (Blackler 1995, 1038). Practices formed by individuals that are part of semi-permanent work groups are an example of knowledge as a social process (Daskalaki & Blair 2002).

Person. The view on knowledge as bound to persons emphasizes the state or fact of what has been perceived, discovered or learnt by individuals and focuses on enabling people to expand their competences (Alavi & Leidner 2001, 110). The term *competence* is referred to in order to denote individual knowledge, abilities and skills (Beck 2005, 69ff; Becker 2005, 4ff): *Knowledge* in this context is a person's implicit and explicit knowledge. *Abilities* are cognitive, mental and physical predispositions of an individual. *Skills* are learnable and observable proficiencies. The terms competence and *qualification* are very close to each other. The difference is that competencies are defined with regard to the accomplishment of tasks whereas qualifications are related to formal education and the obtainment of certificates (Beck 2005, 70f; Becker 2005, 7ff). On an organisational level, core competencies, also called core capabilities, are defined as "teams of resources working together" (Grant 1991, 120) or an "interconnected set of knowledge collections" (Leonard-Barton 1992, 122) and comparable to individual competencies emphasize the capacity to act, in this case that of an organisation to generate customer value. It represents an important concept for the development of a KM strategy. Nevertheless, this view on knowledge in the following will be referred to as *person perspective*. This puts the individual holders of knowledge into the centre and emphasizes the relevance of individual competences. The three media of knowledge are summarized in Figure 4.

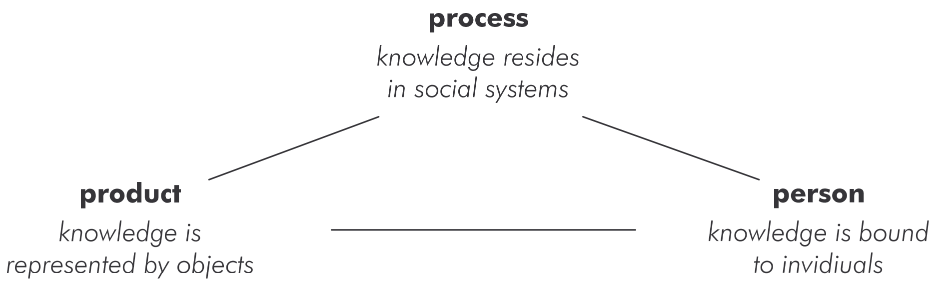

Figure 4. Media of knowledge[4]

The perspective on knowledge as an object is emphasized in the context of IT-supported KM. Concerning the other views, IT plays a less dominant role and primarily targets the facilitation of interaction between individuals (Zack 1999b, 51). Though this work is concerned with support of knowledge work with technical systems, it maintains a neutral position with regard to the question which one of the views should be primarily followed. In contrast, KM approaches rather may suffer from overly emphasizing one of them. This work thus promotes the integration of these perspectives. Each describes aspects that cannot be completely neglected by an integrative KM approach. The relevance of single perspectives surely may differ and should be decided based on the main goals of the KM measure that is applied.

Representation of knowledge in information systems

If it is accepted that knowledge can be represented in IS, the question arises in which forms and ways this can be done. It is represented by semi-structured data such as text documents, Web pages, emails, reports, news, pictures and audio or video. Semi-structured data in contrast to structured data is not formalized in a way so that its semantics can be easily processed with computers. It does not follow a relational structure as known from data management (Sullivan 2001). The distinction between structured and semi-structured data mirrors that between hard and soft information (Watson 2002, 34f) as well as between quantitative and qualitative information (Bange 2005, 1f). They all have in common that they in fact are not based on clear-cut classes but rather represent continua.

In the context of this work, the term *content* is preferred to refer to documented knowledge because it is widely-used in relation to system classes relevant in KM. Content is defined as any set of meaningfully arranged data that can be addressed and manipulated by a human

[4] based on (Maier 2004, 75)

or a system as a discrete entity (Gersdorf 2002, 75; Gill, Gilliland & Woodley 2005; Gulbins, Seyfried & Strack-Zimmermann 2002, 150).[5] In the context of Web content management, the requirement of a strict separation between content and its layout is posed (Kerer & Kirda 2000). This enables their easy transformation over different media. The term is applied to refer to semi-structured data stored in IS and will be used accordingly in this work, though the definition principally also subsumes structured data.

Meta-data can be used to store contextual information about contents which is important for the reconstruction of knowledge. From a technical perspective, it acts as a means to integrate contents maintained in different systems (Maier 2004, 260f). Literally, meta-data means "data about data" and refers to "… data associated with either an information system or an information object for purposes of description, administration, legal requirements, technical functionality, use and usage, and preservation" (Gill, Gilliland & Woodley 2005). An information object is defined as "... anything that can be addressed and manipulated by a human or a system as a discrete entity" (Gill, Gilliland & Woodley 2005) and corresponds to the term content preferred in this work. *Ontologies* can be used in order to represent the structure of knowledge and allow formalizing meta-data (Staab 2002, 201f). The term ontology can be defined concisely as a formal specification of a shared conceptualization (Gruber 1993). Ontologies are used to represent the basic terms of a domain area as well as rules for combining terms and relations. More precisely, an ontology models objects in domains, relationships among them, properties, functions and processes involving the objects and constraints and rules about objects (Daconta, Obrst & Smith 2003, 166f). In contrast to hierarchical taxonomies, they also describe extended relationships between concepts, e.g., symmetric, transitive or inverse associations. Inference rules describe how knowledge can be gained from existing statements. An example is: If two companies operate in the same industry and in the same geographic region, then they are competitors (Maier, Hädrich & Peinl 2005, 177). This enhances flexibility, e.g., of handling or searching electronic contents, and enables for validity checks not only on a syntactic but also on a semantic level.

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[5] As this work is primarily concerned with contents stored in IS, the terms *content* and *electronic content* in the following will be used synonymously.

2.3 Knowledge work

The terms knowledge work and information work were coined in order to emphasize the differences to traditional blue collar work and corresponding changes and challenges associated with its support (Drucker 1969, 287ff). They are not new concepts but have been popularized more then thirty years ago. They are attributed increasing relevance in today's economies. Within the United States, the share of information workers increased from 37 percent of the work force in 1950 to 59 percent in the year 2000 (Wolff 2005, 38). Knowledge workers were the fastest growing group during the last decade with increasing growth rates. Amongst others, this is explained by technological change within each industry that substituted other types of labour by information labour (Wolff 2005, 42). The many different views and conceptualizations of knowledge outlined in section 2.2 already suggest that knowledge work cannot be straightforwardly defined and delimited from other types of work. Wiig even argues that "all work is invariably knowledge-intensive" (Wiig 1995, 27). Conceptualizations differ depending on the perspective taken on knowledge work, which will be outlined in the following. Afterwards, this section turns to characteristics of knowledge work and challenges of its support.

Perspectives on knowledge work

Schultze (2003) distinguishes three perspectives on knowledge work: economic, labour process and work practice perspective. They are outlined in the following:

Economic perspective. The economic perspective emphasizes the differences of knowledge work to other types of work. The nature of knowledge that workers possess is highlighted, which is characterized as abstract and theoretical. A high level of formal education is used as a proxy for this. The second point made is that knowledge workers produce new knowledge instead of applying existing knowledge (Kelloway & Barling 2000, 292; Schultze 2003, 46). As only a small share of work accomplished in organizations would classify as knowledge work according to this definition, it is proposed to focus on information work (Maier 2004, 44) that comprises knowledge work, data work and management work (Schultze 2003, 45). *Data work* is concerned with the use of knowledge and information as well as its transmission (Wolff & Baumol 1989, 21f). *Management work* is performed by executives and supervisors that need to process, communicate and translate large amounts of information and prepare, take and execute decisions (Drucker 1974, 465ff). Excluded is all *goods labour* that transforms or operates on physical goods or objects (Wolff 2005, 39; Wolff & Baumol 1989, 21f) as well as *service work* that does not differ fundamentally from goods labour and includes clerical jobs such as billing, answering customer inquiries and the handling of insurance claims (Drucker 1993, 76). An approach within this perspective is the series of studies conducted by Wolff et al. that divides data work, information work and knowledge work based on a somewhat arbitrary classification of occupations recorded within the United States census data (Baumol, Blackman & Wolff 1991, 144f; Wolff 2005; Wolff & Baumol 1989, 37ff).

Work practice perspective. As Blackler et al. (1993, 857f) argue, definitions of knowledge work that are based on what knowledge workers know as well as proxies for it such as profession or education are problematic because the knowledge concept is inherently ambiguous. The work practice perspective thus focuses on what knowledge workers do rather than what they know (Schultze 2003, 47ff). It is based on the view on knowledge as a process or social system (section 2.2). Knowledge work is characterized by specific *informing practices* such as acquisition, gathering, systemizing and communication of knowledge (Stehr 1994, 395), acquisition, creation, packaging and application of knowledge (Davenport, Jarvenpaa & Beers 1996, 54), creation, application, packaging and acquisition of knowledge (Kelloway & Barling 2000, 292), procurement, organising, storing, maintaining, analyzing, creating, presenting, distributing and applying knowledge (Holsapple & Whinston 1987, 78f) and also roles with specific tasks such as data gatherer, information user, knowledge user and knowledge builder (Snyder-Halpern, Corcoran-Perry & Narayan 2001, 17f). More generally, knowledge work is coined as production and reproduction of information, involving specific processes such as generation, interpretation and representation of knowledge (Schultze 2003, 51).

Labour process perspective. The labour process perspective is primarily based on the formation of knowledge workers as a new class of workers located between blue collar workers and capital owners, in terms of the Marxist theory between proletariat and bourgeoisie (Schultze 2003, 47). One of the key questions discussed is whether this grouping will stabilize and remain as a new middle or will split and join the above and lower classes. Figure 5 visualizes these three perspectives on knowledge work.

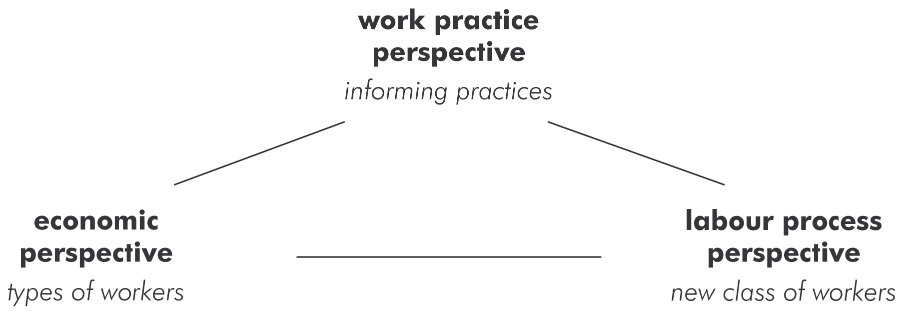

Figure 5. Perspectives on knowledge work

This work follows the arguments of the work practice perspective and focuses on what knowledge workers actually do rather than what they possess. This resolves the issue that knowledge work is not a category of work(ers), but rather a continuum along which work varies (Kelloway & Barling 2000, 291), or in other words: It is a share of work that every worker accomplishes to a different degree. However, the practices proposed within this perspective have to be detailed in order to offer reasonable starting points for the design of an organisational and technical environment. This issue will be referred to later in this work.

Characteristics of knowledge work and challenges for support

A number of characteristics related to work tasks is used in order to further delimit knowledge work from traditional work (Drucker 1974, 32f; 1993, 75ff; Kelloway & Barling 2000; Kidd 1994, 187f; Maier, Hädrich & Peinl 2005, 25ff; Newell et al. 2002, 27ff; Pyöriä 2005, 124; Schultze 2000, 5f; Schultze 2003, 44f). These are outlined followed by challenges that result from them which concern organisational design, support by IT systems and economics (Maier 2004, 45ff; Maier, Hädrich & Peinl 2005, 26ff):

Work tasks. Knowledge work is distinguished from traditional work by the need to solve ill-structured problems in complex domains as well as by a high degree of variety and exceptions. This requires individuals to continuously familiarize with new topics and thus is involves continuous learning. Tasks and expected work results typically are defined only generally and need to be broken down individually. This requires a sufficient degree of autonomy for decisions. Creation of new knowledge requires creativity. The objects of knowledge work are symbols and people rather than physical materials. Correspondingly, intellectual and social rather than physical abilities are required which implies an increased need for training. Knowledge work is strongly based on sharing knowledge with other people. Thus, it requires close cooperation with other people, mobility and is accomplished decentrally. Overall, this leads to strong communication, coordination and cooperation needs.

Organisational design. With respect to organisational design, knowledge work has stronger communication and cooperation needs, is weakly structured and has less foreseeable processes. It is characterized by the assignment of multiple formal and informal roles to one person and an increasing importance of teamwork as well as membership in communities. It requires new management techniques apart from traditional business process reengineering approaches since knowledge processes cannot easily be foreseen and defined in advance. Communication, coordination and cooperation relationships between knowledge workers span organisational boundaries.

IT support. Knowledge work thus requires intensive yet flexible support by IT systems. Technical infrastructures are regarded as an enabler for knowledge work. Only few researchers question their relevance arguing that only data can be managed with IT systems, neglecting the perspective on knowledge as an object (e.g., Galliers & Newell 2001). Knowledge work deals with semi-structured data such as hypertext documents, email messages and multimedia files, rather than structured data such as database records and tables (section 2.2). It relies on systems such as Groupware, CMS and learning management systems instead of data base management systems and data warehouses. Due to its unstructured processes and low predictability, workflow management systems are only suited to support a low share of knowledge work. Messaging systems and Groupware are more relevant in this context. Due to the strong communication and cooperation requirements, knowledge work requires repeated and ideally continuous access to the organisational network infrastructure. This also leads to the need for support by mobile technologies such as personal digital assistants, smartphones or notebooks.

Economics. From an economical view, an important challenge is that success of knowledge work cannot be measured with financial metrics but rather the perspective needs to be shifted from tangible to intangible resources and values, from periodic reporting to continuous measurement and instant access to measures, from past orientation to future orientation, from valuing things to valuing flows, from statistics of production to statistics of innovation and from standardized reporting to common yet customized reports (Güldenberg 1997, 303ff; Skyrme 2000, 322). Table 2 gives a concluding overview of the characteristics and challenges described.

area	characteristics
work tasks	Knowledge work is creative work that solves ill-structured problems, involves continuous learning, is characterized by a high degree of variety and exceptions, requires autonomy for decisions, is based on intellectual and social abilities and thus has increased training needs, is strongly based on knowledge sharing, requires mobility and has strong coordination, coordination and cooperation needs,
organisation	has strong communication and cooperation needs, is weakly structured and has less foreseeable processes, is characterized by the assignment of multiple formal and informal roles, involves teamwork and membership in communities, spans organisational boundaries,
IT support	deals with semi-structured data and information, relies on systems such as Groupware, CMS and learning management systems, has a continuous need for network access, needs to be supported by mobile technologies
economics	and its evaluation ideally should be based on intangible resources and values, be conducted continuously, have a future orientation, value flows, apply statistics of innovation and is described by customizable reports.

Table 2. Overview of characteristics of knowledge work

2.4 Knowledge management

KM is still a young field though its roots can be traced back to organisational learning, e.g., to works by Cyert & March (1963; 2001) that transformed earlier largely anecdotal evidence of organisational learning into a formal theory (Argote, McEvily & Reagans 2003, 571). The term KM as used today was coined in the mid-1980s (Sveiby & Lloyd 1987; 1990; Wiig 1988). Research on organisational learning and KM is characterized by a high diversity and spans disciplines such as economics, information systems, organisational behaviour, organisational theory, psychology, strategic management and sociology (Argote, McEvily & Reagans 2003, 571f). From the view of computer science and MIS, roots also lie in the information processing approach, systems theory and artificial intelligence (Maier 2004, 27f).[6] The field is characterized by a wealth of empirical evidence and many theoretical perspectives (Argote, McEvily & Reagans 2003, 571).

Roehl (1999, 15f; 2000, 88ff) identifies three development lines of KM: ICT line, business line and sociological line. The *ICT line* is concerned with designing technical support for knowledge work in order to enhance its effectiveness. Here, KM can be characterized as the next

[6] For an overview of the roots of KM, see Maier (2004, 20ff) and also Lehner (2000).

step in a development from data management to information management (Maier 2004, 37ff; Rehäuser & Krcmar 1996) which partly reflects the hierarchical relationship between data, information and knowledge (section 2.2). The *business line* focuses on the economical value of knowledge as a resource. The foundation is an extended resource-based view of the organisation as already referred to in section 2.2. The *sociological line* deals with the organisation as a learning system that has a collective expertise and capability for innovation (Willke 1998, 6). As this work is concerned with support of knowledge work by technical systems within an organisational context, it can be classified to be in the tradition of the first as well as the second line.

Definitions of KM depend on these development lines. Maier in close relation to the first two lines defines KM as "… the management function responsible for regular selection, implementation and evaluation of knowledge strategies that aim at creating an environment to support work with knowledge internal and external to the organisation in order to improve organisational performance" (Maier, Hädrich & Peinl 2005, 38). Implementation of knowledge strategies "… comprises all person-oriented, product-oriented, organisational and technological instruments suitable to improve the organisation-wide level of competencies, education and ability to learn" (Maier, Hädrich & Peinl 2005, 38).[7] Hence, KM is a strategic effort that has to be closely linked to business strategy. KM strategy guides KM initiatives that are concerned with creation of an organisational and technological infrastructure that enables or supports effective knowledge work. The four areas addressed by the definition, i.e. strategy, organisation, instruments and systems will be outlined in more detail. KM is asked to follow a holistic approach rather than concentrating on one area in isolation (Wiig 1997). Hence, all of the areas are relevant and KM should not focus on one of them in isolation.

Strategy

The view on knowledge as strategic resource implies the need for a strong link between business and KM strategy. According to Zack (1999a, 135), KM should head to close the *knowledge gap* between what a firm knows and what it must know. It is determined by the *strategic gap* between what a firm can do and what it must do is addressed by business strategy. An organisation can *explore* new knowledge to close its internal or external knowledge gaps, i.e.

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[7] This definition is developed in Maier (2004, 55). See Maier (2004, 49ff) for a comprehensive discussion of other KM definitions.

the differences in internal knowledge processing or that compared to its competitors. Simultaneously, it needs to *exploit* its knowledge in order to generate revenues. Exploitation provides the financial capital for innovation and thus these two orientations should be regarded as complementary rather than as being exclusive (Zack 1999a, 137). Firms consequently need to maintain the right balance between exploitation and exploration. The distinction between exploitation and exploration is well recognized in the organisational literature (March 1991; Noteboom 2003) and also referred to as the flexibility paradox (Choo 1998; Volberda 1998) or as a trade-of between coordination and specialization (Demsetz 1988).

A prominent distinction of main strategic foci is that between codification and personalization by Hansen et al. (1999) that eventually is also based on the distinction between reuse of knowledge and innovation. *Codification* builds on knowledge reuse based on externalization, storage and dissemination of knowledge, what the authors coin as people-to-documents approach. IS play a dominant role by representing containers for documented knowledge and connecting people based on codified knowledge. *Personalization* targets the creation of new solutions by channelling expertise. It concentrates on sharing of knowledge by means of direct communication between people and thus is also referred to as people-to-people approach. IS only play a secondary role by facilitating conversations and exchange of individual knowledge. It is proposed to concentrate on one strategy and to use the other one as complement (Hansen, Nohria & Tierney 1999, 112).

Wiig (1999, 157f) refers to these two orientations as people focus and technology focus. However, these labels are regarded inappropriate as both of them can be supported with ICT. He identifies two additional focus areas of KM: enterprise effectiveness and intellectual capital. KM with an *enterprise effectiveness focus* is concerned with operational effectiveness and maximizing the application of knowledge assets. KM with an *intellectual capital focus* concentrates on strategic management of intellectual capital (Teece 2002, 12f), i.e. building, management and exploitation of assets including knowledge assets. Wiig suggests that all four orientations in fact are isolated but complementary tactical approaches to KM. He expects that effective enterprises in the future will pursue all four of them as part of their overall strategy. Maier summarizes and presents concepts suited to integrate these orientations under the topic *bridging the gap KM* (Maier 2004, 355ff; Maier & Remus 2003, 63ff). Important concepts in this context are business processes and knowledge processes as well as KM instruments (Maier 2004, 50). Figure 6 summarizes the four focus areas discussed.

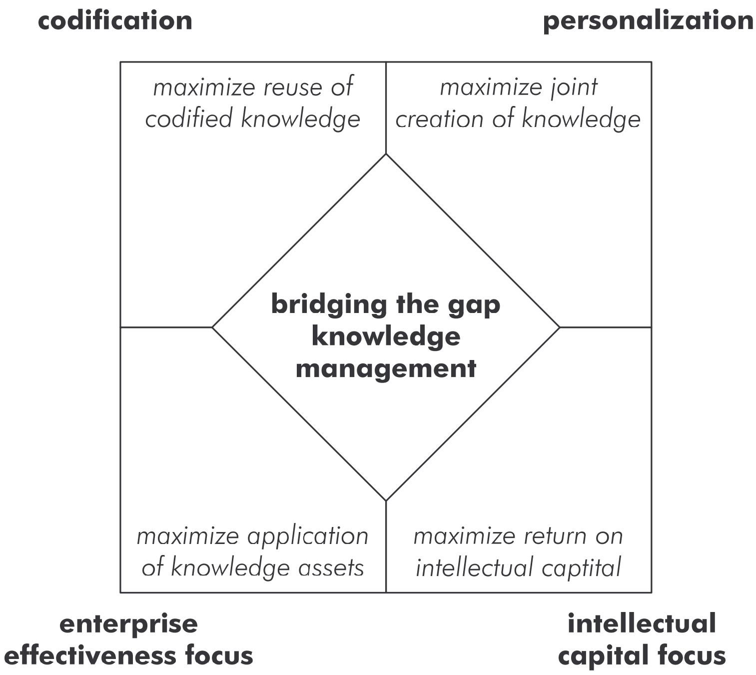

Figure 6. Strategic foci of KM[8]

Organisation

KM requires new organisational metaphors for and approaches to organisational design that account for the relevance of a systematic management of knowledge (Maier 2004, 139f). Examples for new organisational metaphors are the infinitely flat organisation, the inverted organisation, the hypertext organisation, the starburst organisation and the spider's web organisation (Maier 2004, 139f; North 1999, 79ff). The hypertext organisation (Nonaka 1994, 32ff)[9] is a good example of a metaphor that integrates exploitation and exploration of knowledge by distinguishing three interlinked organisational layers: business system, project system and knowledge base layer. On the *business system layer*, the routine daily operations are performed within a formal and bureaucratic organisational structure. Workers are also part of multiple self-organising and loosely coupled projects guided by a corporate vision that are located on the *project system layer*. The *knowledge base layer* comprises an organisation's tacit and explicit knowledge incorporated by, e.g., organisational culture, procedures, documents and data bases. Employees are able to dynamically switch between these layers which en-

[8] based on (Wiig 1999, 158)

[9] This article is based on Nonaka et al. (1992) (in Japanese).

ables a dynamic organisational learning cycle (Nonaka 1994, 33). This establishes many links between the layers that motivate the metaphor's name.

Coordinating and administrative KM tasks can be implemented in a centralized organisational unit. Other tasks are fulfilled by decentralized KM roles. Based on social role theory, a role is defined as consistent bundle of expectancies towards the holder of a social position, which includes privileges and obligations (Wiswede 2004, 1289). Examples for roles are *Chief Knowledge Officer* (CKO) who oversees KM initiatives, designs a KM strategy and ways for its implementation and also highlights awareness for KM (Davenport & Prusak 2000, 114ff), *subject matter specialist* who reviews and evaluates knowledge, e.g., contributions to a knowledge base, is expert in one or more topics and acts as a linking pin to agencies and research institutions (Probst, Raub & Romhardt 2006, 245), *knowledge broker*, who helps people locating knowledge needed within an organisation (Brown & Duguid 1998, 103; Ruggles 1998, 86) and *boundary spanner*, who networks different fields of expertise by brokering between experts and groups (Probst, Raub & Romhardt 2006, 246) and is also called *translator* (Brown & Duguid 1998, 103).

Groups of people are discussed frequently in the context of KM besides the general organisational structure and roles. They are the most important unit for development and sharing of knowledge and can be classified along various criteria such as size, amount of direct interaction between members and relation to organisational structure (Antoni 2004, 381f). Different types of groups are distinguished. *Teams* are defined as "… a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach & Smith 1993, 45). They are joined by assignment. A team has the primary goal of accomplishing given tasks. Though effective handling of knowledge is discussed on organisational level, managing knowledge is already a major challenge on team level requiring systematic ways and approaches (Eppler & Sukowski 2000, 334).

Another form of group is referred to in the KM literature: *communities* (Brown & Duguid 1991; Lave & Wenger 1991; Wenger 2002). In contrast to teams, they are joined voluntarily in order to satisfy individual needs. A community is defined as "… a long lasting group, composed of a large number of people with common recognized objectives that satisfy some of their individual needs, with low coordination but with many weak ties among members, where no member is critical for the survival of the group or the accomplishment of the common objectives“ (Ferrán-Urdaneta 1999, 130). Communities promise to be an efficient instrument for knowledge creation and sharing, amongst others because they are a long-lasting organisational phenomenon which motivates members to develop mutual trust, can be drivers of the implementation of a business strategy if they are aligned with it and may enhance motivation for learning and individual development as they are linked to personal needs (Maier 2004, 169ff). The view on knowledge as bound to processes in social collectives highlights the importance of communities (section 2.2). However, they can only be set-up and managed indirectly by offering a generative ground, i.e. an organisational and if appropriate also a technical infrastructure (Wenger, McDermott & Snyder 2002, 34f). Different types of communities are distinguished. For example, Communities of Practice are characterized by shared activities and similar tasks of their members (Brown & Duguid 1991; Lave & Wenger 1991). The participation in a Community of Interest in contrast is mainly driven by shared interests (Armstrong & Hagel III 1995).

Instruments

KM instruments are means for the implementation of a KM strategy. Maier et al. (2005, 41) based on Roehl (2000, 156ff) state that "KM instruments are part of an ICT-supported intervention into an organisational knowledge base and consist of a collection of organisational, human resources and ICT measures that are aligned, clearly defined, can be deployed purposefully in order to achieve knowledge-related goals, target contextualized information as object of intervention and are independent of a particular knowledge domain". The definition emphasizes the product perspective on knowledge by referring to knowledge as contextualized information (section 2.2) and thus also the possibility and need for IT support.

Maier et al. (2005, 42ff) propose a classification of KM instruments according to the media of knowledge person, process and product:

Person. Person-oriented instruments are knowledge source maps that visualize the location of people or of IS that bear knowledge and their relation to topics (Eppler 2003a, 192), competence management for systematic analysis, visualization, evaluation, improvement and usage of competencies of individuals (Beck 2005, 121ff; Deiters, Lucas & Weber 2000; Gebert & Kutsch 2003) and personal experience management for documentation, sharing and application of personal experiences (Reinmann-Rothmaier & Mandl 2000).

Process. Process-oriented instruments are knowledge application and development maps that describe application of knowledge in business processes by means of process models or learning paths that can be performed by individuals or groups (Eppler 2003a, 192f; Maier, Hädrich & Peinl 2005, 44), community management that targets creation of an environment supportive for communities and the development and exchange of knowledge within their context (Wenger, McDermott & Snyder 2002) and knowledge process redesign (KPR) that aims at re-designing business processes from a knowledge-oriented perspective (Allweyer 1998, 42f; Davenport, Jarvenpaa & Beers 1996). Process-oriented KM instruments will be described in detail in section 2.6.

Product. Product-oriented instruments comprise knowledge structure maps that visualize (types of) relationships between different topics (Eppler 2003a, 192) which can be formalized by ontologies (section 2.2), lessons learnt that target documentation of joint experiences made, e.g., in projects (Schindler & Eppler 2003, 221ff), identification and sharing of good or best practices that represent practice, knowledge, know-how or experience proven valuable and that may have applicability to other organisations (O'Dell & Grayson 1998; 2003, 606ff) and semantic content management that deals with semantic description, i.e. the assignment of machine-processable meaning and structure, and management of electronic contents (Jablonski, Meiler & Petrov 2004; Maier, Hädrich & Peinl 2005, 46f; Maier & Peinl 2006).

Systems

The KM definition cited above refers to technological instruments. In the context of this work, these are mainly *information and communication systems* or short *IS* that are defined as socio-technical systems that comprise human and machine components (WKWI 1994, 80). They are applied to fulfil business tasks and offer information for the management of operational processes as well as for satisfying information needs of humans or machines responsible (ibid.). The narrower term *ICT* is used to refer to the technical components of IS, i.e. all resources available for storage, processing and communication of information (Krcmar 2005, 27). In relation to KM, it can be distinguished between integrative and interactive ICT (Zack 1999b, 50ff): *Integrative ICT* represents a repository for documented knowledge that is used as the primary medium for knowledge transfer. It is applied with a focus on the support of tasks related to documented knowledge and thus emphasizes the perspective on knowledge as an object. *Interactive ICT* initiates and supports interaction between people and by this way the sharing of tacit knowledge. Hence, it is centred on knowledge bound to individuals. The term EKI was coined for ICT applied in the context of KM (Maier, Hädrich & Peinl 2005). Its characteristics and services will be discussed in detail in section 5.3.

KM is not without critique though few authors go as far to call it "nonsense" or a "management fad" (Wilson 2002). A popular argument is that knowledge principally cannot be managed. Opinions whether knowledge can be managed or not differ with regard to fundamental assumptions about the two concepts *knowledge* and *management*, how knowledge is defined and particularly whether tacit knowledge can be managed at all (Roehl 1999, 22f; Schultze & Leidner 2002, 221ff; Schultze & Stabell 2004, 550f). This work subscribes to the pragmatic view of Maier that is also reflected by his KM definition. He argues that KM is concerned with establishing an environment to support dealing with knowledge and acknowledges that systems applied in this context strictly speaking do not contain knowledge nor they do manage it (Maier 2004, VII). Nevertheless, that KM in fact is a misnomer does not necessarily mean that knowledge-oriented interventions are useless and that ICT cannot be applied to enhance the effectiveness of knowledge work.

2.5 Business process orientation

The distinction between structural operation and operational structuring determined organisation science approaches in German-speaking countries for a long time (Lehner 2000, 63). Kosiol in his influential work takes up this separation (Kosiol 1962). Organisation as a whole is concerned with creating a framework that enables making dispositions and fulfilling tasks based on a division of labour (Kosiol 1962, 28). Structural operation targets the constitution of organisational units based on organisational tasks (Frost 2004, 46). Operational structuring on the other hand is concerned with the combination of single work steps to processes and sequences in respects of time and place (Kosiol 1962, 32). Kosiol emphasizes that the distinction between structure and process is only a theoretical one and in fact deals with one and the same objects (Kosiol 1962, 32). Nevertheless, one of the two perspectives has to be given priority. In German-speaking countries, this question traditionally was decided in favour of structural operation. However, this may lead to an overly deterministic view on organisations and their goals and thus to inefficiencies (Frost 2004, 51f).

Business process orientation puts business processes into the focus of organisation (Hammer 1990; Hammer & Champy 1993). It is characterized as new, third perspective on organisations and can be explained from a praxeological, economical and constructivistic perspective

(Gaitanides 2004, 1210ff). Within the *praxeological perspective*, process organisation directly follows from the distinction between two traditional perspectives and thus mainly is concerned with design of task sequences independent of the other organisational context. From an *economical perspective*, processes can be explained based on transaction cost theory (Williamson 1983) as a hybrid structure that interlinks different hierarchical functional structures specialized based on products and services and differentiated according to markets. Process organisation in this view combines advantages of hierarchical and market-based coordination (Gaitanides 2004, 1211). From a *constructivistic perspective*, processes represent an attractive model to communicate the need for overcoming internal organisational boundaries and for organisational change. A radical redesign of an organisation needs such motives in order to communicate and induce change (Gaitanides, Scholz & Vrohlings 1994, 13). Process organisation in this view ultimately is created by communication and interaction as a socially constructed reality. In practice, business process orientation was discussed during the last decade under the topic of business process reengineering (BPR). The development will be summarized shortly in the following before turning to different types of business processes and the role of IT.

From business process reengineering to process management

Business process orientation was intensively discussed at the beginning of the 90s as a way out of the crisis of the predominantly functional organisational structures that were more strongly oriented towards realizing cost advantages than at creating customer value (Gaitanides, Scholz & Vrohlings 1994, 2). Porter's value chain was one of the first models that put the analysis of activities based on their contribution to creation of customer value at the centre of strategic analysis (Porter 1985, 36ff).

Davenport (1993, 10f) contrasts process improvement and business process redesign (BPR) as two opposite process-oriented approaches. *Process improvement* follows a quality management approach, targets incremental change of existing processes over a long period of time and actively motivates employees to reflect on and enhance the quality of processes. *BPR* starts with a "clean slate", promotes radical change and is driven by senior management and a cross-functional reengineering team. Hammer & Champy (1993) as the main representatives of BPR promote a radical reengineering approach and discontinuous thinking as an alternative to a stepwise improvement. The headline of Hammer's seminal article "Don't

Automate, Obliterate" highlights this position (Hammer 1990, 104). These radical approaches hit the pulse of the age and led to a wave of reengineering projects during the 1990s.

However, the striking distinction between process improvement and BPR bears many internal contradictions (Melão & Pidd 2000, 106). Though discontinuous thinking is applicable for the design of processes, their actual implementation nevertheless needs to be done over several phased projects (Davenport & Stoddard 1994, 123). In practice, a pure "clean slate" approach is rarely found (ibid.). Critics of BPR point to the fact that the majority of BPR projects fail with the main reasons being lack of management commitment and leadership, unrealistic scope and expectations as well as resistance to change (Malhotra 1998). A few years later, the main proponents of reengineering had to admit that reengineering in this radical view is finished (Davenport 1995; Hammer 1997, 23f). The insight remains that the focus on processes yet is highly promising for the effective organisation of an enterprise (Melão & Pidd 2000, 108).

Process management evolved afterwards as a less radical, more holistic and more context-specific approach (Melão & Pidd 2000, 109). It comprises "… planned, organisational and control measures for goal-oriented steering of an organisation's value chain with respect to quality, time, costs and customer satisfaction"[10] (Gaitanides, Scholz & Vrohlings 1994). Ultimately, it is concerned with the effective interaction of different organisational functions (Becker & Kahn 2003, 4f). This characterization highlights core ideas of business process orientation: strong orientation towards creation of customer value, organisation based on processes along the value chain and process management as a strategic management effort (Remus 2002b, 14f). From an IT perspective, process management is described as an integrated management approach comprising process design and control, process execution by means of workflows and the design of ICT (Scheer 2002, 54ff). Process management targets enhancements of existing business processes rather than radical design of new processes through elimination of weaknesses in existing processes by, e.g., analysing process with respects to time, cost, quality and customer satisfaction, estimating contribution of single activities to value creation, assessing outputs based on customer requirements, analysing information flows and eliminating redundant information creation and evaluation activities as well as benchmarking processes, i.e. comparing internal and external processes (Scholz &

[10] In German: „…planerische, organisatorische und kontrollierende Maßnahmen zur zielorientierten Steuerung der Wertschöpfungskette eines Unternehmens hinsichtlich Qualität, Zeit, Kosten und Kundenzufriedenheit."

Vrohlings 1994, 107). It distinguishes different types of business processes that are defined and outlined in the following.

Types of processes

In general, a process is defined as "… a natural phenomenon marked by gradual changes that lead toward a particular result, … a continuing natural activity or function … (or) a series of actions or operations conducing to an end" (Merriam-Webster 2003, 990). The last definition is relevant for this work as processes in an organisational context are always targeted towards achieving particular results. A *business process* can be defined as "… recurring sequence of actions that conforms to more or less rigid control patterns. It is goal-oriented and directly related to the market-oriented creation of goods and services by an organisation. … The execution of business processes requires the application of scarce resources" (Frank & van Laak 2003, 18).[11] This definition is narrow in the sense that it strongly links business processes to value creation for customers.

Others in this respect describe the term more broadly. Davenport & Short (1990, 12) for example define business processes as "… a set of logically related tasks performed to achieve a defined business outcome". Scheer (2002, 3) defines it as "… a sequence of related organisational activities having the goal of value creation".[12] He adds that it runs from customer to customer, i.e. it is activated by customers that also receive its output (ibid.). Staud (2001, 9) after a review of various definitions characterizes business processes more detailed as to "… consist of a series of interrelated self-contained series of operations required to fulfil an operative task. Tasks are accomplished by task performers in organisational units through usage of the required production factors".[13] The last three definitions also include creation of values for internal customers. Staud's definition will be followed here as it is regarded as the most specific one but broad enough to also include processes only indirectly related to value creation. It should be noted that the task of organisational design is concerned with types

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[11] In German: „… eine wiederkehrende Abfolge von Aktivitäten, die mehr oder weniger rigiden Regelungsmustern genügt. Er ist zielgerichtet und steht in einem direkten Zusammenhang mit der marktgerichteten Leistungserstellung eines Unternehmens. … Die Ausführung von Geschäftsprozessen erfordert den Einsatz knapper Ressourcen."

[12] In German: „… eine zusammengehörende Abfolge von Unternehmensverrichtungen zum Zweck der Leistungserstellung."

[13] In German: „… besteht aus einer zusammenhängenden abgeschlossenen Folge von Tätigkeiten, die zur Erfüllung einer betrieblichen Aufgabe notwendig sind. Die Tätigkeiten werden von Aufgabenträgern in organisatorischen Einheiten unter Nutzung der benötigten Produktionsfaktoren geleistet."

rather than instances of business processes, i.e. classes of similar business processes (Frank & van Laak 2003, 18).

Business processes can be distinguished based on their relation to value creation into core processes and service processes, which reflects Porter's distinction between primary and support activities as part of the value chain (Porter 1985, 39ff). *Core processes* contribute directly and in a significant amount to the creation of revenues and require the application of organisational core competencies (Frank & van Laak 2003, 18) that were outlined in section 2.2.[14] *Service processes* enable the execution of core processes and thus are only indirectly related to value creation for external customers (Becker & Kahn 2003, 7). Common examples are human resource administration and the maintenance of machines. *Management processes* are service processes that control, regulate or design other types of business processes (Remus 2002b, 105). Examples are corporate management or improvement processes.

The role of information technology

The IT function and quality management were one of the first to recognize the need for a process-oriented perspective, initially within production areas (Gaitanides, Scholz & Vrohlings 1994, 3). At least, they were the first to perceive the pressures that processes orientation promises to relieve. IT is seen as an enabler for process-oriented organisation as it enables the integrated development and management of business processes (Gaitanides 2004, 1214). Reengineering regards computers as an important tool for organisational redesign beyond automating processes (Hammer 1990). IT also can be applied in order to capture process information for the purposes of understanding, enable the parallel execution of processes, monitor the process status and objects, improve analysis of process information and decision making, manage processes across distances, coordinate between tasks and processes, capture and distribute intellectual assets and in order to eliminate intermediaries from a process (Davenport 1993, 50ff). However, the IS function within an organisation is a partner in a cross-functional reengineering team rather than taking over a leadership role (Davenport & Stoddard 1994, 123f). On the other hand, IT can also be a constraint for BPR. If data and systems architectures are built to serve local and functional needs, this may lead to inconsistent

[14] For a detailed account on the relation between business processes and core competencies see, e.g., Siegle (1994). An example for a competence-based distinction of processes is that whether they incorporate an organisation's creation, realization or transaction competence (Scholz & Vrohlings 1994, 101f).

data structures, non-communicating systems and inconsistent models (Earl 1994, 16). Their process-oriented integration in practice may represent a substantial challenge.

Modelling is one of the key tasks for process presentation, analysis, simulation, optimization and documentation (Gaitanides 2004, 1214; Rosenkranz 2006, 16f).[15] The application of software tools in order to support these tasks is essential because manually created process models fast get too complex and error-prone (Lehner, Maier & Hildebrand 1995, 109f). Thus, the process modelling approaches that have been proposed to a large share are based on specialized software tools, e.g., the Architecture of Integrated Information Systems (ARIS) (Scheer 1992; 2002), ADONIS (Junginger et al. 2000), Integrated Enterprise Modelling (IEM) (Spur, Mertins & Jochem 1993), Multi-Perspective Enterprise Modelling (MEMO) (Frank 1994), PROMET for process development (Österle 1995) and the Semantic Object Model (SOM) (Ferstl & Sinz 1995). Model types that represent business processes are also included in independent standards such as activity models in the Unified Modelling Language (UML) (Hitz et al. 2005; Oestereich et al. 2003), the Business Process Modelling Notation (BPMN) (OMG 2006) and the Integrated Definition Methods (IDEF) family (Mayer et al. 1995).

The term *process-aware information system* (PAIS) is used to refer to the subset of IS that links IT to business processes (Amberg 1999, 42f; Dumas, van der Aalst & ter Hofstede 2005, 6). Dumas et al. (2005, 6) define PAIS as "… a software system that manages and executes operational processes involving people, applications and/or information sources on the basis of process models." An important means for implementing PAIS is the integration of IT along processes discussed in the field of enterprise application integration (EAI) and more recently in relation to service-oriented architectures (SOA).[16] Traditionally, workflows are used to coordinate or automate tasks as part of business processes. They are defined as "computerized facilitation or automation of business processes, in whole or in part" (WfMC 1995, 6). Workflows define activities to be performed, their sequence as well as related data structures and flows (Jablonski 2001, 513). They model single tasks of business processes in more detail (zur Mühlen & Hansmann 2002, 389ff). In order to distinguish the two different levels of granularity, activities in business processes are referred to as *function* and those that are part of workflows as *tasks*. Workflow management systems (WfMS) are used to define, manage and execute workflows and offer support for implementation and enactment of workflows

[15] Models and modelling in the context of IS and KM will be discussed in detail in section 4.

[16] SOA will be described in detail in section 5.2.

(WfMC 1995, 6). PAIS are not limited to traditional WfMS. PAIS will be discussed in section 5.3.2 in relation to EKI.

2.6 Business process-oriented knowledge management

The term PKM is used to subsume a variety of approaches that combine KM and business process orientation as described in the last two sections. The integration of KM into business processes currently is regarded as the dominant recommendation and the most pressing research issue (Scholl et al. 2004, 31). A possible starting point is the creation of a framework of different types of KM processes that allows structuring KM interventions (Hofer-Alfeis 2007). Wiig was one of the first who argues for the inclusion of the knowledge-based perspective in BPR by describing an extended procedure model for BPR (Wiig 1995, 257ff). A process-oriented view on KM offers a number of advantages such as a stronger link of KM to creation of customer value, the availability of widely accepted management methods and the possibility for evaluation of KM success based on process controlling (Jennex, Smolnik & Croasdell 2007; Maier & Remus 2002, 105f; Remus 2002b, 33ff). Business process orientation offers ways for establishing a link between the different foci of KM, i.e. personalization, codification, intellectual capital and enterprise effectiveness (section 2.4), and thus is a promising direction for a KM that bridges the gap between these different orientations. PKM puts the enhancement of the effectiveness of knowledge work in the context of business processes into the centre of interest. Though methods and approaches for a systematic integration of knowledge and business processes would be desirable, they are not available and their relation is only described on a very general level (Hoffmann, Goesmann & Misch 2001, 6). Particularly, PKM approaches up to now direct their attention primarily towards knowledge application and exploitation in business processes and only marginally regard knowledge exploration.

Strohmaier (2005, 47ff) identifies the following challenges for PKM that yet are not resolved: (1) *business processes modelling and analysis*, i.e. description and investigation of selected aspects deemed relevant from a knowledge perspective as a foundation for most PKM approaches, (2) *business process learning*, i.e. conceptualizing learning as an integral part of business processes that has to be supported by personalized, problem-oriented and context-sensitive provision of learning resources, (3) *business process support*, i.e. readily offering the resources required for the accomplishment of knowledge-intensive tasks, (4) *business process* *execution*, i.e. guiding through and coordinating knowledge-oriented tasks which implies the need for the extension of traditional WfMS, and (5) *business process improvement*, i.e. enhancing business processes from a knowledge perspective as the next step after BPR, process management and related approaches such as quality management and lean management.[17]

Various approaches have been proposed that tackle one or more of these challenges, e.g., Business Process Knowledge Management (Bach, Österle & Vogler 2000), GPO-WM[18] (Heisig 2003), Improvement of Knowledge Work Processes (Davenport, Jarvenpaa & Beers 1996), Integrative Design of Knowledge Systems (Nissen, Kamel & Sengupta 2000), KM Blueprint (Remus & Schub 2003), the KM Reference Model (Warnecke, Gissler & Stammwitz 1998), Learning in Process (Schmidt 2005), Model-based KM (Allweyer 1998) and PROMOTE (Hinkelmann, Karagiannis & Telesko 2002).[19] PKM is dominated by German-speaking authors. One explanation for this is the strong tradition of the German MIS discipline in developing business process-oriented approaches that are now proposed to be extended in a knowledge-oriented way (Scholl et al. 2004, 31). Modelling is an important foundation for analysis and enhancement of business processes and thus, most of these approaches include a modelling approach that extends one of the business process modelling approaches enlisted in section 2.5. They will be discussed in more detail in chapter 4. The main concepts, advantages and also limitations of PKM as before can be structured according to the areas strategy, organisation, instruments and systems. In addition, generic KM activities frequently referred to in the PKM literature will be discussed in the remainder of this section.

Strategy

On a strategic level, the concentration on business processes offers ways to avoid problems of core rigidity and of overstretching of competencies. *Core rigidity* based on a resource-based view describes the circumstance that core capabilities that have grown inappropriately may deter from considering marked-oriented factors such as new customer groups or emerging substitutes (Leonard-Barton 1992, 118ff). Hence, they represent the "flip side of core capabilities" (Leonard-Barton 1995, 30). The result is a loss of competitiveness. *Overstretching of com-*

[17] Strohmaier separates *analysis of business processes* and *modelling of business processes* that are summarized here.

[18] GPO-WM® is an abbreviation for the German term "Geschäftsprozessorientiertes Wissensmanagement" that is translated with business process-oriented KM.

[19] For an overview and comparison of selected approaches see Remus (2002b, 36ff).

petences refers to a market-oriented perspective and describes the overestimation of the markets that can be supplied with available resources and knowledge which also may erode an organisation's competitive position (Raub & Romhardt 1998, 154f). Business processes promise a way out of the dilemma as they can be designed from a market-oriented perspective based on a "customer-to-customer" approach and simultaneously from a resource-based perspective around selected organisational core competencies (Maier 2004, 103).

Organisation

On organisational level, PKM directs the focus towards *knowledge-intensive business processes*. They are defined as business processes that require substantially more knowledge for the creation of products and services than traditional business processes and are characterized by a significant contribution of knowledge to value creation (Eppler & Seifried 2000, 20; Maier & Remus 2003, 67f). Furthermore, compared to traditional processes their outputs typically contain more knowledge. Typical examples are research and development or planning processes (Eppler & Seifried 2000, 20).

Knowledge intensity can be judged based on a variety of partially overlapping characteristics (Eppler, Seifried & Röpnack 1999, 223f; Picot & Reichwald 1987, 61ff; Schwarz et al. 2001, 3f). Remus (2002b, 110ff) aggregates a list of characteristics of knowledge-intensive business processes from the literature. He distinguishes between (1) *process-spanning characteristics*, e.g., knowledge-oriented culture, knowledge-intensive industry and corresponding competitors, (2) *process-related characteristics*, e.g., high complexity of the process flow, low structure and level of detail of the process, many exceptions and many participants, (3) *task-related characteristics*, e.g., ambiguous definition of goals, unclear evaluation, long time required for learning and high communication needs, (4) *employee-related characteristics*, e.g., high autonomy for decisions, personalized or unstructured rules and need for high skills in learning, creativity and innovation and (5) *resource-related characteristics*, e.g., dominance of semi-structured data and need for cost-intensive resources. Some characteristics are similar to those of knowledge work described in section 2.3. If KM concentrates on knowledge-intensive business processes that represent core processes along an organisation's value chain (Maier & Remus 2003, 67f), then a direct link is established to the success of an organisation. This also offers ways to approach the challenge of evaluating the economical success of KM and thus to justify efforts invested into KM (Maier 2004, 316ff; North 1999, 183ff; North, Probst & Romhardt 1998), e.g., by judging knowledge-intensive business processes based on criteria such as time, costs, quality and customer satisfaction as suggested by process management (section 2.5).

PKM offers starting points for the systematic analysis of knowledge-oriented aspects within an organisation as well as established business process-oriented management approaches. *KM processes* are meta-processes that analyse, design and evaluate organisational knowledge processing (Hofer-Alfeis 2007; Hoffmann, Goesmann & Misch 2001, 6f; Nissen, Kamel & Sengupta 2000, 29ff; Remus 2002b, 120f; Riempp 2004, 81f, 143ff). Processes are also proposed for the description of knowledge-oriented aspects related to business processes. *Knowledge processes* can be broadly defined as sequences of activities accomplished in order to develop, use, distribute, secure, reuse or evaluate knowledge (Hoffmann, Goesmann & Misch 2001, 8). This work follows the more focused definition of Remus (2002b, 118) who describes knowledge processes as sequences of formally organised activities that are targeted at the processing of knowledge and have the goal to support other business processes. Examples for such activities are identification, development, evaluation or distribution of knowledge (Remus 2002b, 119f). KM roles may be held responsible for the accomplishment of (parts of) knowledge processes (Bach 1999, 71ff). A clear delineation of business processes and knowledge processes is not always possible since principally all functions of business processes to a more or less large extent deal with knowledge (Remus 2002b, 120).

The characteristics of knowledge work and of knowledge-intensive business processes yet suggest that not all knowledge-oriented work can be described by processes. If it is sought to describe knowledge work activities on a more detailed level, the term knowledge-oriented action or short knowledge action is preferred as it does not suggest a recurring sequential order. In fact, standard routines may contradict the needs for autonomy and flexibility of employees accomplishing knowledge work (Davenport, Jarvenpaa & Beers 1996, 55). Hence, this work acknowledges the merits of a process-oriented approach but is critical with respect to the application of the process metaphor without further reflection.

Instruments

Process orientation is proposed by PKM to offer good starting points for KM interventions and thus for the design of KM instruments. KM instruments that focus on knowledge in process-oriented form are: personal knowledge routines, self-managed ad-hoc learning, expert advice, technology-enhanced learning, good/best practices, communities and knowledge process reengineering (Maier 2007, 203ff). They are outlined in the following:

Personal knowledge routines. This instrument targets the support of selected knowledge-oriented activities that are partly routinized[20]. Knowledge routines thus comprise existing, allowed, recommended or prescribed activities of knowledge work that may be made available in order to structure and assist individual knowledge work, e.g., by means of KM roles such knowledge brokers or based on an appropriate ICT infrastructure. Knowledge routines may concern the publication of knowledge, the acquisition of knowledge from outside the organisation as well as its integration, the maintenance of awareness about the developments in areas such as topics, projects or business processes as well as the collaboration between people.

Self-managed ad-hoc learning. The support of individual, ad-hoc and self-managed learning processes is increasingly important and thus focused by a separate KM instrument (Maier 2007, 204). It aims at the systematic structuring and support of individual learning processes, e.g., by means of offering appropriate learning resources and supporting reflection on learning by peers and experts internal or external to the organisation. Thus, it focuses on a special knowledge routine and is part of more comprehensive approaches and of a technical infrastructure that targets the enhancement of learning processes by means of ICT.

Expert advice. In case advice is required, the problem especially in large organisations is not only whether colleagues that are knowledgeable in certain areas exist but also how to identify them. Consequently, this instrument comprises organisational and technical measures that support and structure the process of posing requests for knowledge (Maier 2007, 204). For example, standardized procedures might distinguish between urgent and ordinary requests and route the question to an electronic discussion forum, to a community of people or to certain KM roles such as subject matter experts.

Technology-enhanced learning. This instrument focuses on the support or enhancement of learning processes through ICT (Maier 2007, 205f). In contrast to more traditional terms such tele-learning, programmed instruction, computer-based training and more recently e-learning, it emphasizes that learning cannot be automated with technologies but rather needs to be supported flexibly. It is not traditionally part of KM but its inclusion emphasizes the need for a systematic integration of learning support and KM.

[20] The concept of routinization is based on activity theory and will be described in detail below (section 3.2).

Good/best practices. Remus (2002b, 173) points to the fact that good or best practices are documented by means of textual or graphical processes. They are stored in best practice data bases and may contain links to other sources such as Web pages, articles or other best practices (O'Dell & Grayson 2003, 612ff). In analogy to data warehouses (Mucksch 2000), the term process warehouse is used to refer to knowledge about processes stored systematically within a repository (Scheer 2002, 74f). Knowledge about processes is not only restricted to their sequence, involved organisational units and required resources as in BPR but should be conceptualized broader to comprise skill and training requirements, quality and objectives, impacts and implications of a process as well as performance and tools, history and discourses associated with a process and knowledge about outputs and performance of a process (Amaravadi & Lee 2005).

Communities. Community management aims at the creation and the support communities or knowledge networks (Maier 2007, 206). This comprises, e.g., the provision of space and time for employees to share thoughts, the establishment of an IT infrastructure, the creation of new roles such as community managers and, which establishes a link to PKM, the support of specific community management processes such as the invitation of new members or the dissemination of knowledge to the community. Another relationship is established by so-called process communities that comprise all people involved in a business process and having an interest in a frictionless process flow (Eppler & Seifried 2000, 27). However, they may also be involved into multiple different business processes. Communities thus may also connect various processes throughout an organisation. For example, participants of research and development processes may share common interests with those responsible for quality assurance in production processes.

Knowledge process reengineering. KPR describes the analysis and improvement of knowledge-intensive business processes and of knowledge processes (Maier 2007, 207; Maier, Hädrich & Peinl 2005, 45). Davenport et al. (1996, 57ff) in this context contrast possible objectives of improvement methods with the help of the two extremes reengineering and laissez-faire. *Reengineering* describes an approach strongly oriented at BPR principles that strives for radical change, decomposition of processes based on organisational goals down to micro-level steps and daily activities as well as daily or even hourly performance evaluations. The *laissez-faire* approach on the other hand can be characterized as “finding good people and leaving them on their own devices” (Davenport, Jarvenpaa & Beers 1996, 59) and is oriented towards outputs. Neither extreme is appropriate for most organisations though different tendencies can be identified (Davenport, Jarvenpaa & Beers 1996, 59). Improvement of knowledge creation processes often implies an orientation towards the laissez-faire approach while the reduction of administrative activity in knowledge work processes puts measures closer to the reengineering spectrum. Ultimately though, the detailed flow of activities always must be left to the individual knowledge worker (Davenport, Jarvenpaa & Beers 1996, 61). Organizations need to find the right balance between defining how things are supposed to be done and leaving enough freedom for adoption (Brown & Duguid 2000).

Systems

Analysis of business processes principally is a good starting point for the design of ICT that supports knowledge work (Nissen, Kamel & Sengupta 2000, 40). The focus on support of business processes diminishes the discrepancy between integrative and interactive systems (section 2.4). Furthermore, it directs the attention towards the enhancement of individual work tasks in business processes. The term *Just-In-Time KM* was coined in this context in order to emphasize the importance of a tight integration of KM with daily work processes and its embedding into the ICT that employees use at their workplaces (Davenport & Glaser 2002, 108). Snowden (2002; 2003) emphasizes that it is not restricted to provision of codified knowledge.

During the last years, a number of approaches and prototypes for process-aware support of knowledge work based on workflow models have been developed. Amongst others it is proposed to include abilities to change the flow of actions (Reichert & Dadam 1998), to use case-based reasoning technologies in order to gather process knowledge (Weber & Wild 2005; Weber, Wild & Breu 2005), to link descriptions of required information to workflow tasks in order to support the increased information needs of knowledge work (Abecker et al. 2000; Goesmann 2002) or to identify process patterns with the help of process mining methods (Hammori, Herbst & Kleiner 2006; van der Aalst et al. 2003). However, though these approaches contribute ideas for more flexible support of knowledge work, they still stick to the workflow metaphor. In order to support knowledge work, e.g., specific knowledge routines, more flexible approaches are required. SOA are discussed more recently as they promise to enhance the flexibility of the integration of IT systems along processes. This will be discussed in detail within a separate chapter together with an overview of classes of services offered by knowledge infrastructures (chapter 5).

Modelling tools are also relevant here as they support tasks associated with the process-oriented analysis and design of knowledge infrastructures. Models of processes and workflows may not only be used during design-time of an infrastructure but also during run-time, e.g., for navigating the organisational knowledge base (Maier & Remus 2002, 106). They thus may also support the process-oriented structuring of electronic contents, e.g., by offering a foundation for the definition of meta-data used to link them with functions or tasks of business processes (Mertins, Heisig & Alwert 2003, 546f).

KM activities

Some KM authors and particularly proponents of PKM describe sets of generic activities posed to be relevant in PKM (Holsapple & Jones 2005; Nissen, Kamel & Sengupta 2000, 30f; Remus 2002b, 125ff). They represent tasks that need to be supported and improved by PKM in order to enhance organisational effectiveness and performance (Maier 2004, 175; Probst, Raub & Romhardt 2006, 28). Other terms used are functions of knowledge processing (Allweyer 1998, 39f), knowledge processes (Armistead 1999, 145f), knowledge-building activities (Leonard-Barton 1995, 8ff), KM (core) activities (Davenport & Prusak 2000, 52ff; Heisig 2001; 2002, 55, 59; Probst, Raub & Romhardt 2006, 28ff; Riempp 2004, 81f), problem and action fields for KM (Pawlowski 1999, 115ff), KM tasks (Maier 2004, 175ff) and knowledge manipulation activities (Holsapple & Joshi 2002).

Table 3 provides an overview of selected KM activities. They have been identified based on review articles that discuss the related literature (Holsapple & Joshi 2002; Maier 2004, 175; Nissen, Kamel & Sengupta 2000, 30f; Remus 2002b, 125ff). The activities were compiled and selected with a focus on concrete individual activities. Activities that mainly concern the tasks of an organisational KM function such as the securing of knowledge by means of patents, the placing of decisions on what knowledge should be developed further as well as the evaluation of the overall success of KM have been left out.

KM activity	Allweyer (1998, 39f)	Armistead (1999, 145f)	Davenport & Prusak (2000, 52ff)	Heisig (2001; 2002, 55, 59)	Holsapple & Joshi (2002)	Holsapple & Jones (2005)	Leonard-Barton (1995, 8ff)	Maier (2004, 175)	Nissen et al. (2000, 30f)	Nonaka & Takeuchi (1995, 61ff)	Pawlowski (1999, 115ff)	Probst et al. (2006, 28ff)	v.d. Spek & Spijkervet (1997, 39f)	Riempp (2004, 81f)	Remus (2002b, 125ff)	Schüppel (1997, 191f)
identification	x				x	x		x			x	x		x	x	
acquisition	x				x	x	x	x				x		x	x	
publication			x					x	x	x				x		
combination	x						x	x	x	x	x		x		x	x
distribution		x	x	x		x		x	x		x	x	x	x	x	x
search & retrieval								x							x	
application	x	x		x	x			x	x		x	x		x	x	x
development								x	x			x	x	x	x	
deletion & archiving	x							x				x				
learning					x					x						
networking								x		x						

Table 3. Overview of generic KM activities proposed

Eleven activities are distinguished that subsume the other activities described: (1) *Identification* is concerned with the creation of transparency about internal and external knowledge (Probst, Raub & Romhardt 2006, 28ff). It also comprises the selection and filtering of knowledge that is potentially relevant. (2) *Acquisition* is the obtainment of external knowledge and its adoption to the needs of an organisation. It may be accomplished by engaging experts, accessing documented knowledge or by participation in knowledge-related events and processes such as exhibitions or industry organisations (Maier 2004, 176). (3) *Codification* refers to the documentation of knowledge in order to prepare its distribution and reuse (Davenport & Prusak 2000, 52ff). (4) *Combination* is the integration of internal and external primarily explicit knowledge from various departments as well as its structuring in order to make it readily available for all members of the organisation. (5) *Distribution* refers to the storage and the dissemination of knowledge to colleagues, e.g., by distributing documented knowledge or by giving advice. It also can be referred to as knowledge push (Maier 2004, 177). (6) *Search & retrieval* can be regarded as the opposite process to knowledge distribution. It is initiated by participants and can be supported either organisationally by specialized roles such as knowledge brokers or technically by structuring electronic contents and systems in a way that facilitate their easy identification and retrieval.

(7) *Application* is the (re-)use of knowledge in the context of business processes. It particularly concerns the transfer of knowledge developed in one context to another. (8) *Development* is the improvement and refinement of existing knowledge. It is also concerned with safeguarding the timeliness and relevance of the organisational knowledge base, e.g., by regular evaluation of electronic contents based on expiration dates (Nissen, Kamel & Sengupta 2000, 31). (9) *Deletion & archiving* focuses on codified knowledge and refers to the need to preserve knowledge for a longer amount of time, e.g., based on document management systems (DMS) and archiving systems, as well as to the deletion of outdated contents (Allweyer 1998, 39f). (10) *Learning* focuses on individual self-directed learning processes, particularly based on the internalization of codified knowledge such as learning units intentionally prepared for training. (11) *Networking* highlights the relevance of collaboration for knowledge work and refers to the establishment of contacts as well as to the direct interaction between people. It enables socialization which is described as the direct exchange of implicit knowledge (Nonaka & Takeuchi 1995, 61ff).

The relevance of single KM activities differs among organisations depending on the organisational goals and the general strategic orientation of KM (Remus 2002b, 136). They are sometimes arranged in a life-cycle that emphasizes the evolutionary development of knowledge. A popular example is Nonaka's knowledge spiral (Nonaka & Takeuchi 1995, 70f). It proposes that knowledge creation is characterized by a cyclic execution of the processes socialization, externalization, combination and internalization and suggests that individual tacit knowledge can be mobilized to higher levels so that the spiral may also span individual, group, organisational and even inter-organisational levels. Another metaphor used in order to structure the KM activities is the knowledge value chain that is based on Porter's (1985, 36ff) idea of the organisational value chain (Holsapple & Jones 2005; Yang & Lee 2000). It emphasizes the value added by KM activities that otherwise may not be directly related to organisational value creation and thus represents an extended knowledge-based view of the original value chain. These holistic frameworks are suited for structuring KM interventions and identifying knowledge problems on a general level (Probst, Raub & Romhardt 2006, 30). However, they are not applicable to distinguish different classes of KM initiatives or types of knowledge processes because these frequently involve multiple types of KM activities rather than only one.

2.7 Summary

This chapter has outlined the theoretical foundations of this work. It has been stated that the increasingly important concept of knowledge cannot be easily defined. One reason is that different views and schools of thought as well as paradigms exist that fundamentally determine the perception of knowledge. Knowledge has been defined generally, various types of knowledge have been described and three media of knowledge have been outlined, i.e. process, person and product. Different perspectives on the term knowledge work have been characterized and the work practice perspective has been selected as the most suited one for this work.

The need for a KM approach that bridges the gap between the four alternative strategic foci on personalization, codification, intellectual capital and enterprise effectiveness has been pointed out. Business process orientation has been characterized as an alternative third perspective compared to the traditional separation between structural operation and operational structuring. PKM has been presented as an approach that seeks to transfer some of the advantages of process orientation to the field of KM, e.g., its concentration on the value chain, the availability of accepted methods and the opportunity for process-oriented evaluation of KM success. KM and PKM have been characterized in more detail related to strategy, organisation, instruments and systems.

Figure 7 summarizes and highlights key contents of this chapter. In vertical direction, they are arranged according to selected main areas discussed, i.e. knowledge, knowledge work, knowledge management, improvement of business processes and systems applied in KM. Horizontally, they are aligned based on the orientations *exploration of knowledge* versus *exploitation of knowledge* that have been referred to at several points throughout this chapter while emphasizing the need for their integration.

Reuse of *knowledge* is strongly based on documented knowledge which can straightforwardly be supported by IS. Creation of new knowledge on the other hand is related to direct exchange of tacit knowledge. Hence, the former is more strongly related to a product perspective on knowledge while the latter emphasizes people as bearers of knowledge. The view on knowledge as bound to processes within social collectives comprises exploration as well as exploitation of knowledge since processes and practices may describe both, reuse of existing knowledge or innovation processes.

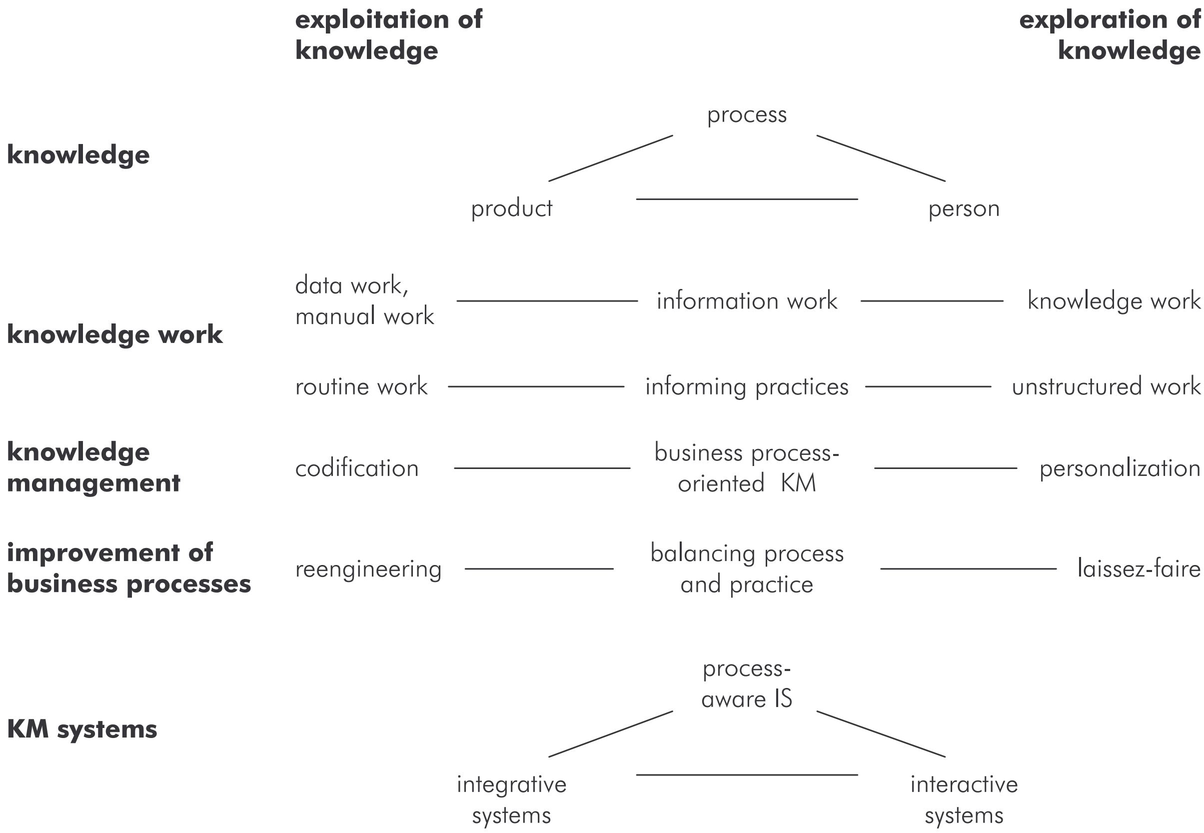

Figure 7. Overview of selected concepts of the chapter *Foundation*

The economical perspective on *knowledge work* distinguishes it from other types of work such as data work and manual work mainly based on the criterion whether new knowledge is created or not, which directly corresponds to the distinction between exploitation vs. exploration of knowledge. The term information work has been identified as a good compromise that is not restricted only on the exploration of new knowledge. The problem of the economical perspective is that it relies on proxies such as high formal education or selected types of occupations. The work practice perspective has the advantage that it alternatively focuses on selected informing practices. As indicated in the figure, these lie in-between the unstructured and ill-defined processes of knowledge creation and the clearly defined processes of routine work that merely applies existing knowledge and in this regard is located between knowledge exploration and exploitation.

Knowledge management has been characterized to have the four focus areas codification, personalization, enterprise effectiveness and intellectual capital. The first two represent the most dominant ones are included within the framework. Codification is mainly concerned with reuse and thus exploitation of knowledge. Personalization is explicitly oriented towards the development of new knowledge and thus oriented at exploration of knowledge. Business process-oriented KM has been characterized as an approach that is suited to bridge the gap between the different foci and thus has been placed in-between them.

The two main approaches reengineering and laissez faire for the *improvement of business processes* have been contrasted in relation to the reengineering of knowledge processes. The former is more suited for reuse of knowledge within a predictable environment whereas the latter is better suited for creation of new knowledge in changing environments. It has been argued that organisations need to find the right balance between these two extremes.

On the level of *systems in KM*, the two classes of integrative and interactive systems have been identified. The former have been categorized under exploitation of knowledge as they primarily support the sharing of documented knowledge. Interactive systems are more suited for knowledge exploration as they support the identification of and communication with knowledgeable individuals and collectives. PAIS have been grouped in-between them as they connect documented knowledge, people and processes. They are not necessarily limited to routine work and strongly structured processes but also may offer more flexible support. Hence, they represent a possible means to bridge the gap between knowledge exploitation and knowledge exploration. However, current PAIS lack adequate support of knowledge work and specifically of informing practices.

In conclusion, when being concerned with enhancing the effectiveness of knowledge work in the context of a bridging the gap KM approach, it can be stated that PKM in general and a focus on support of informing practices in particular promise to be good starting points. However, the integration of these orientations yet only has been achieved on a superficial level. KM needs more concrete concepts and approaches that apply processes and practices in order to integrate these diverging orientations. Specifically, they should be able to guide the modelling of knowledge-intensive processes as well as the design of technical infrastructures. The following chapter focuses on the development of such a concept that later on is detailed and empirically explored.

3 The knowledge work situation concept

The goals of this chapter are to motivate the need for a situation-oriented approach in the context of PKM and to develop a concept that can be applied for the description of individual knowledge work in order to design a supportive organisational and technical environment. From the three levels of system design, i.e. concepts, models and systems, this part primarily focuses the level of concepts as it deals with the units of description that subsequently are discussed on the levels of modelling and of systems.

3.1 Overview

Figure 8 gives an overview of this chapter. The following section discusses the relation of business processes and learning (section 3.2). As a way for their integration, a situational approach is proposed. The features of the situation concept are reviewed across different disciplines in order to provide a foundation for a situation-oriented approach (section 3.3). Afterwards, the knowledge work situation concept is defined and its components are detailed (section 3.4). The chapter closes with a summery of results (section 3.5).

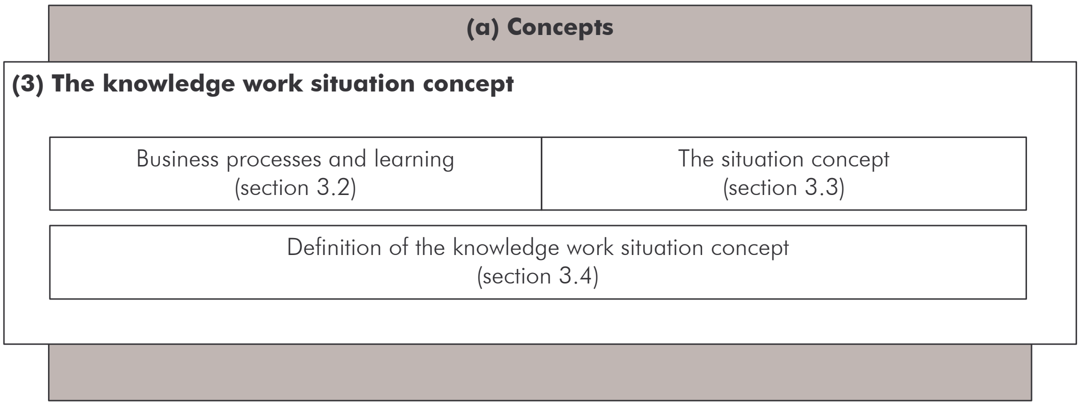

Figure 8. Overview of the chapter *The knowledge work situation concept*

3.2 Business processes and learning

The last chapter identified two primary orientations of KM: knowledge exploitation and knowledge exploration (sections 2.4 and 2.7). It has been argued that both orientations are equally important because knowledge exploitation creates the revenue stream needed for the survival of an organisation and knowledge exploration develops the resources and core competencies that enable an organisation to stay competitive. It also has been pointed out that PKM promises to bridge the gap between these different orientations (section 2.7). Concepts applied in process management and also referred to in the context of PKM, e.g., business processes, roles and information flows, are well suited for the description of routine work that primarily aims at the application and thus exploitation of knowledge. However, knowledge work differs fundamentally from this type of work (section 2.3) and appropriate concepts are not available so far. Consequently, PKM requires alternative approaches that are suited to describe the unstructured, learning-oriented and creative processes of knowledge work in order to equally consider knowledge exploitation and knowledge exploration.

Activity theory has been proposed for the study of knowledge work (Blackler 1993, 1035ff). The reason is that knowledge should be regarded as something that people do rather than something they possess, which is the foundation for the view on knowledge as a process and thus consistent with the description of knowledge work based on informing practices (section 2.3). Consequently, the foundations of activity theory are outlined in the following. Afterwards, the units of description applied within process management and by activity theory will be contrasted which motivates the need for a situation-oriented approach to KM.

Activity theory

The origins of activity theory can be found in the works of the Russian psychologist Vygotsky who is the founder of cultural-historical psychology and recognized the importance of concepts that were only beginning to appear in Western social science about 40 years later at the end of the 1970s (Blackler 1993, 867f; Engeström 1987, 58). His starting point is Karl Marx's conception of human nature as not to be fixed but rather continuously shaped by productive activity, which includes material goods as well as mental ideas (Blackler 1993, 867f; Tolman 2001). He proposes that higher mental processes fundamentally have their origin in social processes. The smallest possible unit suggested for the analysis of these processes is the so-called activity. It draws the attention to the relationship between motives and the contexts of action and focuses enquiry on the processes through which the activities are enacted (Blackler 1993, 868).

Engeström (1987) developed a contemporary version of activity theory. It is frequently referred to in MIS-related fields such as human-computer interaction and computer-supported cooperative work (CSCW) (Collins, Shukla & Redmiles 2002; Kaptelinin, Nardi & Macaulay 1999; Kuutti 1991; Nardi 1997; Nardi & Engeström 1999; Nardi, Whittaker & Schwarz 2002) and in the context of KM (Boer, Baalen & Kumar 2002; Clases & Wehner 2002; Hasan 2002). Engeström uses the term activity system in order to describe the context of human actions. Engeström's model of the socially-distributed activity system displays the essentials of such contexts by locating human subjects, their objectives and the instruments they use within their broader social and structural settings (Blackler 1993, 868). Figure 9 visualises the model of an activity as presented by Engeström.

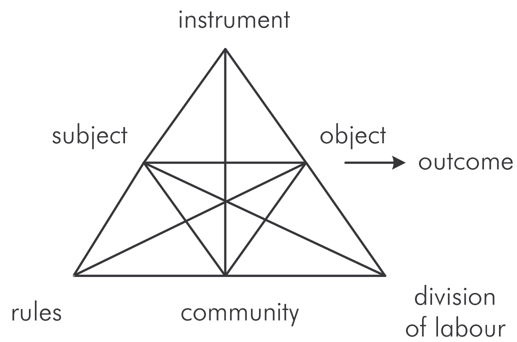

Figure 9. General structure of human activity systems[21]

An activity is constituted by the following components (Hasan & Gould 2003, 110; Kuutti 1997, 27ff; Maier 2004, 211f): The *object* is the purpose and the motives that define the reasons why an activity exists. It can be a material thing such as a plan or immaterial such as a common idea. *Outcome* represents the intended and unintended results of an activity. The *subject* is the person or the people who carry out the activity. *Community* refers to all subjects that share the same object and who are involved within the transformation process of the activity. Subject, object and community are not associated directly with each other. Their relationship rather is mediated by instruments, rules and a division of labour. *Instruments* are physical and non-physical tools such as technologies and language that are applied during the conduct of an activity. *Rules* are formal and informal norms, laws, regulations and principles

[21] based on Engeström (1987, 78)

that are imposed on the subject and that govern the conduct of an activity. The *division of labour* is the explicit and implicit organisation of the community that is related to the activity.

The development of an IS can be used as an example of an activity (motivated by Mursu et al. 2007). Object is to enhance the productivity of selected work processes of an organisation. Software programs and technical solutions are outcomes of the activity. The project coordinator who is responsible for the successful completion of the project is its subject that applies material instruments such as project plans, communication media and modelling tools or immaterial ones such as the object-oriented programming paradigm or procedure models. The community consists of people that either are directly engaged within the activity such as software architects, programmers and potential users of the solution or that are only indirectly involved such as the members of a process standardization team or external experts from the vendor of a software product applied. Their relationship to the subject is governed by formal rules such as organisational regulations or a support contract concluded with the software company and also informal ones such as organisational norms that are used to decide when and how meetings should be called and who should be invited. The participants take over roles such as coordinator, software engineer and user which determine their relation with and contribution to the object of the activity.

Mediation is a central feature of Engeström's theory. It points to the fact that instruments, rules and a division of labour do not just help to do things easier, but rather introduce a new quality into the transformation process of an activity (Blackler 1993, 869). For example, instruments can be enabling as they empower the subject in the transformation process with the social and collective experience that is "crystallised" in it but on the other hand restricts the interaction to the perspective of a particular instrument only (Nardi 1997, 27). Hence, the mediating components represent the context that shapes human action but also may be reshaped by the activity. Activity theory approaches analyse tensions between the components of an activity, e.g., if a tool agreed upon in an organisation such as a project management software does not help but actually hinders a subject to reach the objective of the activity. The reason for the choice of this focus is that the resolution of tensions is a major driving force for the development of activities and thus for learning.

Activities are conceptualized to have a hierarchical structure as depicted in Figure 10 (Hasan & Gould 2003, 110f; Kuutti 1997, 30ff). The whole activity is driven by a common motive which reflects a collective need. It is accomplished by actions directed to goals that are coupled with the motive. A specific action principally can belong to multiple activities and the object of an activity in turn can be reached by multiple alternative actions. Actions consist of an orientation and an execution phase: the first comprises the planning for action, the latter the actual execution of an action by a chain of operations. The better the model upon which the planning is based fits the conditions, the more successful the action will be. Actions can collapse into operations if the model is accurate enough so that no planning is required. Operations are executed under certain conditions and are the most structured part that is easiest to automate by means of technical systems.

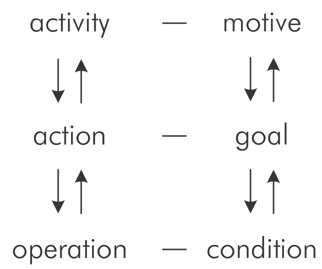

Figure 10. Hierarchical structure of an activity[22]

These three levels share a dynamic relationship. Elements of higher levels may collapse to constructs of lower levels if learning takes place. This process is also referred to as routinization. They can unfold to higher levels if changes occur and learning is required. This can be illustrated based on the activity of learning to drive a car (Hasan & Gould 2003, 111; Kuutti 1997, 31f). Changing the gears of a car by an inexperienced driver is handled on the level of goals because the actions `ease gas pedal`, `push clutch pedal`, `move gear lever to new position`, `release clutch` and `press gas pedal` require a separate planning and execution phase. As the driver becomes more experienced, these actions change to a smooth series of operations that do not require separate attention. Furthermore, the activity of driving a car changes to an action with the goal to reach a specific destination in the context of a broader activity.

[22] based on Kuuti (1997, 30)

Two perspectives on knowledge work

Figure 11 maps out the concepts used in process management and those applied by activity theory on the three levels of motives, goals and conditions (based on Maier 2004, 213f). In the following, these are referred to as process-oriented and as learning-oriented perspective on knowledge work.

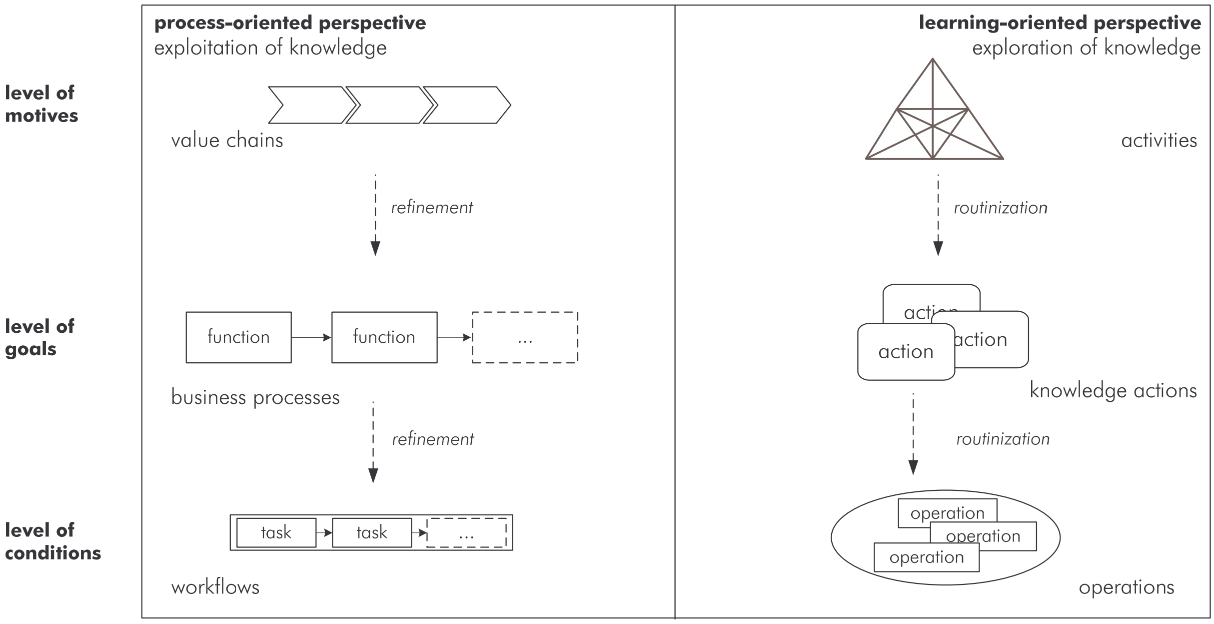

Figure 11. Process-oriented and learning-oriented perspectives on knowledge work[23]

Process management aims at the improvement of routine and well-structured work processes that are mainly concerned with the application of knowledge. The process-oriented perspective thus corresponds to the main strategic orientation of knowledge exploitation. The relationship of the three levels can be characterized as a process of refinement. *Value chains* on the level of motives structure primary activities and support activities of an organisation on a high level of granularity.[24] Parts of them are refined to *business processes* that consist of a series of functions that each contribute to the overall process goals. Each *function* can be detailed by number of tasks that need to be fulfilled in order to accomplish the function's goals. Workflows may be implemented in order to automate specific functions by a series of tasks that are executed by an IS depending on specific conditions.

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[23] based on Maier (2004, 213)

[24] For the definition of the following main units of description see section 2.6.

Knowledge exploration within an organisational context can be described by activity systems which are part of the learning-oriented perspective. Here, the relationship between the three levels is characterized by the process of routinization. On the level of motives, *activities* can be used in order to describe and analyse the collective development of knowledge related to organisational resources and core competencies. They are enacted by accomplishing a number of *knowledge actions* on the level of goals. Further routinization leads to *operations* that can be conducted automatically and are oriented at conditions.

As knowledge exploitation and knowledge exploration are both important, both perspectives need to be integrated. This represents a challenge for PKM that remains unresolved so far. It is proposed to integrate the two perspectives on the level of goals. It is specific enough to describe single functions and actions suited to pursue specific goals but leaves room for the selection from multiple alternative tasks or operations that may be equally fitting with the respective goals. However, neither process management nor activity theory offer concepts suited to integrate both perspectives. This work proposes to connect them with the help of a situation-oriented approach. The term situation amongst others is referred to by activity theory-based approaches, e.g., when emphasizing the situatedness of knowledge sharing (Boer, Baalen & Kumar 2002). Furthermore, the terms situation and context are used by technical approaches that aim to support knowledge-related processes. The meaning of the concepts situation and context in the following will be reviewed in more detail in order to pave the ground for the definition of a situational concept.

3.3 The situation concept

The term situation is used to indicate the position of an entity with respect to conditions and circumstances (Merriam-Webster 2003, 1166). The meaning of the term context is very close to this and refers to *information about* "… interrelated conditions in which something exists or occurs" (Merriam-Webster 2003, 270). A more concrete definition can only be given when focusing on specific fields and disciplines, e.g., cognitive science, linguistics, management science, sociology and MIS. Each of them has its own interpretation of the term. However, this section is not primarily concerned with a comparison of definitions of situation and context but rather with typical characteristics of situation-oriented approaches that are suited to inform the definition of an integrative concept. The following section thus presents features of as well as typical issues discussed in this relation. These are the distinction between objective and subjective situations (section 3.3.1), the challenge of determining the context information relevant (section 3.3.2), the distinction between deliberate and routine behaviour in specific situations (section 3.3.3), the concept of fit (section 3.3.4) and collective features of situations (section 3.3.5).

3.3.1 Objective vs. subjective situation

The distinction between an objective situation and the subjective interpretation of a situation amongst others is drawn in relation to subjective reality in psychology, the subjective definition of a situation in sociology and associated with the discussion of context in discourse analysis. These views will be outlined in the following.

Subjective reality in psychology

Psychology understands situations as the whole of the social and conceptual environment of an individual (Imoberdorf 1971, 7ff). The objective situation can be described independently of an individual whereas the subjective situation is characterized by its experiences, motivations and emotions (Imoberdorf 1971, 13). Humans in contrast to animals are able to impose a distance between themselves and their situation and thus are capable to reflect on the subjectively perceived situation (Imoberdorf 1971, 16).

The assumption of a subjective reality is grounded in the work of Gestalt theorists such as Koffka (1935) and Krüger (1948). They emphasize that it is not only an external stimulus that influences human behaviour but rather the perception of it, i.e. the way in which reality is mentally constructed and represented (Bless, Fiedler & Strack 2004, 6; Metzger 1966). The perception in turn is influenced by the context in which a stimulus is embedded. Social cognition goes beyond this and proposes that cognition not only depends on contextualized external stimuli but also on the motivation, expectancies, desires and the self-conception of humans (Augoustinos, Walker & Donaghue 2006; Bless, Fiedler & Strack 2004, 6ff; Higgins & Bargh 1987, 370). The interpretation of human behaviour consequently needs also to take into account personal factors as well as social aspects of a situation such as the people present and their roles (Higgins & Bargh 1987, 371; Imoberdorf 1971, 10).

This is reflected by the fact that in an organisational context, the analysis of work situations targeted at the discovery of weaknesses of organisational structures and the preparation of changes does not only take into account the objective situation, i.e. the technical and organisational design of the work environment, but also the subjectively perceived work situation, i.e. the work conditions as experienced by employees (Staehle, Conrad & Sydow 1999, 683f).

The definition of a situation in sociology

The discussion of the term situation in sociology goes back to a famous sentence that the American sociologist Thomas coined in 1928: "If men define situations as real, they are real in their consequences" (Thomas & Thomas 1970, 572). As in relation to subjective situations in psychology, it is not relevant what is actually present within some situation but rather the factors that are perceived to be relevant, imagined or expected (Thomas 1965, 14). This is related to the well-known notion of self-fulfilling prophecy, which can be defined as "… an expectation that helps cause what it predicts" (Brym & Lie 2005, 101). Thomas calls for the analysis of situations as a basic methodological principle (Thomas 1965, 86ff). Sociology refers to the subjective interpretation of a situation as the actor's *definition of a situation*, which is defined as "… a more or less clear conception of the conditions and consciousness of attitudes" (Thomas & Znaniecki 1927, 68). It structures preferences and expectancies that in turn represent the foundation for the subsequent choice of action (Esser 2004, 110).

Nevertheless, the objective situation of an actor is also taken into account, which is proposed to be described by means of *social production functions* (Esser 2004, 115ff; Lindenberg 1990, 271ff). The basic idea is that all human action is directed towards the production of goods and services. Humans ultimately strive for social approval and physical well-being (Lindenberg 1989, 53f). Production is regarded as a means to achieve these states. These two types of well-being are described as the utility of a set of interdependent production functions that fundamentally depend on specific, material, technical, organisational, institutional and cultural conditions (Esser 2004, 118). Individual action cannot disregard these conditions because the "wrong" interpretation of a situation is potentially connected with high losses. A subject's perception of a situation thus may not wander too far off the "right" interpretation. Consequently, it can be stated that situations have a subjective definition but with an objective grounding (Esser 2004, 121).

Context in discourse analysis

The distinction between subjective and objective situations also can be identified in relation to the term context as discussed in discourse analysis, which is a part of linguistics concerned with the sensitivity of ways of speaking and writing to situational and cultural differences

(Trappes-Lomax 2005, 137). Discourse analysis uses the term context in order to refer to the roles and statuses of individuals as well as their uniqueness as individuals (Trappes-Lomax 2005, 144). It is closely related to the function of the interaction between individuals, which is defined as "… the socially recognized purposes to the fulfilment of which the interaction is directed" (Trappes-Lomax 2005, 144). These two aspects are referred to as the whos and whats of discourse (Gee 1999, 13f). The former refers to the "… socially-situated identity, the 'kind of person' one is seeking to be and enact here and now" and the latter means the "… socially situated activity that the utterance helps to constitute". Context and function of interaction are closely interrelated (Trappes-Lomax 2005, 145). For example, the context such as a classroom can be recognized by the communicative functions that are typically realized in it, e.g., eliciting, replying and evaluating. Context in this relation is something psychological and dynamic, within the minds of the participants and part of the discourse process (Trappes-Lomax 2005, 145) and thus is closely related to the subjective situations as discussed before. The distinction between objective and subjective situations is most explicitly reflected by the differentiation made by Hymes (1972) between a setting, i.e. the physical environment, and a scene, i.e. the psychological setting that refers to the participant's understanding of what is going on.

Consequences for this work

The principal idea that the objective environment is perceived subjectively by each individual has already referred to in relation to constructivism that builds on the idea that reality is constructed subjectively (section 2.2). As a conclusion for this work, it can be stated that when being concerned with the description of situations in KM, e.g., that of knowledge workers focused by a KM initiative or of prospective users of a system, not only the objective situation needs to be taken into account but also the subjective views of the relevant parties on the work environment. The description of the individual context may not only comprise objectively measurable factors but also incorporate the subjective view of each individual.

3.3.2 Relevance of context information

The question of what belongs to the context and what does not is discussed in relation to context-aware applications in MIS and associated with the discussion of context in discourse analysis and conversation analysis. Since this work deals with situation-oriented technical support of knowledge work, the role of context in MIS is particularly relevant and will be outlined firstly.

Context-aware applications in management information systems

Context is investigated by MIS in relation to so-called context-aware applications. This is motivated by the fact that users frequently do not face a desktop machine within a relatively predictable office environment but rather have do deal with diverse mobile or fixed devices with different interfaces used in changing environments (Dey, Abowd & Salber 2001, 100). Ultimately, this is a step towards the vision of ubiquitous computing where information processing is integrated tightly into everyday objects and activities so that no one notices their presence (Weiser 1991). The hypothesis shared by approaches dealing with context-aware applications is that enabling devices for the automatic adaption to changing physical and electronic environments will lead to a significantly enhanced user experience (Dey & Abowd 1999; Dey, Abowd & Salber 2001, 100). Therefore, the devices need to obtain information about the context of the interaction, which broadly is defined as "… any information that characterizes a situation related to the interaction between users, applications, and the surrounding environment" (ibid.). Context is referred to in relation to mobile devices such as smartphones or personal digital assistants where information about the user's current location information is exploited to offer context-dependent services (Amberg & Wehrmann 2003).

However, the definition of context noted above is not specific enough to determine which information is relevant. Dey et al. (1999; 2001, 100) identify three basic types of context definitions: Definitions by example, by synonyms and operational definitions. *Definitions by example* enumerate examples for information types that are part of context. Brown et al. (1997, 58) for instance refer to context as information such as location, time of day, season of year and temperature. Though at first sight they are very concrete, such definitions do not help to classify information as belonging to the context or not. For example, it cannot be decided whether user preferences or interests are part of the context. *Definitions by synonyms* more generally refer to context as the environment or situation of a user or of an application. Brown (1996, 260) for example refers to context as "… the elements of the environment that the user's computer knows about." Dey et al. argue for *operational definitions* that are concrete enough to decide what is part of the context and simultaneously general enough to comprise the other definitions described. A good example is the definition by Schilit et al. (1994) who state that the three important aspects of context are "where you are, who you are with, and what resources are nearby". Based on their review, the authors define context comprehensively as "… any information that can be used to characterize the situation of entities (i.e., whether a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves" (Dey, Abowd & Salber 2001, 106). They further state that context typically is "… the location, identity, and state of people, groups, and computational and physical objects" (ibid.). As the authors themselves note, this definition is still very general. It is concretised based on the classification of typical context information such as information about places, people and things (Dey, Abowd & Salber 2001, 107). These classifications will be discussed in more detail in section 3.4.3.

Approaches discussed under the topic of *personalization* focus on the characteristics of the user as a specific part of the context. Personalization is understood as "… a process that changes the functionality, interface, information, content or distinctiveness of a system to increase its personal relevance to an individual" (Blom 2000, 313). It is frequently discussed in relation to Web-based systems such as personalized search engines (Pitkow et al. 2002) or information portals (Firestone 2003) though it is not limited to this area. The personalization of Web-based systems amongst others is discussed under the topic of adaptive hypermedia, which targets at offering an alternative to the one-size-fits-all approach of creating hypermedia systems (Brusilovsky 2001, 87). It targets the adaption of hypermedia in order to fulfil user needs based on a model of her or his goals, preferences and knowledge. An important application area are educational systems that are adjusted based on individual learning styles, pace, goals and the history of users (Bry & Henze 2005, 230).

Context in discourse analysis and conversation analysis

The differentiation between relevant and irrelevant context information is discussed in the linguistic fields discourse analysis and conversation analysis. *Discourse analysis* deals with the question to which degree the social and cultural background of participants influences a discourse. Individuals are constrained by established conventions and regulations. However, they do not simply act out social roles because they have "have room for manoeuvre" so that they are not directly determined by their social context (Widdowson 1995, 158f). The question that cannot be easily resolved is to which degree the individuality of the participants needs to be taken into account as a part of the context. *Conversation analysis* can be regarded as a specialization of discourse analysis that focuses on talk. Here, context is regarded as the environment of actions of talk (Gardner 2005, 269). Any utterance is considered to be context-shaped and simultaneously context-renewing because it may maintain, adjust or alter the context (ibid.). Context thus is not a set of variables that statistically surround strips of talk but rather stands in a mutual reflexive relationship to talk and to the interpretive work that talk generates (Goodwin & Duranti 1992, 31). In contrast to discourse analysis, the methodology considers only such contextual information as being relevant if it is displayed by the participants to be significant, e.g., during the analysis of ethnographic data (Gardner 2005, 270). It is argued that otherwise, the context of talk could be indefinitely extended. Consequently, conversation analysis has a more focused view on context than discourse analysis.

Consequences for this work

What can be learnt from the discussion of context in MIS and linguistics is that the relevant context cannot be defined on its own but only based on its effects. This is summarized by Hörnig: "If we make context to the object of research then we are interested in the effect – the interaction – of selected characteristics of context on a certain type of process. Context as an object of research is always a secondary research object, in the way that always its effects on a process primarily investigated are studied: context effects"[25] (Hörnig 1997). In relation to this work, specifically the context information is relevant that affects the design of organisational and technical support of knowledge work. The context thus will be defined based on the concepts within the process-oriented and learning-oriented perspectives on knowledge work as they highlight the relevant aspects. Nevertheless, the main concern of this work is the situation-oriented provision of technical support, specifically of knowledge services. The

[25] In German: „Machen wir Kontext zum Forschungsgegenstand, so interessiert uns der Effekt – die Interaktion – bestimmter Eigenschaften des Kontextes auf eine bestimmte Art von Prozeß. Kontext als Forschungsgegenstand ist in dem Sinne immer sekundärer Forschungsgegenstand, als daß stets dessen Auswirkung auf einen primär untersuchten Prozeß thematisiert wird: Kontexteffekte."

context thus can be detailed based on the context information regarded relevant in the area of context-ware support by IS.

3.3.3 Deliberate vs. routine actions

The concept of routinization has already been outlined in relation to activity theory, e.g., in relation to the distinction between deliberate actions and the processing of operations without specific attention (section 3.2). This differentiation can also be found when analysing situation-oriented approaches. It is discussed in relation to situated cognition, referred to by the MODE model in sociology and by Wiig's situated approach to KM.

Situated cognition in cognitive science

The differentiation between deliberative and routine action ultimately led to the formulation of situated cognition approaches. *Traditional cognition* proposes a computer metaphor of mind that explains mental functions as the internal rule-bound manipulation of symbols (Lefrancois 2006, 190ff). In contrast to behaviourism (Skinner 1974; Thorndike 1923; Watson 1930), individual behaviour is understood as the result of information processing and not as a direct function of the external situation. However, this approach has been criticised for the view on mind and environment as two distinct realms where thinking and acting happen asynchronously and disjunctively (Law 1998, 4). The problem is that according to the information processing metaphor, individuals would need to engage in a complex internal translation process in order to perform an action (Johnston 2001, 234): They need to perceive and select the information relevant from the outside world and are required to map it to existing descriptions that internally represent encoded knowledge. Afterwards, it has to be simulated what will happen based on abstracted rules generalized from prior experience until the intended result is achieved. This subsequently needs to be translated back to a concrete action performed in the outside world. Hence, the problem is that this view introduces a divorce between perceiving and knowing (Law 1998, 7). It entails the issue when to stop acting and to start this deliberative process. Vice versa it is not clear on which condition the thinking process should be halted in order to perform an action, which is an issue formulated as the so-called frame problem in AI (Shanahan 1997, 1).

Situated cognition resolves the gap between knowledge and action by putting perception from the periphery back at the core of human nature and by re-conceptualizing the assumptions that underlie memory and thinking (Law 1998, 7). Prominent scholars that advocate a dialectical relationship between perception and action are Dewey and Gibson. They maintain the position that acting does not entail the suspension of thinking and vice-versa (Law 1998, 7). Hence, the problem is not in deciding which action to perform based on given sensory data but rather that the ongoing task of perception lies in deciding how to maintain and modify routine actions based on the stream of results one is obtaining from current actions. Situationists represent a diverse group that focus on different aspects such as situated learning (Lave & Wenger 1991), situated action (Suchman 1987) or distributed cognition (Hutchins 1995).

The distinction between deliberate and routine (or ad hoc) actions becomes very evident in relation to the *situated action* approach introduced by Suchman (1987) in order to offer an alternative view on human-computer interaction. She promotes a radically new conception of plans. The basic tenet of her theory is that all purposeful actions are primarily ad hoc and dependent on the context. Individual actors respond to situations using a limited repertoire of reactive response actions. In this perspective, situations are agent-centred views of the world from their intention-laden point of view (Johnston 2001, 235). Plans are regarded as a product of actions and relevant for reasoning about them rather than being mechanisms for action (Suchman 1987, 39). According to Suchman, they only serve as an organisational or predictive function prior to action or act as a justification of the actions taken. During action, they only play a minimal role. However, this radical view on plans was subject to critique and empirical results do not fully support them. If plans are conceived, they are followed generally but complemented with ad hoc actions (Law 1998, 23). Actions thus perhaps are best described as being both at the same time, improvised and planned.

It remains open what in this relation exactly can be understood under "situatedness". Clancey (1997, 23ff) offers a comprehensive framework that distinguishes between a functional, a structural and a behavioural aspect of situatedness. The *functional (or social) aspect* refers to the understanding of the meaning of action and entails an agent's understanding of who he is within a society, which refers to his role and place in and the values of a society. The *structural (or neural) aspect* describes how perception, conception and action are physically coordinated. The *behavioural aspect* relates cognition to spatial-temporal settings and considers the local feedback and time-sensitive nature of action in place. Broadly speaking, social sciences emphasize the functional and behavioural aspects whereas neurobiology emphasizes the structural aspect (Clancey 1997, 25). The framework helps to understand why explanations of situated cognition by social scientists may be unsatisfactory for psychologists and AI researchers.

The MODE model in sociology

The conditions that influence when individuals turn from routine behaviour to more rational and complex modes of information processing are also researched by sociology. The so-called MODE model is based on the idea that the strength of the activation of a known model also determines the mode of information processing (Esser 2004, 124; Fazio 1990): The more directly a model is activated, the less rational is the mode of information processing. The MODE model includes three variables: motivation, effort and opportunity (Fazio 1990, 91ff): The *motivation* to turn from an automatic to a theory-driven mode is determined by the increasing opportunity costs of a wrong decision. *Efforts* refer to the costs of information processing and thus also influence the motivation. *Opportunity* refers to the fact that more costly heuristics require time and freedom from interruptions. In conclusion, individuals only turn to more deliberate modes if the model of the situation does not really fit, if their motivation is high enough to outweigh additional efforts and if actors have the opportunity for reflection (Esser 2004, 127; Payne, Bettman & Johnson 1988, 551f).

The reliance on established models for a situation and thus on learnt behaviour is also referred to as framing. More specifically, it means the concentration on one single main goal, guided by the recognition of a model of a situation and the knowledge about the conditions where such a frame is relevant, reasonable and valid (Esser 2004, 128). The MODE model explains why rationality and framing are not antagonisms but rather are complementary. Purely rational behaviour results from the fact that established models do not fit. This represents one special case that is covered by the model.

Situation-oriented approach to knowledge management

Wiig (2003; 2004, 117ff) proposes a situation-oriented approach to KM. Situation-handling is understood as the placement of decisions and the execution of actions within situations. A situation is understood as anything from a short episode with a duration of a few seconds to more complex situations that exist for a longer time and require collaborative actions (Wiig 2003, 7). Nevertheless, Wiig states that "… situations rarely are single events. Instead, they are ongoing situations that require repeated attention and multiple actions" (Wiig 2003, 7). He distinguishes different types of situations based on the amount of knowledge that an entity possesses into those that are well-known and involve routine action, those that follow generally known scripts and abstract patterns and those that are completely unknown to an individual.

Situation-handling involves four basic types of tasks: sensemaking, decision-making / problem solving, implementation and monitoring (Wiig 2003, 11ff; 2004, 126ff): (1) *Sensemaking* is the receipt and acceptance of information about a situation and the usage of knowledge in order to make sense of it. (2) *Decision making* is the placement of decisions concerning the actions to be taken. It is related to situations well-known or at least generally known. *Problem solving* is linked to unknown situations where mental models or patterns for appropriate actions are not available. (3) *Implementation* refers to the actual accomplishment of actions. (4) The *monitoring* task obtains feedback from the former three tasks and is concerned with the evaluation of the goal-achievement. It delivers corrective adjustments to these tasks if required. The tasks and their relationships are depicted in Figure 12.

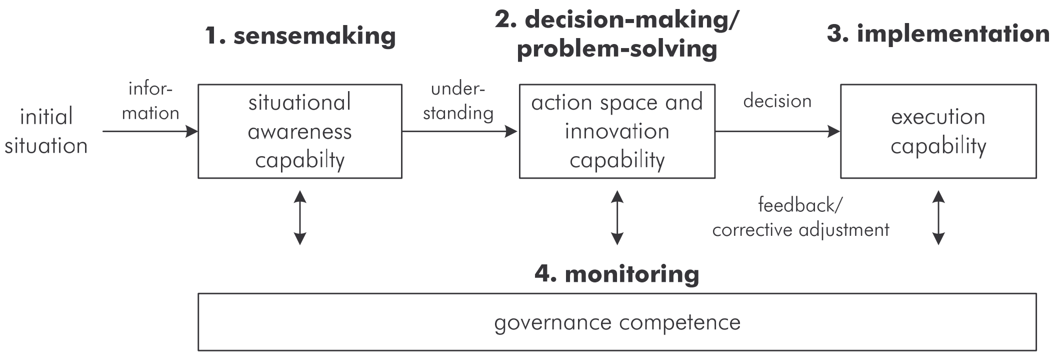

Figure 12. Wiig's model of situation-handling[26]

Four types of capabilities correspond to these tasks: situational awareness capability, action space and innovation capability, execution capability and governance competence: (1) The *situational awareness capability* is the ability to observe and perceive a situation adequately. It relies on mental reference models that are based on prior experience but also on other types of knowledge such as facts and rules. The sensemaking task is influenced by many factors, particularly the degree of attention that determines the priority of situations. (2) The *action space capability* denotes the space "… within which the person is competent, willing, comfortable or otherwise prepared to make decisions and act" (Wiig 2003, 12). It is associated with the decision making task. The *innovation capability* in contrast is linked to problem solving

[26] based on (Wiig 2003, 9)

and relies on methodological mental models. (3) The *execution capability* includes the knowledge required to understand decisions and to implement actions appropriately. (4) The *governance competence* refers to the ability to assess the performance of tasks and to provide corrective actions.

Wiig's situation-handling approach already offers some starting points for KM. However, the generality of the proposed model also limits its applicability. Particularly, no details are offered with regard to how the capabilities or four steps related to a situation could be analysed, enhanced or supported. Nevertheless, it represents a suitable metaphor which also encourages the choice of a situation-oriented approach by this work.

Consequences for this work

As described in section 3.2, PKM lacks approaches that do not only concentrate on a process-oriented perspective on knowledge work but also include a learning-oriented perspective that focuses on knowledge exploration. Hence, those situations are particularly relevant that cannot be accomplished routinely. Dewey's view on situations emphasizes this. He regards situations as instances or episodes of breakdown or imbalance within the dynamic interaction of an individual with its environment that otherwise can be characterized as naturalistic, noncognitive and conative (Burke 1994, 22ff). When being concerned with the integration of a process-oriented and a learning-oriented perspective on knowledge work, the switch from routine to non-routine behaviour is particularly relevant. Consequently, it appears as a fruitful approach to focus on those points in business processes where individuals turn from more routine to non-routine behaviour since here, learning is triggered that may lead to the creation of new knowledge which is potentially relevant for an organisation.

3.3.4 The concept of fit

Another subject frequently discussed in relation to situational approaches is the concept of fit. It is referred to by contingency approaches discussed in management science and by task-technology fit as discussed in MIS.

Contingency approach in management science

During the 1960s and 1970s, the contingency approach represented the dominant research paradigm of organisation science. Lawrence & Lorsch (1967) were the first to define an explicit contingency theory of organisation (Staehle, Conrad & Sydow 1999, 49). The theory argues that different formal and informal organisational structures have a different effectiveness and efficiency depending on specific situational factors, also called contingency factors (Donaldson 1996, 57; Ebers 2004, 653). These are related to the organisation's environment, e.g., education systems and cultural values of a society, the external task environment, e.g., the complexity and dynamism of the environment, and the internal situation of an organisation, e.g., its production technologies and procedures (Ebers 2004, 656f). Consequently, there is no single organisational structure that is highly effective for all organisations (Donaldson 1996, 57) but rather the organisational effectiveness is determined by a good fit between situational factors and the organisational structure (Ebers 2004, 653). Figure 13 visualizes this basic model.

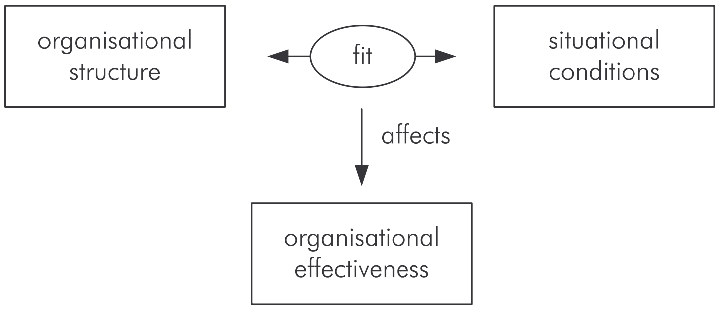

Figure 13. Basic model of the contingency approach[27]

Goal of situational approaches is the identification of specific relationships between defined situational variables and organisational structures based on the empirical collection of comparable problem situations, influencing factors, possible alternative actions and efficiency indicators (Staehle, Conrad & Sydow 1999, 50). For example, it is proposed that enterprises with a less bureaucratic, organic organisational structure are more successful in accomplishing changes within their market environment than organisations with a bureaucratic structure (Burns & Stalker 1968, 123ff). Another example is the information processing view (Galbraith 1974; Keller 1994). It assumes that a dynamic environment characterized by factors such as fast technological change or strong competition requires the coping with significantly more information than within a static setting. Organisations with tightly networked team structures and redundant resources are supposed to have a higher information processing capacity. A fit is characterized by the circumstance that a firm has just as much informa-

[27] based on (Ebers 2004, 655f)

tion processing capacity as it is required depending on the situational factors (Galbraith 1974, 36; Keller 1994, 177).

One of the main critiques of the contingency approach states that it could not generate consistent findings concerning the relationships between situational factors and the organisational structure (Ebers 2004, 660). The reason is that related research approaches differ largely with regard to research strategies, variables focused and operationalization of variables (Ebers 2004, 655). In fact, they are not based on a shared theory but only represent a research approach that principally can be concretised differently (Staehle, Conrad & Sydow 1999, 53). Nevertheless, it contributed largely to a more empirically informed picture of the structure of organisations (ibid.). This development points to the fact that the analysis of partial aspects may be a more suitable approach for organisation science than the creation of an all-encompassing theory (Ebers 2004, 664f).

Task-technology fit in management information systems

The *task-technology fit approach* as discussed in MIS proposes that performance impacts result from a task-technology fit, which is understood as the circumstance that a technology offers features and support that fit with task requirements (Goodhue & Thompson 1995, 214). It can be regarded as a specialization of the contingency approach. Figure 14 depicts the model proposed. Tasks are the actions carried out by individuals (Goodhue & Thompson 1995, 216). Examples for their characteristics are the degree of routineness or of interdependence (Goodhue & Thompson 1995, 221f). Technologies are tools used by individuals in order to carry out tasks, particularly computer systems and user support services (Goodhue & Thompson 1995, 216). They can be characterized, e.g., with respect to the degree to which they support communication or process structuring (Zigurs et al. 1999, 39ff).

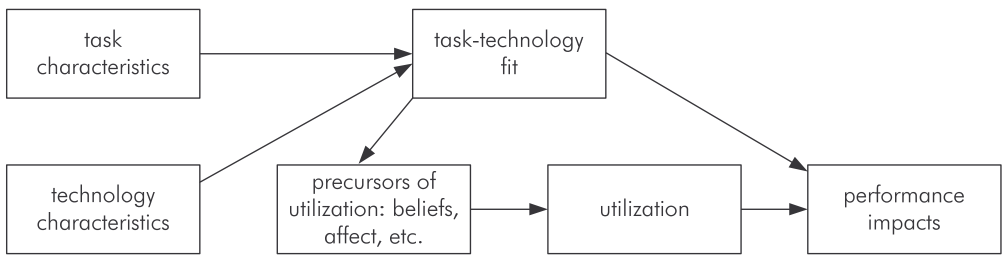

Figure 14. Task-technology fit as part of the technology-to-performance chain[28]

[28] based on (Goodhue & Thompson 1995, 215)

The characteristics of technologies and of tasks influence the task-technology fit, which is defined as the correspondence between task requirements, individual abilities and the functionality of the technology and can be expressed by the factors quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability and relationship with users (Goodhue & Thompson 1995, 221f). Utilization is the behaviour of employing the technology in completing tasks. It is influenced by precursors such as the attitude of a user towards using a specific technology. These in turn depend on the task-technology fit. The model proposes that both, task-technology fit and utilization influence individual performance and in this sense represents a concretisation of IS success models (DeLone & McLean 1992; 2003). Examples for performance impacts are enhanced efficiency, effectiveness or quality of the accomplishment of individual tasks (Goodhue & Thompson 1995, 218).

Consequences for this work

It is not the goal of this work to hypothesise on the fit of situational and technological characteristics. Nevertheless, the concept of fit motivates the assumption that selected ICT services can be used in order to support specific situations. The specification of the situations in question thus should help to decide on the technical support. The concept to be proposed thus is required to include respective information.

3.3.5 Collective features of situations

Another observance that can be made when investigating situational approaches is that the concept of situation is not only applied on the individual level but also on the level of groups or of organisations. Amongst others, this is emphasized by the situated learning approach which is strongly related to the view on learning as advanced by activity theory (section 3.2) and to the situated cognition approach (section 3.3.3). This will be described firstly. Furthermore, the group and organisational levels are referred to in relation to framing (section 3.3.3), the situation-handling approach to KM (section 3.3.3) and the task-technology fit approach in MIS (section 3.3.4), which will be summarized in the second half of this section.

Situated learning

Situated cognition proposes that cognition is not exclusively found in the head but needs a more comprehensive understanding that transcends the simplistic organism/environment distinction (Law 1998, 8). Lave and Wenger (1991) use the term *situated learning* in order to point to the fact that all learning is contextual and embedded in a social and physical environment. As activity theory, this approach investigates the processes through which people develop shared conceptions of their activities (Blackler 1995, 1035). The view on learning as being situated means more than "learning in situ" or "learning by doing" (Lave & Wenger 1991, 31). Instead, it has the proportions of a general theoretical perspective that claims a relational character of knowledge and learning, a negotiated character of meaning and a concerted nature of the learning activity (Lave & Wenger 1991, 33).

Learning as a situated activity is characterized by a process known as *legitimate peripheral participation* (Lave & Wenger 1991, 29ff; Wenger 2002). It concerns the way by which newcomers become experienced members of a Community of Practice (section 2.4). Initially, they take over superficial yet productive and relevant tasks. These represent a chance to become acquainted with the tasks, the vocabulary, and the organising principles of a community. By observing, understanding and accomplishing the practices of experts within the community, they gradually move to its centre and take over increasingly important tasks for the community. Knowledge in this context is compared with tools. They can only be understood fully through use, which "… entails both changing the user's view of the world and adopting the belief system of the culture in which they are used" (Brown, Collins & Duguid 1989, 33). Learning thus is a process of enculturation rather than the acquisition of facts (Brown, Collins & Duguid 1989, 33f). It is described as a continuous process, as an aspect of all activity (Lave & Wenger 1991, 37f). The approach is not an educational form or a pedagogical strategy though it is sometimes interpreted in this way. Rather, it represents "… an analytical viewpoint on learning, a way of understanding learning" (Lave & Wenger 1991, 40).

Other approaches

The process of *framing* as described in section 3.3.3 is not only an individual process but may also be determined by social groups. Collective models of situations are acquired in an interactive learning process where they are reciprocally constructed and confirmed (Esser 2004, 142). The investigation of these processes is the concern of the sociological frame analysis which has the purpose "… to try to isolate some of the basic frameworks of understanding available in our society for making sense out of events and to analyse the special vulnerabilities to which these frames are subject" (Goffman 1974, 10). It is relevant, e.g., for the analysis of social movements where "… framing refers to the interactive, collective ways that movement actors assign meanings to their activities in the conduct of social movement activism” (Buechler 2000, 41).

Wiig suggests to use the *situation-handling approach to KM* he proposes not only on individual but also on organisational level (section 3.3.3). Situation-handling on enterprise level can be described by multiple interlinked situations, e.g., actions on top management level are executed by delegation which causes situations at lower management levels. He suggests that this model is an easily comprehensible framework that can be used to analyse and understand personal and organisational processes (Wiig 2003, 19). However, this has not been empirically investigated so far.

Goodhue and Thompson (1995) developed the model of *task-technology fit* for the individual level of analysis (section 3.3.4). Zigurs et al. (1999) found that it also operates on the group level. Since then, the task-technology fit model was applied in numerous studies, partially with modifications in order to satisfy the specific requirements of the research approach and setting.

Consequences for this work

The application of the situation concept on individual, group and organisational level shows that it is principally suited to integrate the process-oriented and learning-oriented perspective on knowledge work on different levels (section 3.2). Since this work is concerned with the enhancement of individual knowledge work, the level of individuals will be used as a starting point for the integration of the two perspectives. However, situated learning and activity theory emphasize that collectives play an important role for learning and thus have to be taken into account in this context.

3.4 Definition of the knowledge work situation concept

This section defines a situational concept that is suited to integrate the process-oriented and learning-oriented perspectives as outlined in section 3.2. It is labelled the concept of knowledge work situations. Firstly, an overview of this concept is provided (section 3.4.1) and afterwards its single components are described in more detail, i.e. occasions (section 3.4.2), context (section 3.4.3) and knowledge actions (section 3.4.4).

3.4.1 Overview

A knowledge work situation is defined as a class of recurring situations in knowledge work defined by occasion, context and mode resulting in knowledge actions.[29] It does not represent any situation of knowledge work but rather those that are most relevant for KM and shared by a number of individuals. KWS describe a situation in which a knowledge worker can, should or must switch from a business-oriented function to a knowledge action. It connects the process-oriented and the learning-oriented perspectives on knowledge work (Figure 15).

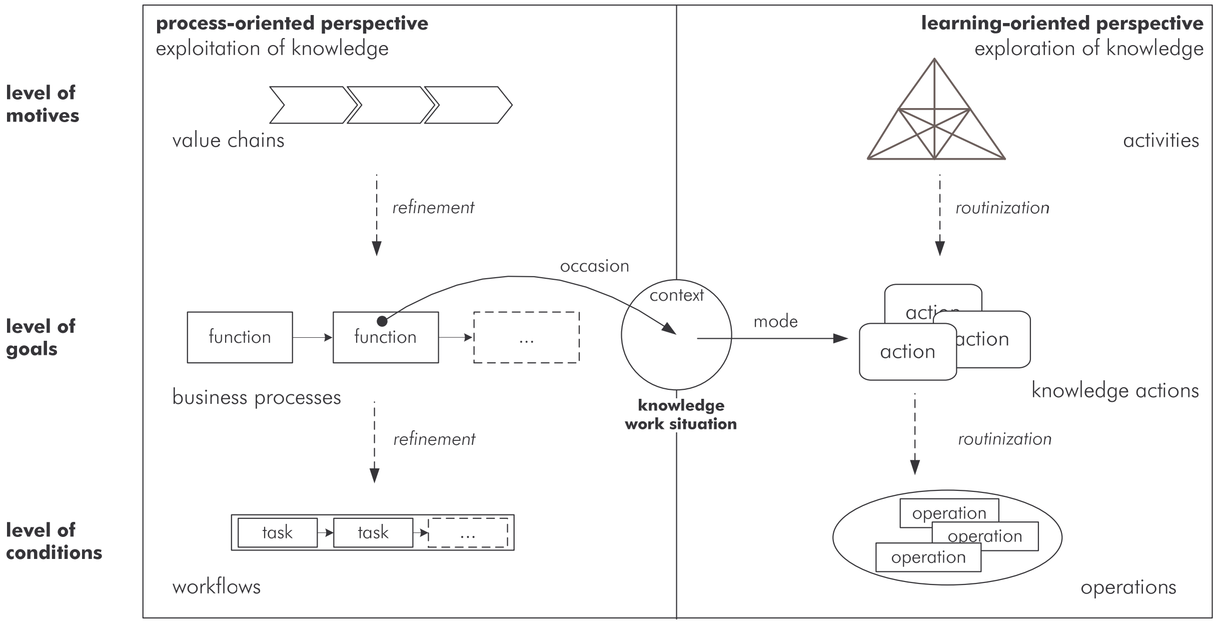

Figure 15. The knowledge work situation concept

In a process-oriented perspective, an employee accomplishes functions on the level of goals that belong to a value chain on the level of motives by fulfilling a sequence of tasks on the level of conditions. Simultaneously, he can be involved in an activity framing knowledge actions and corresponding operations. An activity and its corresponding actions and operations can be focused on the business process or pursue a motive not related to the business process, e.g., an effort to build competencies, and thus may make a direct or only an indirect contribution to process goals.

[29] The concept and its application have been described in several earlier publications, e.g., Hädrich & Maier (2004; 2005), Hädrich & Priebe (2005a; 2005b) and Maier & Hädrich (2007).

A business process offers several *occasions* to learn and to generate knowledge related to the core competencies of an organization. They are a means to focus on the points where knowledge workers are required to switch from routine to deliberate action (section 3.3.3). Occasions trigger KWS and are associated with functions of business processes by offering the opportunity or the need for knowledge actions. Occasions are driven by problems or challenges as well as by individual curiosity. KWS describe situations where new knowledge is created and thus they are near to Dewey's view on situations described as instances or episodes of breakdown or imbalance (Burke 1994, 22ff). Nevertheless, they may also include the translation and application of knowledge created outside the KWS.

The *context* comprises all relevant information suitable to describe the actual situation of the worker. It includes both perspectives on knowledge work and thus comprises information about the current process like other subjects involved, desired outcomes, formal rules or other related process steps and on the other hand information about related activities, their learning objectives, the community of people involved and instruments applied in this relation. It is not limited to the objective situation but also incorporates aspects as perceived to be relevant from an individual point of view, e.g., individual learning objectives or interests (section 3.3.1). This definition of the context is still very general. It thus will be detailed in section 3.4.3 based on the requirement that it should contain all information relevant for the situation-oriented provision of knowledge services (section 3.3.2).

The *mode* classifies what actions can be performed and refers to four informing practices identified by Schultze (2000; 2003): expressing, monitoring, translating and networking. They will be described in more detail in section 3.4.4. Context, mode and occasion are means to specify the set of available, allowed or required *knowledge actions*. In contrast to the clearly defined sequences of functions in the process-oriented perspective, there is no predetermined flow of actions as they typically describe deliberate and non-routine behaviour. Knowledge actions may be directed towards to knowledge-handling of individuals or groups. This acknowledges the relevance of collectives for learning (section 3.3.5). Examples for knowledge actions are the authoring of documented knowledge and the identification of a knowledgeable person. Table 4 summarizes the components of KWS that will be described in the following sections (sections 3.4.2 to 3.4.4).

component	description
occasion	is a type of opportunity to learn and to generate knowledge related to the (core) competencies of the organization within the function of a business process and indicates the need to switch from routine to deliberate actions
context	describes objectively or subjectively relevant aspects of the actual work situation, i.e. the process-oriented and learning-oriented context of knowledge work, and specifically comprises information suited for the situation-oriented provision of knowledge services
mode	classifies knowledge-oriented actions into the four modes expressing, monitoring, translating and networking
knowledge action	refers to unstructured knowledge actions that are specified by occasion, context and mode which target the knowledge handling of individuals or groups

Table 4. Components of the knowledge work situation concept

The learning about effective office product procurement in a consulting company can be described as an *example of a KWS*. It is related to the procurement process of the organisation, more specifically to the function "order product". The situation is triggered by the occasion that no suitable supplier is known for a certain product to be procured, e.g., a notebook with uncommon characteristics such as a pre-installed open source operating system and respective office software. The KWS is not limited only to this specific function because other business processes may also offer occasions that lead to learning about procurement, e.g., the quality of a notebook may not suit the needs of consultants that are required to switch between the organisation's internal technical environment and that of selected customers. Consequently, a KWS may connect various business processes that are unrelated in the view of traditional process management.

The context specifies the situation further with regard to, e.g., the urgency of the case, the knowledge typically required by the role[30] that is responsible for this function, the relevant topics and the available technical services. The exemplary case is urgent, the procurement role typically does not need to have any advanced technical skills related to computers and software and the topics relevant can be specified by the keywords mobile computing, components of notebooks, open source operating systems and office software. Technical services available are communication systems, a document repository and a system for electronic procurement but the access is restricted by a set of privileges that depend on the roles of the user.

[30] This example intentionally refers to roles instead of concrete individuals as KWS describe typical situations of knowledge work that need to be specified not on instance level but on type level.

Possible knowledge actions that result from and are specified by this context are the search for suitable suppliers based on written documents or the enquiry of colleagues that have skills related to the topics of the current situation. The second action for example may comprise operations such as the application of communication systems and directories, the search through inventory lists or the creation of personal notes. These operations represent daily and well-known work activities and thus are conducted routinely. Technical services that might support the knowledge actions are email, phone, the Intranet search engine and the department's file server.

3.4.2 Occasions

Occasions represent the turning points where individuals switch from a mode of work that is primarily concerned with knowledge application to a way of working that is oriented towards the generation of new of knowledge which involves learning. Occasions are particularly related to problems and challenges associated with work tasks in business processes and also are driven by individual curiosity. This is motivated by the situated learning perspective which characterizes learning as being engaged and dilemma-driven (Lave & Wenger 1991, 33), by activity theory that primarily focuses on the ambiguities and conflicts that propel collective learning within activity systems (Blackler 1993, 870f) and by Dewey's conception of situations as being "… instances or episodes … of disequilibrium, instability, imbalance, disintegration, disturbance, dysfunction, breakdown" and as emerging during the normal, routine interaction within an organism/environment system (Burke 1994, 22f). Furthermore, Wiig explicitly distinguishes between well-known and unknown situations and acknowledges the relevance of learning associated with new situations though he does not focus specifically on one of these types (section 3.3.3).

Challenges and problems that result in learning are referred to in relation to many approaches relevant in KM, particularly in relation to KM instruments (section 2.4). For example, the "story" section as an important part of a micro article typically describes how a problem has been resolved (Willke 1998, 107ff), an important goal of documenting lessons learnt is the learning from mistakes (Schindler & Eppler 2003, 221ff) and storytelling is concerned with supporting knowledge dissemination based on stories "… that tell something about success or failure, effective or failed solutions to problems, about good luck, justice, beauty, etc." (Schreyögg & Geiger 2004, 5). Furthermore, it is stated that information seeking behaviour is typically triggered by problems, more specifically by a state of uncertainty resulting from a discrepancy between the typification applied to the life-world and a phenomenon that cannot be fitted in those typifications (Wilson 1999a, 840). Some technology-oriented approaches to KM also explicitly refer to problems, e.g., the CBR cycle is triggered by a problem, followed by the retrieval of similar cases as well as their reuse and potential revision (Watson 1997, 16f).

Rothwell (2002, 78) provides a list of circumstances that trigger workplace learning such as feel a need to learn more about a problem, hear a complaint from a customer, try to perform a task and fail / do it moderately well, hear questions posed by others, experience challenges stemming from other people in the workplace such as customers, supervisors or co-workers, receive feedback about oneself or performance of self, notice an opportunity for improvement, feel a need to pursue knowledge for its own sake, recognize a deficiency in a standard operating procedure, react to / anticipate changes in the external environment or find oneself in a new setting. However, this list lacks a classification scheme and only contains exemplary and partially overlapping occasions that are not necessarily driven by curiosity.

It is suggested here to classify occasions based on the degree of how strongly they relate to actual work tasks in business processes. This is based on a taxonomy of learning processes as suggested by Eraut & Hirsh (2007, 25ff). In a typology of early career learning processes, the authors differentiate between *work processes* with learning as a by-product, e.g., `working alongside others`, `tackling challenging tasks and roles` or `trying things out`, and *learning processes* at or near the workspace, e.g., `being coached`, `participating in conferences` and `working for a qualification`. In-between these two types of processes, they place generic and shorter *learning activities* such as `asking questions`, `reflecting` and `locating resource people` that may be executed multiple times as part of the daily work activities. Consequently, it will be distinguished between primarily *task-oriented occasions* that trigger knowledge actions mostly contributing to the goals of the business process and having learning as a by-product and *learning-oriented occasions* that lead to knowledge actions mainly dedicated with learning and thus contributing stronger to the development of competences. Some of the generic learning activities will be used in section 3.4.4 in order to detail selected knowledge actions.

This reflects the distinction between a process-oriented and a learning-oriented perspective on knowledge work. While the task-oriented occasions are associated with challenges as a part of one's work tasks, the latter are more strongly associated with individual interests and learning objectives, the achievement of long-term career goals and the membership in communities that may also span organisational boundaries and thus are only indirectly coupled with the goals of an organisation. Starting point for the analysis of occasions are particularly those business processes and business process functions that can be classified as knowledge-intensive based on the criteria outlined in section 2.6. The relevancy of specific occasions for an organisation may be judged based on business process goals and on medium-term or long-term development goals of an organisation.

3.4.3 Context

The context of KWS has been defined to comprise the relevant aspects of the process-oriented and learning-oriented perspective (section 3.4.1). This is a very broad definition and it should be detailed which information exactly is understood to be part of the context. The conclusion has been drawn that context cannot be defined on its own but only in terms of its effects (section 3.3.2). Here, the effects of the context on knowledge actions and specifically on their technical support are relevant. Rosemann & Recker (2006, 154) define the context of business processes as the set of factors containing all relevant information that impact their design and execution. Based on that, the KWS context can be characterized as the set of factors that impact the design and execution of knowledge actions. Examples are the degree of urgency, the availability of resources and also individual preferences. This draws attention to the fact that KWS are not only a concept targeted at analysis and understanding of knowledge work but also at its design.

As stated, particularly the information is relevant that concerns the situation-oriented provision of knowledge services. The KWS context thus can be characterized to comprise those factors that influence the selection of services or that represent information required as input for services suited to support knowledge actions that result from KWS. However, this definition is not operational in the sense that is allows to decide which information is part of the context and which is not. Consequently, the KWS context is further detailed by means of context dimensions that classify the information that is part of the context. Moreover, the context can be characterized on a meta-level concerning aspects such as the source or lifetime of context information which will be discussed afterwards.

Dimensions of the KWS context

Typical dimensions of context are frequently discussed in relation to context-aware computing (Amberg & Wehrmann 2001, 3; Amberg & Wehrmann 2002, 3; Dey, Abowd & Salber 2001, 107; Henrich & Morgenroth 2003; Klemke 2000, 6; Schilit, Adams & Want 1994; Shkundina & Schwarz 2005; van Elst, Abecker & Maus 2001; Zacarias et al. 2005) as well as in relation to the structuring and presentation of electronic contents (Maier & Sametinger 2002; 2003; 2004). Some contributions strive for the creation of a general framework of the aspects and dimensions that are part of the context (Dey, Abowd & Salber 2001; Klemke 2000). Others pragmatically create a list of context dimensions that suits their respective research goals (van Elst, Abecker & Maus 2001). Though at first sight many different facets of context information are included, they can be subsumed under six general dimensions: product, process, person, productivity tool, location and time. Table 5 lists the approaches investigated and indicates the dimensions that are addressed.

context dimension	Amberg & Wehrmann (2002, 3)	Amberg & Wehrmann (2001, 3)	Dey, Abowd & Salber (2001, 107)	van Elst, Abecker & Maus (2001)	Hitz et al. (2002, 227f)	Henrich & Morgenroth (2003)	Klemke (2000, 6)	Maier & Sametinger (2002; 2003; 2004)	Schilit, Adams & Want (1994)	Shkundina & Schwarz (2005)	Zacarias et al. (2005)
product			x	x			x	x		x	
process		x		x		x	x	x		x	x
person		x	x	x	x	x	x	x	x	x	x
productivity tool	x				x				x	x	
time	x	x	x		x	x	x	x		x	x
location	x	x	x		x	x	x	x	x		

Table 5. Overview of context dimensions

The generic dimensions identified are proposed as basic categories for structuring the KWS context and described in more detail in the following.

Product. The dimension product represents the subjects or topics that are relevant within a situation. It may be represented in the form of taxonomies or ontologies and also includes the types of information, e.g., file types such as Postscript or a document in the Hypertext Markup Language (HTML).

Process. The process dimension subsumes the processes that an individual participates in or is responsible for. This does not only include well-structured business processes or workflows that directly contribute to an organisation's value chain but also less structured activities and actions in the sense of activity theory that have the object of knowledge generation. Process goals and the objectives of activities that relate to the level of motives are also subsumed here (section 3.2).

Person. The person dimension relates to individual characteristics such as interests, preferences, individual goals, the organisational position and roles. The latter also includes individual roles that are part of the work division of activity systems. The level of expertise such as novice, advanced beginner, competent, skilful master and expert (Dreyfus & Dreyfus 1986, 16ff) can also be included here as well as links between people such as communication or advice relationships. This allows establishing links between the individual and the group level and thus acknowledges the collective features of situations (section 3.3.5).

Productivity tool. The productivity tool dimension embraces characteristics of the technological infrastructure such as types of available services, access privileges and characteristics of end user devices in use, e.g., their memory capacity and display resolution.

Location. The location dimension refers to the past or current geographical location of people, places and things. Examples are the user's location and specific points of interest. This dimension is highlighted by contributions on context-aware support with mobile devices and systems.

Time. The time dimension refers to the current time, selected points in time such as milestones as well as to fixed periods of time such as hours, days, weeks and months.

The former three dimensions directly correspond to the three media of knowledge, i.e. product, process and person (section 2.2). Hence, the KWS context can be used in order to specify the knowledge relevant within a situation in an ICT-oriented way from one or preferably multiple perspectives. The last three dimensions can be determined relatively easily and sometimes are referred to as the physical context of an individual. Technically, the context can be represented and managed by various means such as relational databases. More recently, ontologies are discussed intensively in relation to topics such as the Semantic Web and the representation of the structure of documented knowledge (section 2.2). They may be applied for representing the KWS context as this allows to infer new relationships between contextual factors. Surely, this is not a trivial challenge.

Meta-information about the KWS context

The specification of context information on a meta-level is not as explicitly discussed by the approaches cited as the context dimensions. Meta-information about the context can be used in order to specify the source of context information, its electronic accessibility, the rate of change, the need for protection, the level of generalisation and the degree of reliability.

Source. This category refers to the way how context information is acquired. Mertens & Höhl (1999, 203f) refer to implicit vs. explicit information acquisition. The former relies on the tracing of user actions in order to infer information about her behaviour. Explicit acquisition directly asks the user to describe aspects of his situation, e.g., learning goals or media preferences. Dey et al. (2001, 107) point to the fact that a small set of primary context information can be used to infer many additional pieces of the context.

Electronic access. The category electronic access distinguishes whether context information is electronically accessible or not. It can be gained by hardware and software sensors, e.g., Global Positioning System (GPS) hardware sensors or software components that monitor the interaction of user and interface. Dey et al. criticise that the choice of context information based on the context acquisition mechanisms available which rather should be determined by the design goals (Dey, Abowd & Salber 2001, 102). Electronically inaccessible context can be acquired by directly questioning the user to provide the information. Principally, it is desirable that the relevant context information is acquired automatically as far as possible based on electronic sources. EPOS[31] is an example of a research project in this area.

Change rate. Information about the context can either remain static over a longer amount of time, e.g., the name of the user or his preference for selected communication media, or it may change within short time periods, e.g., his online status or geographical location. This is reflected by the distinction between static and dynamic user profiles (Amberg & Wehrmann 2002) or that between static user context and dynamic interaction context (Henrich & Morgenroth 2003).

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[31] URL: http://www3.dfki.uni-kl.de/epos/project_lines/context, last accessed: 2007-12-02

Protection. This category distinguishes public from private context information. It is argued that privacy of context, i.e. the individual's control over their personal context data, is a complex issue (Ackerman, Darrell & Weitzner 2001, 167). One reason is that context information is not necessarily stored on a single device that is under the control of the user (Ackerman, Darrell & Weitzner 2001, 171). The Federal Trade Commission (FTC) has defined a set of four fair information practices originally targeted at the use of Web sites that also should be regarded here: The user should have a clear notice of the information collected, he should have the ability to choose not to have data collected, he should be able to see and change the information collected and reasonable measures should be taken to secure the data from unauthorized access (FTC 2000, iii).

Generalisation. Context information can be classified according to its generality as to be on instance level or on type level (based on Goesmann & Herrmann 2001, 95). Instance level in this relation means that the KWS context is restricted to the current case, e.g., the order #36342 concerning a notebook with open source software is processed by Sally Miller. Context on type level is independent of concrete actions and individuals, e.g., orders of notebooks that are handled by procurement administrators. As KWS are defined to be typical and recurring situations of knowledge work, they need to be described on type level during analysis and design.

Reliability. This category distinguishes reliable from ambiguous context information. Context information ideally is entirely reliable. However, it can be associated with varying degrees of ambiguity. Sources of ambiguity are that inferences made based on a restricted set of contextual data are only valid with a limited probability, that information cannot always be definitely categorized or that user input may not be correct. The issue of reliability also relates to the distinction between objectively observable and subjectively perceived aspects of a situation (section 3.3.1).

Figure 16 summarizes the six dimensions of context information and the categories of meta-information. This represents a preliminary version of a framework for structuring the KWS context. It will be refined based on further conceptual and empirical results of this work (section 8.2).

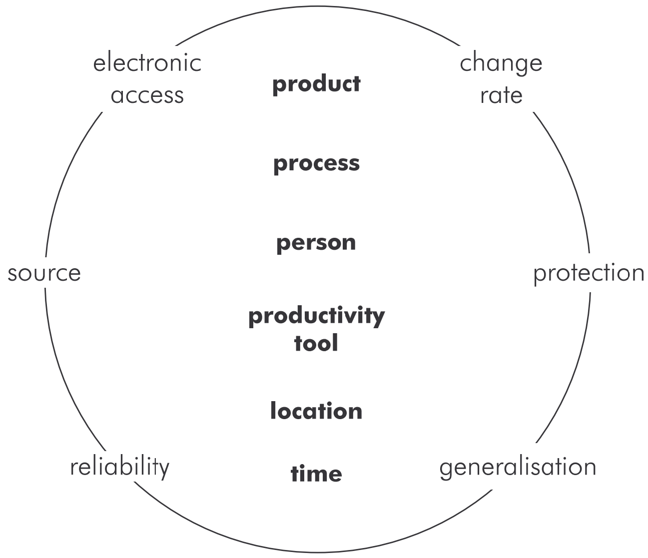

Figure 16. Preliminary framework of the KWS context

3.4.4 Knowledge actions

PKM intentionally selects processes and activities as a starting point for enhancing the effectiveness of knowledge work (section 2.6). Knowledge actions thus are of primary interest for the design of organisational and technical support. They may contribute more or less directly to the function of a process, i.e. a share of them may be understood as a part of the business process and another to be accomplished outside of the process flow. Based on the concept of fit (section 3.3.4) it is proposed that specific configurations of ICT services fit with the particular affordances of knowledge actions that are further defined by occasions, the KWS context and their mode. This section firstly proposes a classification of knowledge actions with the help of two dimensions: the mode of knowledge actions and the distinction between individual and group level. Based on this, eight typical knowledge actions are described that can be supported by means of technical infrastructures. These are not only relevant in order to detail what is understood by knowledge actions but also are an important subject of the empirical study that was conducted as a part of this work (chapters 6 and 7). There, it is explored of which single steps the proposed set of actions is composed of. One reason for this is that to the current state of knowledge in this area, only a relatively rough characterization is possible.

Classification of knowledge actions

The high-level knowledge processes referred to in the PKM literature are too generic to define specific knowledge actions that are suited to decide on appropriate support (section 2.6). Informing practices more concretely describe actual activities of knowledge work (section 2.3). Schultze (2000) has identified three informing practices based on an ethnographic study in a large Fortune 500 manufacturing firm: expressing, translating and monitoring. She also proposes the practice of networking researched by Knights et al. (1993) to be relevant (Schultze 2003, 50). These four practices are the result of a certain research focus and thus further ones may exist not yet identified. However, they currently represent the most substantial results of empirical research on knowledge work in a work practice perspective and thus they are applied to represent the mode used to classify knowledge actions. They are described as follows:

Expressing. Expressing is the practice of self-reflexive converting of individual knowledge and subjective insights into informational objects that are independent of the knowledge worker. Knowledge workers have to suspend their subjectivity in order to become an objective observer. A typical example is the work of system administrators documenting their thoughts and actions.

Translating. Translating involves the creation of information by ferrying it across multiple realms and different contexts until a coherent meaning emerges. The search strategy of corporate librarians is an example of this practice. They iteratively and coherently try to combine the interpretation of their customers' questions with answers resulting from their search.

Monitoring. Monitoring describes the continuous non-focused scanning of the environment and the gathering of useful "just in case"-information. It identifies important events and keeps up to date in the area of interest. The practice is typical for the work of corporate competitive intelligence analysts with the mission of objective, accurate and reliable reporting.

Networking. The practice of networking describes the building and the role of relationships with people inside and outside the organisation that knowledge workers rely on (Knights, Murray & Willmott 1993). It acknowledges the relevance of social capital that knowledge workers apply in their work (Schultze 2003, 50).

Knowledge actions explicitly take into account both, the knowledge-handling by individuals and in groups. This requirement so far was stated primarily based on the importance of collectives for learning processes as emphasized by situation-oriented approaches (section 3.3.5). Nevertheless, the relevance of collectives has also been referred to at other points of this work. It has been described the collective processes represent a medium of knowledge that needs to be taken into account besides the two other knowledge media products and persons (section 2.2). Knowledge work has been characterized to involve strong communication, cooperation and collaboration needs (section 2.3). The relevance of communities for KM has been highlighted as they promise to be an efficient instrument for knowledge sharing (sections 2.4). The process-oriented KM instrument community management has been introduced that includes specific community management processes (section 2.6). Last but not least, the fact that knowledge and knowledge work are fundamentally collective motivated the application of activity theory for the description of the learning-oriented perspective (section 3.2). Consequently, the second dimension used for the classification of knowledge actions is based on the distinction between individual and group level.

Based on the two dimensions mode and individual versus group level, a framework of eight classes of knowledge actions can be created that is depicted in Table 6. For each category, a knowledge action is introduced that is concretised as far as possible based on related literature, i.e. authoring and co-authoring for the mode of expressing, training and acquisition for the mode of translating, update and feedback for the mode of monitoring and expert search and invitation for the mode of networking. The characterization of these actions particularly includes the description of possible steps that are accomplished as a part of these knowledge actions. Due to their complexity, these steps will remain on the level of goals and thus principally also represent more fine-grained knowledge actions. Nevertheless, parts of knowledge actions may also be routinized so that some of these steps represent operations that are executed routinely on the level of conditions. Table 6 also includes the perspectives on knowledge primarily focused by a specific informing practice. When taking into account that the knowledge actions themselves represent a process view on knowledge, it can be stated that all perspectives on knowledge are covered by this framework, i.e. product, person and process (section 2.2).

mode[32] (perspective on knowledge)	**individual level**	**group level**
expressing (product)	authoring	co-authoring
translating (product, person)	training	acquisition
monitoring (product, person)	update	feedback
networking (person)	expert search	invitation

Table 6. Overview of knowledge actions

Expressing actions

The informing practice expressing is defined as the self-reflexive conversion of individual knowledge and subjective insights into informational objects (section 2.3). It is also very close to the externalization process which is concerned with the conversion of individual implicit knowledge into explicit knowledge (Nonaka & Takeuchi 1995, 62ff). The two knowledge actions authoring and co-authoring are proposed here that target the generation of documented knowledge.

Authoring. The action authoring describes the individual creation and distribution of documented knowledge in various forms. Examples are the dissemination of ideas or the creation of reports that capture lessons learnt of a project. As a result of this action, the documented knowledge is accessible for other employees in an appropriate format. Related steps can be identified based on a structured publication process described in the literature on CMS and DMS. It consists of steps such as the `creation`, `storage`, `distribution` and `review of contents` as the part of a general content life-cycle (Bach 2000, 76f; Blessing 2001, 100ff; Boiko 2002, 82ff; Christ 2001, 93; Gersdorf 2002, 76; Riempp 2004, 144ff; Walker, Foster & Banthorpe 1997, 75; Zschau, Traub & Zahradka 2002, 54ff). This process concentrates on tasks that can be supported straightforwardly based on CMS or DMS. However, the action authoring is not limited this technical focus. It thus may also include other steps such as so-called integration activities targeted at making information more easily accessible, i.e. `visualize concepts`, `list sources`, `summarize`, `personalize`, `prioritize contents`, `highlight aspects`, `give an overview` and `elicit patterns`, or contextualization activities that provide context for information which improves clarity, i.e. `link content`, `state target`

[32] based on Schultze (2003)

groups, show purpose, describe background, relate to prior information, add meta-information and state limitations (Eppler 2003b, 82f). It may also include the repackaging of contents for different target groups (Maier & Sametinger 2003).

Co-authoring. Co-authoring refers to the joint creation of contents by two or more authors in a mutual and potentially reciprocal process. Technical support of co-authoring is frequently discussed within the CSCW discipline, e.g., related to group editors that should enable synchronous co-authoring (Borghoff & Schlichter 2000, 386ff). The co-authoring process can be described in more detail to consist of multiple interleaved individual writing processes (Borghoff & Schlichter 2000, 384f; Koch 1997, 26ff). Flower & Hayes (1981, 369ff) propose to structure individual authoring processes into the sub-processes planning, i.e. the building of an internal representation of the knowledge that will be used for writing, translating[33], i.e. the transformation of the knowledge into a linear piece of written language, and reviewing, i.e. the planned or unplanned evaluation of the results which may trigger new cycles of planning and translation. On a group level, these local processes join into a global writing process strongly based on shared artefacts and communication between authors (Borghoff & Schlichter 2000, 385f; Koch 1997, 40).

Translating actions

The following two knowledge actions are based on the informing practice translating, which involves the creation of information by ferrying it across different contexts. This includes the transformation of knowledge *from* a different context to the own work context, e.g., a framework created within a project is adapted to suit the case one currently deals with, as well as its translation from the own work context *to* other contexts, e.g., a solution generated is transformed to a template. The former case is focused here in order to emphasize the fact that KWS are not only concerned with the creation of new knowledge from scratch but with the generation of knowledge by means of the application and transformation of existing knowledge. Consequently, the knowledge action training is proposed that describes individual activities of intentional learning. The knowledge action acquisition focuses on the identification and attainment of knowledge for a group of people, which prepares the application of knowledge.

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[33] It should be noted that the authoring process of translating as described by Flower & Hayes (1981, 369ff) is different to the informing practice of translating as described by Schultze (2003).

Training. A challenge that organisations face is the integration of task-oriented daily work with training processes for the goal-directed enhancement of individual skills. More recently, this is discussed under topics such as workplace learning (Eraut & Hirsch 2007; Rothwell 2002), learning in process (Schmidt 2004) or adaptive learning (Wolpers & Grohmann 2005). The process-oriented KM instrument self-directed learning directly addresses this issue (section 2.6). The knowledge action training comprises steps related to formal education but also to informal and problem-driven learning. It may be based on contents that are more or less well-prepared for training, e.g., books, Web-based trainings (WBT), lessons learnt and organisational guidelines, but also on direct interaction with skilled colleagues. Ultimately, this action results in an enhancement of individual skills. Rothwell (2002, 74ff) structures the process of workplace learning into the following steps: `recognize importance for learning`, `experience curiosity`, `seek information`, `process information`, `internalise information`, `apply knowledge`, `reflect on what has been learnt` and `reflect on the learning process`.[34] This action may also include steps that are described in relation to a formal human resource development process such as `competency diagnosis & review`, `skill gap analysis`, `planning of development measures` and `assessment of learning effects` (Kunzmann & Schmidt 2006).

Acquisition. Collaboration as an important part of learning is emphasized by activity theory in general and by didactic approaches such as problem-based learning and collaborative learning in particular (Kienle 2003, 42ff; Zumbach 2003). The knowledge action acquisition describes one aspect of collaborative learning: making available a knowledge resource for a group of people, e.g., the members of a project or of an organisation. As a result of this action, external expertise in the form of documented knowledge or the knowledge of experts is made available for others. Maier & Sametinger (2004) describe acquisition as the access of an external source and its integration into electronic workspaces. This might be preceded by a more or less structured search for appropriate resources. For a focused search, the user needs to be able to clearly describe the problem he deals with and ways to solve it (Belkin, Oddy & Brooks 1982, 62). This is not always possible which leads to alternative search modes. An important example of a more explorative search mode is `browsing`, i.e. a process of retrieving information whose main objectives are not clearly defined in the beginning and whose

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[34] The step `experience triggering circumstance` at the very beginning of this process has been left out as it relates to occasions that trigger workplace learning (section 3.4.2)

purpose might change during the interaction with a system (Baeza-Yates & Ribeiro-Neto 1999, 4; Ellis 1993, 482; 1997, 398). Ellis (1997, 396) characterizes it as "… following chains of different forms of referential connection between sources to identify new sources of information." It is paralleled by a process of formulation, i.e. the gradual specification of the information needed and the focusing of the search (Kuhlthau 1991, 367). Acquisition may also involve activities such as `extracting`, i.e. working through sources to locate material of interest, and `verifying`, i.e. checking the accuracy of information (Ellis 1997, 395ff).

Monitoring actions

The informing practice monitoring has been defined as the continuous non-focused scanning of the environment and the gathering of useful "just in case"-information. This is directly reflected by the knowledge action update. On the level of groups, the action feedback is proposed that deals with the giving of feedback in order to enhance of knowledge.

Update. The knowledge action update comprises the scanning of the environment for relevant subjects which is followed by the collection of significant knowledge. Monitoring is described to be "… characterized by activities involved in maintaining awareness of developments and technologies in a field through regularly following particular sources" (Ellis 1997, 396f). Examples are the regular observation of newspapers, scientific journals and topic-related Web portals which may be followed by the storage of electronic contents within a personal workspace or on the local hard disk. As a result of this action, documented knowledge is instantly available and experts for a topic have been identified. The knowledge action monitoring does not only comprise the active scanning of the environment but also passive modes of search as identified in the context of research on information seeking behaviour. It is distinguished between, e.g., `passive attention` and `passive search` versus `active search` and `ongoing search` (Wilson 1999b) or `non-directed monitoring` versus `active scanning` and `active seeking` (McKenzie 2003, 25ff). `Non-directed monitoring` for example involves serendipitously encountering and recognizing a source in an unlikely place while not seeking information at all or while monitoring information sources with no intend other than to become generally informed (McKenzie 2003, 26f).

Feedback. The knowledge action feedback is concerned with the enhancement of knowledge. It describes the evaluation of documented knowledge or of skills followed by the provision of feedback and the accomplishment of steps for the improvement of knowledge quality. Giving feedback may involve direct communication with authors or is provided more indirectly, e.g., by citing a source (Maier 2004, 294). It is a critical activity of workplace learning and can be distinguished into short-term, task-specific feedback and long-term, more strategic feedback (Eraut & Hirsch 2007, 29). Examples for this action are the recognition of a mistake within a document followed by its annotation or the forwarding of comments to an author. Eppler (2003b, 82f) lists a set of validation activities that aim at analyzing the correctness and consistency of information and thus may be part of the knowledge action feedback: `evaluate source`, `indicate level of certitude/reliability`, `describe rationale`, `compare sources`, `examine hidden interests/background` and `check consistency`. It also may involve the `review` step that might have to be conducted before contents can are published or forwarded to a customer (Riempp 2004, 149). The action also includes steps undertaken for the ongoing maintenance of electronic contents such as the `evaluation of contents`, `formulation of maintenance needs` and `forwarding of maintenance requirements` (Christ 2001, 117f).

Networking actions

The practice of networking describes the building and the role of relationships with people inside and outside the organisation and thus highlights the relevance of social capital. The knowledge action expert search on individual level focuses on the building of individual relationships with experts in a specific domain. The action invitation on group level describes the mobilization of new and existing members to participate the activities of a group. In contrast to the former knowledge actions, both are primarily focused on knowledge bound to individuals.

Expert search. The knowledge action expert search comprises the identification of and communication with individuals that are knowledgeable within a particular domain. Its relevance is also highlighted by the KM instrument expert advice (section 2.6). Examples are the discussion with a colleague who has already gathered experiences related to a problem at hand or the consultation of external experts such as technical consultants. As a result, the competence of another individual is made available, e.g., in order to solve a problem. This action is noted as a generic activity of workplace learning as it is important for developing a network of knowledge resource people (Eraut & Hirsch 2007, 28). This knowledge action can be detailed based on the person-oriented KM instrument competence management, which may include the application of a skill management system that supports the easy identification of experts within an organisation (section 2.4). Relevant in this context are particularly those steps related to competency profiles, i.e. the `creation`, `approval`, `update`, `storage` and `use of competency profiles` as well as the `evaluation and measurement of individual skills` (Bach 2000, 72; Beck 2005, 150ff; Riempp 2004, 154f). However, the action expert search is not limited to the use of a dedicated skill management system. It may also involve communication with colleagues in order to get hints for the localisation of people with the right skills as well as the browsing of the Intranet or Internet. It may also include so-called activation activities conducted to increase the likelihood that information is acted upon such as `notify and alert`, `demonstrate steps`, `ask questions`, `use mnemonics`, `metaphors and storytelling`, `stress consequences`, `provide examples` and `offer interaction` (Eppler 2003b, 82f).

Invitation. The knowledge action invitation is motivated by the relevance of supporting community or network management processes for KM which is addressed, e.g., by the KM instrument communities (section 2.6). It describes the activation of members to join the activities of a larger group that is concerned with the development of knowledge within an area related to the organisational core competencies. An example is the invitation of individuals to a talk on a specific work-related topic. Informal groups are particularly relevant in this context though they cannot always be separated clearly from more formal organisational initiatives or projects. Maier & Sametinger (2004) explicitly refer to a community or network management process that includes the identification, foundation of and participation in Communities of Interest. The action invitation can be detailed by the steps described by Riempp (2004, 162) as part of a community initiation process, i.e. `assignment of roles`, `identification of potential participants`, `arrangement of a virtual environment`, `adjustment of access privileges`, `invitation of members` and `preparation of meetings`. The action invitation may be most important during the initial stages of the development of a community, e.g., during the so-called stage “potential” where members try to find a common ground and attempt to discover people with similar problems as well as the stage “coalescing” where the community is launched by hosting events and motivating members to participate (Wenger, McDermott & Snyder 2002, 65ff).

3.5 Summary

Within this chapter, a situation-oriented concept has been developed in order to integrate a task-oriented and a learning-oriented perspective on knowledge work. This chapter started out with the distinction between the two basic KM orientations of knowledge exploitation and knowledge exploration. Based on this, a task-oriented and a learning-oriented perspective on knowledge work have been identified and contrasted. The foundations of activity theory have been described as it is suited well to describe and analyse the learning-oriented aspects of knowledge work. The first part of this chapter has come to the conclusion that PKM requires new concepts for the integration of these two perspectives. A situation-oriented approach has been suggested for this task.

Several characteristics of situation-oriented approaches have been reviewed, i.e. the distinction between objective and subjective situation, the problem of the delimitation of relevant and irrelevant context information, the differentiation between deliberate and routine behaviour, the application of the concept of fit as well as the applicability of the situation concept on individual and on group level. This represented a foundation for the subsequent definition of the KWS concept. The components of KWS have been discussed in detail which resulted in suggestions for their classification. More specifically, it has been proposed to distinguish task-oriented and learning-oriented occasions and to describe the context based on the six dimensions product, process, person, productivity tool, time and location and to characterize it based on the categories source, electronic access, change rate, protection, generalisation and reliability. A framework for the classification of knowledge actions has been created based on the mode of knowledge actions and the distinction between individual and group level. For each category, a knowledge action has been proposed and concretised, in detail the actions authoring, co-authoring, training, acquisition, monitoring, feedback, expert search and invitation. Table 7 summarizes the steps used to characterize the knowledge actions proposed.

mode	individual level	group level
expressing	**authoring** *publication process*: creation, storage, distribution, review of contents; *integration activities*: visualize concepts, list sources, summarize, personalize, prioritize contents, highlight aspects, give an overview, elicit patterns; *contextualization activities*: link content, state target groups, show purpose, describe background, relate to prior information, add meta-information, state limitations; repackaging of knowledge	**co-authoring** *global writing process*: planning, translating and reviewing based on shared artefacts and communication between authors
translating	**training** *workplace learning*: recognize importance for learning, experience curiosity, seek information, process information, internalise information, apply knowledge, reflect on what has been learnt, reflect on the learning process; *HRM development process*: competency diagnosis & review, skill gap analysis, planning of development measures and assessment of learning effects	**acquisition** access of an external source and its integration into electronic workspaces; *information retrieval*: browsing, extracting, verifying
monitoring	**update** *information seeking behaviour*: passive attention, passive search, active search, ongoing search; or: non-directed monitoring, active scanning, active seeking	**feedback** *validation activities*: evaluate source, indicate level of certitude/reliability, describe rationale, compare sources, examine hidden interests/background and check consistency; *maintenance of electronic contents:* evaluation of contents, formulation of maintenance needs, forwarding of maintenance requirements
networking	**expert search** *maintenance of competency profiles*: creation, approval, update, storage and use of competency profiles, evaluation and measurement of individual skills; *activation activities*: notify and alert, demonstrate steps, ask questions, use mnemonics, metaphors and storytelling, stress consequences, provide examples, offer interaction	**invitation** *community initiation*: assignment of roles, identification of potential participants, arrangement of a virtual environment, adjustment of access privileges, invitation of members, preparation of meetings

Table 7. Overview of steps used to characterize knowledge actions

4 Modelling knowledge work

This chapter deals with the description of knowledge work in the context of business processes by means of modelling languages. While the previous part focused on the conceptual level, the following sections are concerned with the level of *models*. During the last years, a number of approaches have been proposed for knowledge-oriented modelling of business processes. Goal of this chapter is to review the state-of-the-art of these approaches in order to analyse the way how knowledge work is conceptualized. The focus is on the concepts of description applied and their relationships.

4.1 Overview

Figure 17 depicts an overview of this chapter. Firstly, foundations of modelling are summarized and models applied in the context of MIS are classified (section 4.2). Then, goals and perspectives of modelling in KM are outlined (section 4.3). These two sections pave the ground for the definition of a set of criteria suited to evaluate the quality of selected modelling approaches (section 4.4). Each modelling approach is presented in more detail (section 4.5) and afterwards all approaches are compared based on the criteria defined (section 4.6). The chapter closes with a summary of results (section 4.7).

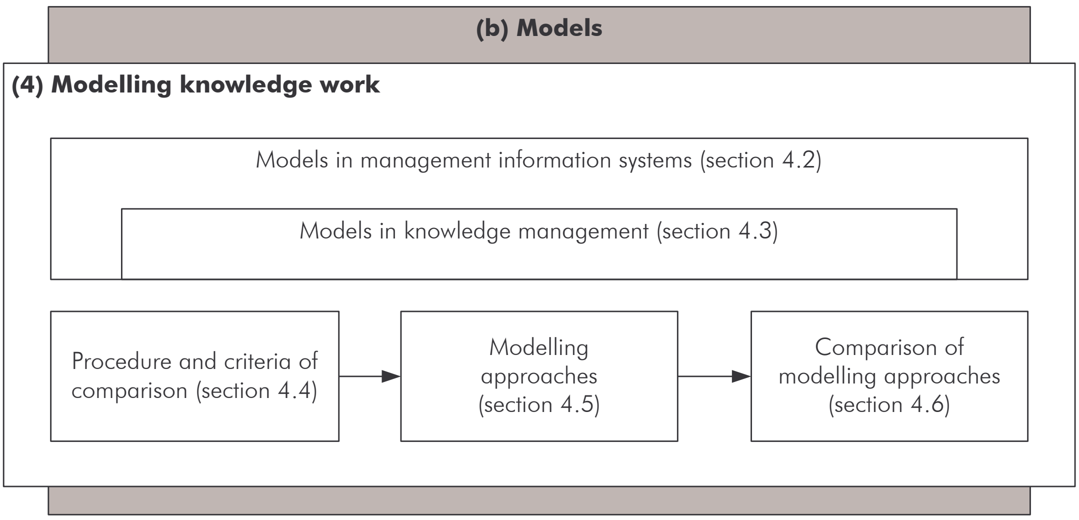

Figure 17. Overview of the chapter *Modelling knowledge work*

4.2 Models in management information systems

Models are an important instrument applied in within the MIS discipline with various goals and during different phases of systems design.[35] The term model is used widely and sometimes ambiguously in order to denote, e.g., the business logic of a firm (business model), the behaviour of a system by means of a mathematical language (mathematical model), cognitive representations of ideas (mental model), behavioural examples for other people (role model) or downscaled physical representations of things (physical model) (Lehner, Maier & Hildebrand 1995, 83). This section firstly discusses the definition of the term model, shortly summarizes the foundations of modelling languages and then outlines selected categorizations of models used in MIS.

Models and modelling

A model is defined as a goal-oriented, simplified representation of a portion of the perceived reality (Heinrich & Roithmayr 1989, 324f; Lehner, Maier & Hildebrand 1995, 27). It comprises a source system that is mapped to a target system based on defined mapping rules (Ferstl & Sinz 2001, 18). A system is a set characterized by its elements and their properties as well as the relationships between these elements and properties (Ferstl & Sinz 2001, 11; Stachowiak 1965, 438). In a business context, the source system is a part of an organisational system. Models are used in order to reduce complexity and to focus on only the relevant facts, e.g., by the highlighting and the contrasting of elements (Stachowiak 1965, 443). Goal-orientation as part of the definition of the term model emphasises that models are about understanding, change, management and control of a part of reality (Pidd 1996, 15). Modelling consequently is defined as the creation of models in order to describe, explain or design phenomena of reality (Fink, Schneidereit & Voß 2005). A model includes only those parts of a natural or artificial system that are judged to be relevant by its creators (Stachowiak 1965, 438), which involves abstraction: parts of reality are left out or simplified and concrete circumstances are classified into broader categories and types (Fink, Schneidereit & Voß 2005, 91). In a strict sense, the correct interpretation of models thus is restricted to a limited set of subjects, defined cognitive or real operations and bounded periods of time (Stachowiak 1965, 438).

[35] The role of conceptual modelling in the German-speaking countries can be assumed to be more dominant since here, the MIS discipline (in German: "Wirtschaftsinformatik") is more strongly concerned with the design and construction of software systems. The Anglo-American IS discipline in contrast focuses on the empirical investigation of socio-technical phenomena (Lange 2005; Schauer & Frank 2007).

Essential feature of models is the similarity between source and target systems. A correct representation of models requires structural and behavioural similarity (Ferstl & Sinz 2001, 18f). *Structural similarity* refers to the correct representation of the original's structure (Ferstl & Sinz 2001, 18f; Stachowiak 1965, 440ff). "Correct" in this context means that mappings between original structure and model structure are homomorphous. Isomorphic models are characterized by maximum similarity that is achieved if mappings between model and original are bijective. *Behavioural similarity* refers to homomorphous mappings between the behaviour of the original and the model.

Models are defined as representations of a portion of reality, but different opinions exist concerning the question whether this representation can be objective (Lehner, Maier & Hildebrand 1995, 29f). These views differ mainly with regard to their stance towards the ontological question, i.e. what the nature and form of reality is, and the epistemological question, i.e. how the relationship is characterized between the knower and what can be known (section 2.2). The *theory of reproduction and correspondence* assumes that the arrangement of objects in reality and their characteristics is reproduced by human thinking, terms, symbols and thus also by models. Mismatches and errors principally can be discovered and corrected. Modelling in this view is the continuous process of refinement and approximation of models towards the structure of an objective reality. This reflects ideas of post-positivism: an objective reality exists (ontological question) and with a certain probability is reflected by models (epistemological question). *Discourse theory* on the other hand is motivated by constructivism and puts the existence of an objective reality or respectively whether it is observable into question (Lehner, Maier & Hildebrand 1995, 30). It assumes that reality is gradually constructed by means of discourses (Floyd 1989, 7). Language and also models as the foundation of any discourse play a constitutional role. Models thus cannot be "true" or "correct" as they are not viewed to reflect an objective reality. Rather, they can be "adequate", i.e. they reflect a consensus about reality and are a means for debate about it (Checkland 1999, A21). This view emphasizes the role of models as a means for the communication between people, e.g., the collaboration between initiators, developers and users of an application system (Lehner, Maier & Hildebrand 1995, 29).

These two views on models are based on normative assumptions about reality and the relationship between observer (or modeller) and reality. They principally cannot be falsified or supported by means of scientific methods (Weik & Lang 2001). Concerning software systems development, this work adopts the stance of discourse theory. The reason is that in MIS, analysis and design of systems are characterized by a continuous need for the negotiation and alignment of differing perspectives rather than being a linear production process based on objective requirements and goals (Floyd 1989). This is also reflected by the definition of the term model that explicitly includes goal-orientation. One could argue that this stance conflicts with the commitment of this work to critical rationalism (section 2.2). However, the types of models relevant here are regarded to primarily reflect local realities that are to be communicated rather than they incorporate scientific theories. In some regards, this reflects a pragmatic view on models.

Modelling language

Language and models are tightly interlinked: Models on the one hand are defined based on a modelling language and on the other hand they define a language (Lehner, Maier & Hildebrand 1995, 81). The definition of a modelling language can be viewed as process of language standardization (Lehner, Maier & Hildebrand 1995, 83f). Standardized languages and forms of presentation are fundamental for many disciplines, especially for those that deal with engineering (Lehner, Maier & Hildebrand 1995, 84). They ease understanding and communication, accelerate learning processes and allow for greater efficiency, e.g., through enabling reuse of solutions. Standardization can be accomplished on various levels, from single symbols and terms up to modules, components, procedures or patterns.

Models ultimately are a linguistic construct (Frank & van Laak 2003, 20). A modelling language is an artificial language formalized by a grammar. A grammar concerns rules that govern the use of a language and is subject of the general study of language called linguistics. Linguistics amongst others comprises phonetics, i.e. the study of physical production and perception of speech, phonology, i.e. the study of the function of sounds within a language and morphology, i.e. the study of basic forms in language and especially of word structure (Yule 2006).

The linguistic fields syntax, sigmatics, semantics and pragmatics are particularly relevant for modelling (section 2.2). The *syntax* defines the constructs of a language and the valid relations between them. The definition of the concrete appearance of symbols that represent a modelling language is within the concern of *sigmatics*. It deals with the meaning of signs and visual expressions and how they convey information. These symbols are also referred to as concrete syntax or notation of a modelling language (Frank & van Laak 2003, 20). Notations are explicit agreements about possible means of expression and representation. A modelling language has only one abstract syntax but can have multiple different notations. *Semantics* deals with the meaning assigned to a language and may complement the syntax by marking syntactically correct combinations as semantically incorrect. *Pragmatics* is concerned with meaning of language, which is influenced by its context. The interpretation of models thus is influenced strongly by the context of their creation and application.

Syntax and semantics are described by means of so-called meta-models (Ferstl & Sinz 2001, 121ff; Fink, Schneidereit & Voß 2005, 93). They represent a special class of models applied for the reflection about and the definition of modelling languages (Lehner, Maier & Hildebrand 1995, 39). They formalize the grammar of a modelling language by defining available types of modelling elements, possible types of relations between them as well as the semantics of elements and their relationships. Thus, they are an important foundation for correct interpretation of models as well as for the evaluation of models, e.g., concerning the consistency and completeness of a model compared to the meta-model (Frank 1994, 13). A meta-model may also include a description of modelling procedures (Fink, Schneidereit & Voß 2005, 93). They also can support the translation of one model type into another, e.g., of conceptual models into implementation models (Frank 1994, 13). Meta-models will be used in the context of this work in order to summarize and analyse the concepts included within each of the modelling approaches discussed.

Types of models applied in MIS

MIS is an interdisciplinary field where a large variety of model types is applied. Modelling is a key task and a foundation for description, analysis, understanding and design of organisational and of IS. Examples for widely applied types of models are (Lehner, Maier & Hildebrand 1995, 85ff): (1) life-cycle and procedure models, e.g., the software engineering procedure model V-model XT (KBSt_BRD 2005) or the Capability Maturity Model (Thaller 1993), (2) business-oriented models, e.g., business process models such as IDEF3 diagrams (Mayer et al. 1995) or comprehensive enterprise models such as MEMO (Frank 1994), (3) system engineering-oriented models, e.g., the entity relationship model for data modelling (Chen 1976) or class diagrams based on UML in software development (OMG 2006), and (4) communication models and person-oriented models, e.g., the communication transmission model (Shannon & Weaver 1949) or user models (Mertens & Höhl 1999). In the context of this work, particularly business-oriented models are important. However, since it deals with an extended, knowledge-oriented description of business processes as well as with the systematic design of IS, other types of models may also become relevant (section 4.3).

Models and modelling languages may be part of a more comprehensive modelling approach. A modelling approach is a set of modelling language, modelling tools and methodological guidelines such as a procedure model (Amberg 1999). The following part provides an overview of the most important aspects that are used to distinguish modelling approaches: primary goal of modelling, format of representation, degree of formalization, implementation level, level of abstraction and tool support. There are other criteria but they are not relevant here, e.g., procedure of modelling, degree of completeness, timeliness or dependence on time, degree of realism, deterministic vs. stochastic models, intangible vs. physical models, way of application of models or target groups (Lehner, Maier & Hildebrand 1995, 40f).

Primary goal of modelling. Models can be distinguished based on whether they target description, prescription or explanation (Lehner, Maier & Hildebrand 1995, 36ff). *Descriptive models* indicate the current state of a system. Examples are charts of the existing organisational structure or models that show the current sequence of functions in business processes. *Prescriptive models* define a desired state. Therefore, they need to include all aspects relevant to fulfil specific requirements or tasks of design and implementation. Examples are decision and planning models. *Explanation-oriented models* describe cause-and-effect relationships and can be applied for making forecasts. In the context of this work, only the first two types of models are relevant. Descriptive models can become prescriptive when they are changed to represent a future state. In the context of business process enhancement or systems design for example, descriptive business process models are used as a first step for analysis and then are changed to prescribe a desired state.

Format of representation. There are manifold alternatives to represent or describe models. Examples for common forms of representation are natural language, formalized notations such as mathematical formulas and abstract-symbolic or descriptive-iconic symbols (Lehner, Maier & Hildebrand 1995, 40). In the context of requirements engineering, systems design and process modelling, abstract diagrammatic representations are most widely applied (Herrmann et al. 2000). Visualisation may contribute to a better understanding which is surely a reason for the widespread use of visual diagrams (Frank 1999, 6). Diagrams may be complemented by additional data, e.g., time and costs required to accomplish a process function. This is especially relevant when models are transformed into alternative ways of representation and for simulation purposes.

Degree of formalization. Three general degrees of formalization of a modelling language are distinguished (Frank & van Laak 2003, 20f): formal, semi-formal and informal. *Formal languages* have a clearly delimited set of constructs and a well-defined semantics. The correct application is ensured by syntactic and if necessary supplementary semantic rules. *Semi-formal modelling languages* have an accurately defined set of constructs, an at least partly defined syntax but only a rudimentary specified semantics. An *informal language* only provides a set of constructs with no explicitly determined syntax and semantics. Semi-formal or informal modelling languages leave more space for interpretation and are suggested to facilitate the negotiation of opinions for the design IS, e.g., by explicitly representing vagueness, incompleteness and contradictions (Herrmann et al. 2000).

Implementation level. An important role of models in MIS is to guide the implementation of software. They are thus classified according to their relation to implementation, referring to three stages of software development, also called levels of implementation: conceptual models, design specification models and implementation models (Fink, Schneidereit & Voß 2005, 96; Scheer 2002, 39ff). *Conceptual models* structure organisational aspects and focus on the application and use of IS. They ideally provide concepts that are well-established in the respective application areas and are easily comprehensible by system users (Frank 1994, 13). *Design specification models* specify a technical solution but are still independent of the concrete technological implementation. *Implementation* models are used to specify the actual implementation of an application system.

Models should support the integration of software life-cycle phases by using similar or the same constructs, by offering possibilities for stepwise formalization and refinement and by avoiding inconsistent transitions between phases (Frank 1994, 76ff). Ideally, it is possible to transform one model type automatically into another, e.g., a conceptual data model into physical data model. This mirrors the stepwise refinement of the specification of a software system, which currently is promoted under the topic of model-driven architecture (OMG 2003). Models then are not only a tool used during build-time, but rather represent a specification applied during the run-time of a system.

Level of abstraction. Three general levels of model abstraction are distinguished: instance level, type level and meta level (Frank & van Laak 2003, 35ff). An *instance level* model describes concrete occurrences of types. A *type level* model describes categories of elements characterized by a selected set of properties. Meta level models or short: meta-models as described above define the elements, characteristics and relationships of a modelling language. In a strict sense, creation of instance-level models is not a matter of conceptual modelling because explicit goals of a conceptual model is the abstraction from those parts of reality that underlie foreseeable changes and to distillation of similarities (Frank & van Laak 2003, 39). Abstraction is not limited to these three levels. The number of levels rather depends on the concepts considered and the goal of modelling. For example, a language for the description of meta-models can be defined with a meta-meta-model.

Tool support. Many modelling approaches are supported by a software tool. This can be regarded as a pre-condition for modelling to be economically feasible (section 2.5). Main functions of modelling tools are enhanced support of visual design, e.g., by evaluation of correct syntactic relationships during modelling, support of analysis and simulation, e.g., by offering graphical animation, as well as support of tasks for managing models, e.g., by providing functions for access, selection, retrieval and deletion of multiple potentially interrelated models (Gastinger & Szegheo 2000; Remus 2002b, 249ff). Modelling tools should support multi-user access, technical interfaces, e.g., for other simulation or monitoring applications and ideally script languages for automating manipulation tasks (Rosemann, Schwegmann & Delfmann 2002, 92ff). Type, maturity and costs of modelling tools may differ significantly from freely available scientific prototypes, e.g., the SeeMe modelling tool[36], to professional products that are sold at comparably high prices, e.g., the ARIS platform[37].

4.3 Models in knowledge management

As can be seen, there is a large variety of models applied even when focusing just on MIS. One reason is that modelling in this context is not only related to the task of designing and introducing MIS, but also supports enterprise planning and decision or design tasks (Fink, Schneidereit & Voß 2005, 91). General goal of process modelling and thus also of modelling in the context of PKM is the enhancement of the efficiency of business processes by supporting process redesign, innovation and optimization (Rosemann, Schwegmann & Delfmann

[36] URL: http://web-imtm.iaw.ruhr-uni-bochum.de/iug/projekte/seeme/inhalt/index.html, last accessed: 2007-12-02

[37] URL: http://www.aris.com, last accessed: 2007-12-02

2002, 53ff). Typical concrete goals of process modelling are the capturing of process knowledge, the enhancement of the transparency of business processes, the support of standardization and certification, the safeguarding of the correct attribution of economic values, utilities and costs, the simulation of processes and last but not least the process-oriented design of IS (Becker, Kugeler & Rosemann 2002; Rosenkranz 2006, 16f; Scheer, Jost & Wagner 2005).

Common goals of modelling in the context of PKM are related to (1) *description*, i.e. representation of knowledge-intensive business processes, creation of knowledge maps, capturing and managing process knowledge in process warehouses, (2) *analysis*, i.e. discovery of challenges or problems as well as potentials for knowledge-oriented improvements, e.g., by analysing knowledge creation and application within business processes or knowledge flows, (3) *knowledge process redesign*, i.e. analysis and enhancement of knowledge-intensive business processes or of knowledge processes (section 2.6), (4) *structuring of KM interventions* on different intervention levels such as strategy, organisation, process and knowledge base, e.g., in order to support KM initiatives during introduction of KM instruments, and (5) *design of technical infrastructures* that should enhance the productivity of knowledge work (Allweyer 1998; Davenport, Jarvenpaa & Beers 1996; Remus 2002a, 114; 2002b, 207ff; Rosenkranz 2006, 16ff).

Modelling perspectives

Enterprise models are an important instrument for the design and introduction of corporate IS that are in line with an enterprise's strategy and organisation (Fink, Schneidereit & Voß 2005, 94). Enterprise modelling methods integrate multiple perspectives on an organisation in order to overcome the isolated observation of only one perspective, e.g., that on data structures or on software architecture. Perspectives are a means to integrate differing perceptions, views and priorities and also help to overcome language barriers (Frank 1994, 162; 2002, 2). They can be defined as sets of assumptions that are based on a shared view and concern aspects of reality deemed relevant in a particular context (Lehner, Maier & Hildebrand 1995, 31). The integration of perspectives should be supported modelling approaches, particularly by the establishment of relationships between elements over different perspectives. A perspective is represented by one or multiple model types. Prominent examples for enterprise modelling methods are ARIS (Scheer 1992), IEM (Mertins & Jochem 2000), UML (OMG 2006) and MEMO (Frank 1994).

Remus (2002b, 26ff) based on a comparison of PKM approaches identifies six possible intervention levels that can be used to identify modelling perspectives relevant for PKM: (1) *Goals and strategy*, i.e. the definition of KM goals and the formulation of a KM strategy, (2) *organisation*, i.e. the design of a formal organisational structure described by tasks, processes, roles or projects, (3) *themes and topics*, i.e. the structuring of documented knowledge with the help of taxonomies, knowledge structures or ontologies, (4) *instruments and systems*, i.e. the implementation of an organisational and technological infrastructure that enhances the productivity of knowledge work, (5) *participants and communities*, i.e. the design of measures related to human resource management (HRM) such as the creation of suitable incentives for the sharing of knowledge as well as the establishment of communities, and (6) *culture*, i.e. the establishment of a culture that fosters knowledge sharing.

Goals and strategy as well as the organisational culture represent an important context of initiatives targeting the design of a technical infrastructure for KM, which also is the concern of this work. However, this context is not changed or addressed explicitly during systems design and thus is not primarily relevant for modelling in KM. The remaining intervention levels are used as a foundation for the definition of four perspectives of modelling in KM depicted in Figure 18 (Hädrich & Maier 2004; Maier 2004, 199f; Remus 2002b, 216ff). They represent a suitable framework for judging whether all relevant aspects are taken into account by a modelling approach.

The *process perspective* highlights the relevancy of business processes for PKM. It comprises concepts suited to describe knowledge-intensive business processes, knowledge actions and also knowledge processes. It is an important means for the definition of tasks and processes of KM and thus corresponds to the organisational intervention level. The *product perspective* models the structure of documented knowledge, e.g., topics, relationships between topics or types of information. It can be formalized by means of taxonomies or ontologies. The *person perspective* focuses the organisational intervention level and includes concepts suited describe the formal organisational units or roles as well as a more informal structures represented by, e.g., different types of links between individuals such as communication or advice relationships. The intervention of PKM on a systems level requires the specification of the technological infrastructure, e.g., the architecture and interaction of software tools applied in the context of KM and particularly the services they offer. This is described by the *productivity tool perspective*. These four perspectives are also designed to reflect the three media of knowledge, i.e. product, process and person (section 2.2) together with the technological infrastructure used to support them.

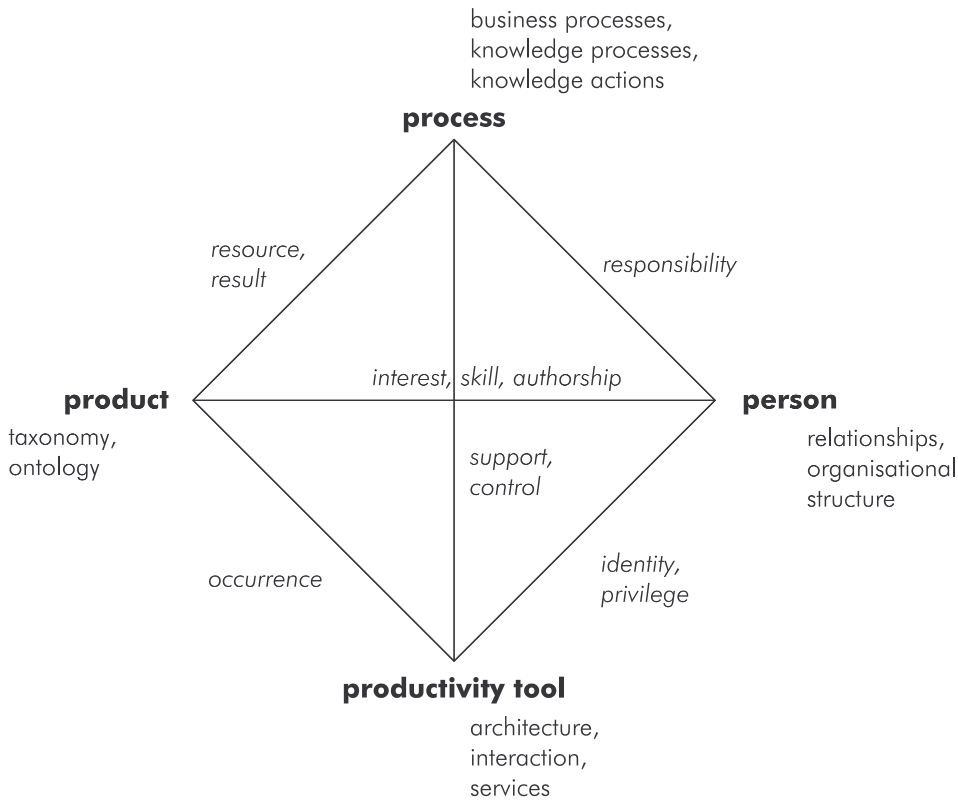

Figure 18. Perspectives for modelling in KM[38]

Each perspective is interrelated with the other perspectives by different types of relationships. They describe important aspects for KM and represent starting points for the integration of perspectives.[39] People are responsible for tasks within processes. They have interests and skills in areas further specified by knowledge structures and are authors or users of knowledge products. Furthermore, they have identities represented in software tools and defined privileges for their access. Knowledge products are the resource for or the result of business processes. The structure of knowledge described in the product perspective can be used in order to refer to electronic contents that occur in various productivity tools. Productivity tools may support tasks in business processes or coordinate them, e.g., by the definition of workflows.

[38] based on Maier (2004, 199)

[39] The following types of relationships reflect only the most important ones and should be taken as exemplary. Further types will be named during the description of the modelling approaches (section 4.5) and identified as a result of the empirical study in relation to the investigation of the KWS context (section 7.5.1).

4.4 Procedure and criteria of comparison

This section firstly outlines the procedure of the selection and analysis of modelling approaches. Afterwards, it develops a set of criteria that are suited for their comparison. This comprises KM-oriented criteria that can be derived from the foundations outlined in section 4.2 and section 4.3 as well as criteria related to the quality of models. This is a subject not discussed so far and thus it will be outlined first before an overview of the complete set of criteria is presented.

Procedure

Frank (1998) argues that evaluations of modelling languages need to take the perspectives of their users into account and that clear roles and tasks need to be defined they are valid for. He criticises that many evaluation attempts too strongly reflect individual preferences of the evaluators and thus remain unsatisfactory. As stated, the goal of this work in relation to the modelling level is to investigate and compare modelling languages with regard to the concepts they propose for a knowledge-oriented description and design of business processes. The task that the models should serve is the design of technical infrastructures to support knowledge work in business processes. Though criteria from the area of quality of models are applied, it is not the goal to comprehensively judge the quality of modelling languages. This work is primarily interested in the concepts proposed for modelling and does not strive for the identification of a modelling approach that is superior to all others.

The approaches to be analysed and compared were identified based on a literature review and a Web survey which took into account sources in English and German language. To be included in the analysis and comparison, an approach needs to have an explicit relation to business process modelling and KM. This excludes all contributions that describe selected aspects of knowledge work without an explicit relation to business processes. For example, Spinuzzi et al. (2003; 2004) conceptualize knowledge work by means of communication-event and genre ecology models that graphically represent the flow of communication events but do not include a business process perspective. Technical support of KM needs at least generally be taken into account though it is not required to represent the main focus. Advantages and disadvantages are best identified when a modelling approach is practically applied, i.e. if models are created in the context of practical projects or at least based on exemplary cases. A further prerequisite for the inclusion thus is the availability of sufficient documentation that allows the analysis and application of an approach. Many approaches are supported by a specialized modelling tool. Tool support is not a prerequisite, but where possible, this modelling tool was obtained and applied. As this work is primarily concerned with the concepts included and not with the general quality of models, those approaches are also included that do not define a modelling notation on their own but at least a meta-model or framework that structures the concepts regarded relevant. This resulted in the inclusion of the approaches ARIS-KM, GPO-WM, KMDL, Knowledge Modelling, PROMOTE, PROMET I-NET and the Reference Model for KM that are described in detail in the next section (section 4.5).

In order to become closely acquainted with the modelling approaches, ARIS-KM, GPO-WM, KMDL and PROMOTE were utilized in student modelling projects in master-level courses on KM during the summer terms 2004 and 2005 at the Martin-Luther-University of Halle-Wittenberg, Halle (Saale), Germany. The students received an introduction on the modelling approaches and access to the documentation of an approach. During the modelling projects that had to be accomplished over a four-week period, they had the task to apply at least two modelling approaches to a case example selected by the author and to compare these approaches with regard to their advantages and disadvantages. ARIS-KM and PROMOTE were applied based on their specialized modelling tools that were made accessible for the students in a university computer laboratory.[40] For GPO-WM and KMDL, the graphical editor Microsoft Visio was used based on a set of so-called shapes that implement the notation due to the lack of an available modelling tool. Knowledge Modelling, PROMET I-NET and the Reference Model for KM do not define a modelling language and thus could not be investigated during these projects. The insights gained are incorporated within the description and evaluation of the approaches (sections 4.5 and 4.6).

Quality of models

Quality can be understood as the total of "… the characteristics of a product or service that bear on its ability to satisfy stated or implied needs … or a product or service free of deficiencies" (Summers 2005, 386). Judging the quality of something thus needs to take its pur-

[40] The author wishes to thank Dr. Hubert Woitsch from BOC GmbH, Austria and Prof. Dr. Dimitris Karagiannis, University of Vienna, Austria for kindly making available the modelling tool ADONIS together with the latest version of the modelling language PROMOTE.

pose into account as it determines the needs to be satisfied. In this regard, quality is "fitness for use" (ibid.). A comprehensive evaluation of model quality thus requires looking at the purposes models are targeted to serve, the people who create them and who is supposed to use them (Frank 1998, 16). Some authors conclude that the validation of models in the sense of a comprehensive demonstration that a model is fully correct is impossible at all (Pidd 1996, 318).

Frank (1998) criticises the tendency of common evaluations and comparisons of modelling languages for imposing the subjective view of the authors on model quality. He suggests a multi-perspective framework as a foundation for a reasonable evaluation process that takes multiple roles and perspectives of the participants involved into account. On the one hand, the models themselves, their applicability and the language they are based on need to be investigated (Hommes & van Reijswoud 2000, 2). On the other hand, they are the product of a modelling process that also needs to be considered, e.g., by analysing the procedure of modelling and how it fits the specifics of the application context. The evaluation thus ideally should be conducted in the context of practice, e.g., by means of structured discourses within an action research approach (Baskerville & Myers 2004), taking creation, review and refinement of models and particularly the diverse perspectives of users and roles involved into account (Frank 1998).

Lindland et al. (1994) present a general framework that structures the dimensions and properties of quality of conceptual models as a foundation for the assessment of models. It takes both, the models and the process of modelling into account and consists of four cornerstones (Figure 19): The *language* consists of all statements that can be made according to the syntax of the language, i.e. alphabet and grammar. *Domain* represents the relevant knowledge for solving a problem and consists of all statements that would be correct and relevant in this context. *Model* represents the set of statements actually made. *Audience* includes everyone who needs to understand the model. *Audience interpretation* is the set of statements that the audience thinks the model contains.

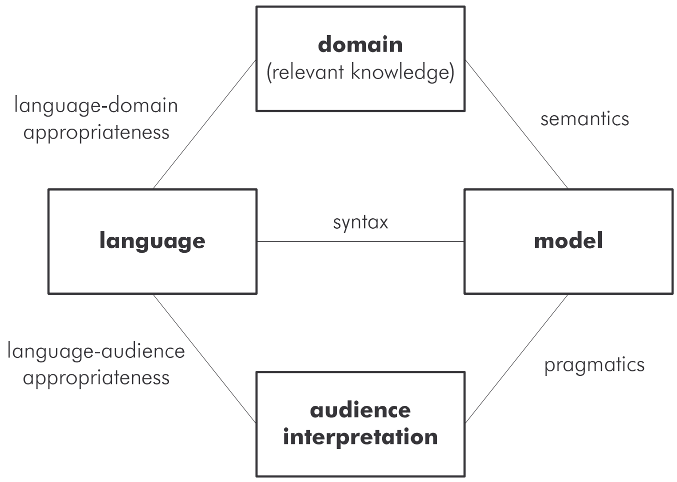

Figure 19. Framework for the quality of conceptual models[41]

The quality of models not only concerns the cornerstones themselves but particularly the relations between them. *Syntactic quality* refers to the extent that models adhere to language rules. *Semantic quality* describes how well models correspond to the domain, i.e. how correct and relevant model statements are regarding the problems to be solved. *Pragmatic quality* refers to the degree the model supports the correct audience interpretation, i.e. how good it expresses meaning. The *language-domain appropriateness* is the extent to which the language supports making the kind of statements needed in the domain. Finally, the *language-audience appropriateness* is the degree to which the language is usable and applicable by the audience.

Criteria used for evaluating the quality of models

This work is concerned with the design of technical infrastructures in order to support knowledge work. A comprehensive evaluation of instance-level models within their context of practice is out of scope. Main goal is the investigation and comparison of modelling languages with regard to the concepts they propose for a knowledge-oriented description and design of business processes. Hence, only criteria are relevant here suited to judge the formal quality of the modelling language, i.e. the cornerstone language, and those to judge the language-domain appropriateness, i.e. the association between the cornerstones language and domain. Criteria within these two areas can be identified based on the literature on quality of conceptual models (Frank 1994, 76ff; Frank & van Laak 2003; Hommes & van Reijswoud

[41] based on Lindland et al. (1994, 44)

2000; Stachowiak 1965, 456) and based on quality for software requirements specifications since they represent conceptual models of IS to be implemented (Krogstie 1998).

The *formal quality of the modelling language* is evaluated based on requirements concerning the correctness, completeness, coherence, freedom from redundancies and reusability of a modelling language:

Correctness. The requirement of correctness poses that the language needs to allow for a non-ambiguous identification of invalid models, on a syntactic as well on a semantic level (Frank & van Laak 2003, 26; Krogstie 1998, 88). Simultaneously, it needs to be able to generate all required valid models.

Completeness. Completeness demands that all concepts of a language and rules for its application are defined clearly (Frank 1994, 77; Frank & van Laak 2003, 26; Hommes & van Reijswoud 2000, 4f; Krogstie 1998, 88). However, especially for conceptual models a non-ambiguous definition of all concepts may not be possible because they need to leave room for interpretation.

Coherence. Coherence refers to the clearness and comprehensibility of the language definition (Frank & van Laak 2003, 26; Hommes & van Reijswoud 2000, 4f; Krogstie 1998, 88; Stachowiak 1965, 456). It has to be clear, concise and as simple as possible. Individual requirements stated within the syntax of the language shall not conflict. This requirement also includes that similar concepts need to be specified in the same way.

Freedom from redundancies. Closely related to coherence, this criterion demands that concepts of a modelling language do not overlap with regard to the aspects they describe (Frank & van Laak 2003, 26; Krogstie 1998, 89).

Reusability. A modelling language needs to support reuse of models. This can be achieved by offering means of abstraction (Frank 1994, 79; Frank & van Laak 2003, 27f; Krogstie 1998, 90). These are the ability to create classes that subsume characteristics valid for all instances, means for information hiding and the possibility to create generalization relationships. This also enhances maintainability of models through reduction of complexity, aggregation of similar aspects and encapsulation of specialized characteristics.

The *language-domain appropriateness* can be detailed by the criteria descriptive power, appropriateness and operationalisability:

Descriptive power. The modeller should be able to capture all aspects considered relevant at the needed levels of detail and precision (Frank & van Laak 2003, 31f; Krogstie 1998, 90). However, business processes may be described with concepts that cannot be completely formalized, i.e. semi-formal or informal models are applied that are often better suited to create a complete picture. Thus, the completeness of a language may not always be proved formally.

Appropriateness. Appropriateness relates the right level of abstraction, level of detail and degree of formalization of a language so that it is suited to structure a domain adequately and to keep modelling economically feasible (Frank & van Laak 2003, 32f; Hommes & van Reijswoud 2000, 4f; Krogstie 1998, 90).

Operationalisability. Models need to prove their usefulness (Stachowiak 1965, 456). They may not only be applied for visualization but also transformed into implementation models or are used for simulation tasks (Frank & van Laak 2003, 33; Krogstie 1998, 89). Suitability for this is fundamentally determined by the modelling language that needs to be able to describe relevant aspects for these applications and should support the mapping to concepts of other modelling languages.

Overview of criteria

In the following, a list of criteria is defined that are applied for the comparison of the modelling approaches selected. The first set of criteria is based on the foundations of modelling (section 4.2) as well as on specifics of modelling in KM (section 4.3) that are included in order to satisfy the requirement that evaluation should take into account the application context of a modelling language. The second part focuses on criteria concerning the quality of a modelling language as presented before.

Modelling approach. With respect to the *format of representation*, *degree of formalization* and the *implementation level*, all approaches fall into the same category and thus these criteria are excluded from the comparison. They all use diagrams with additional annotations as format of representation. They can all be classified to be semi-formal because the set of available constructs is always clearly specified but syntactic and especially semantic rules are only roughly defined and scarcely made explicit. They all can be classified as conceptual models because they do not describe a technical implementation in detail.

Modelling can either target description, prescription or explanation. Explanation-oriented models are not relevant in this context. The use of either descriptive or prescriptive models depends on the *primary goals of modelling* that for the purposes of the comparison is listed in more detail. Basically, it can be distinguished whether an approach is mainly oriented towards the description of knowledge-intensive business processes or whether it is concerned with the design of appropriate interventions.

The approaches in question are classified with respect to the *level of abstraction* into those that focus type level modelling and those that are concerned with instance level modelling. The criterion *level of granularity* furthermore distinguishes whether an approach models sequences of functions of business processes on a high level of granularity in order give a general overview of the conduct of business processes or whether it specifies detailed sequences of tasks that individuals are required to accomplish in order to conduct single process functions.

Tool support describes whether an approach is supported by a professional software tool, a software prototype or whether it is not supported at all by a modelling tool. Professional software tools are distinguished from prototypes by being in a mature software stage that is characterized by freeness from errors and the availability of all functions required within the respective modelling domain. They need to be obtained at cost on the market, a customer support is available and experiences have been gathered with them in commercial projects. *Procedure models* guide the application of a modelling language and thus structure the process of modelling. They differ with regard to the stages addressed, the arrangement of these stages as well as the intervention levels focused. As a first step, it is distinguished whether a procedure model starts out at strategic level, i.e. whether it proceeds in a top-down fashion beginning with definition of strategies and goals or alternatively, on operational level being mainly concerned with enhancing and supporting operative tasks.

The approaches are also investigated with regard to how they model the different *perspectives* product, process, person and productivity tool. This is described and discussed in detail for every approach. Furthermore, the number of distinct concepts within a perspective is counted and compared. New elements compared to traditional process modelling introduced to regard the specifics of KM then is summarized under the criteria *additional concepts* and *additional model types*. The primary *view on knowledge* taken by an approach can be described by the categories product, person and process that are based on the media of knowledge outlined in section 2.2.

Quality of modelling language. The criteria *correctness* and *completeness* as discussed above are excluded since they cannot be applied to the approaches selected. The reason is that all of them are based on semi-formal models that are open for interpretation. Strictly speaking, all semi-formal modelling languages would have to be judged to be incorrectly and incompletely specified. Particularly semantically invalid models cannot be identified clearly. This is left to the interpretation of model creators and users.

The *formal quality of the language* is evaluated based on the remaining criteria within this category: *Coherence* is judged to be high when all concepts and types of models are defined clearly, medium when at least one concept or model type is ambiguous and low when more than one concept or model type is unclear. *Freedom from redundancies* is classified as high in the case no redundant concepts and model types are identified, medium when at least one partly overlapping concept or model type is discovered and low in the case of more than one redundant element. Concepts or model types are judged to overlap when the same semantic meaning can be expressed with them. *Reusability* is evaluated to be high when at least information hiding and generalization-specialization relationships are supported, medium when only one of these ways of abstraction is supported and low when none of them is offered.

The criteria that concern the *language-domain appropriateness* are applied as follows: The *descriptive power* is rated taking into account how many of the perspectives person, process, product and productivity tool and relationships between them can be described with the language. It is rated high when all four perspectives and all six main relationships between them can be described, medium when one perspective is excluded or one or more relationships cannot be expressed and low when more than one perspective and the corresponding relationships are excluded. This admittedly allows only for a rough estimation of the descriptive power in the sense of completeness from the perspective of KM. In order to make the evaluation more concrete, the number of concepts in each perspective is counted as well as the number of possible associations between perspectives.

Appropriateness is conceptualized as a general measure of how good the constructs of the language are suited to guide the knowledge-oriented analysis or enhancement of business processes and to identify starting points for enhancements. It is rated high when the approach and especially the language constructs clearly support the identification of starting points, medium when it at least is able to provide a general overview and thus mainly supports understanding and analysis of the modelled domain and low when it does not provide a substantial contribution for knowledge-oriented process enhancement. *Operationalisability* is evaluated based on a number of selected KM tasks that are supported by the models during build-time, i.e. visualization and (semi-automatic) analysis, and run-time, i.e. simulation, creation of knowledge maps, use for navigation and implementation as workflows. The evaluation emphasises the need for an integration of design-time and run-time use of models. The operationalisability is rated high when models can be used for two or more tasks and if at least one task is related to run-time use, medium in case of at least two or more supported KM tasks with all of them related to either design-time or to run-time use and low if models are used mainly for visualization. Figure 20 summarizes the criteria described.

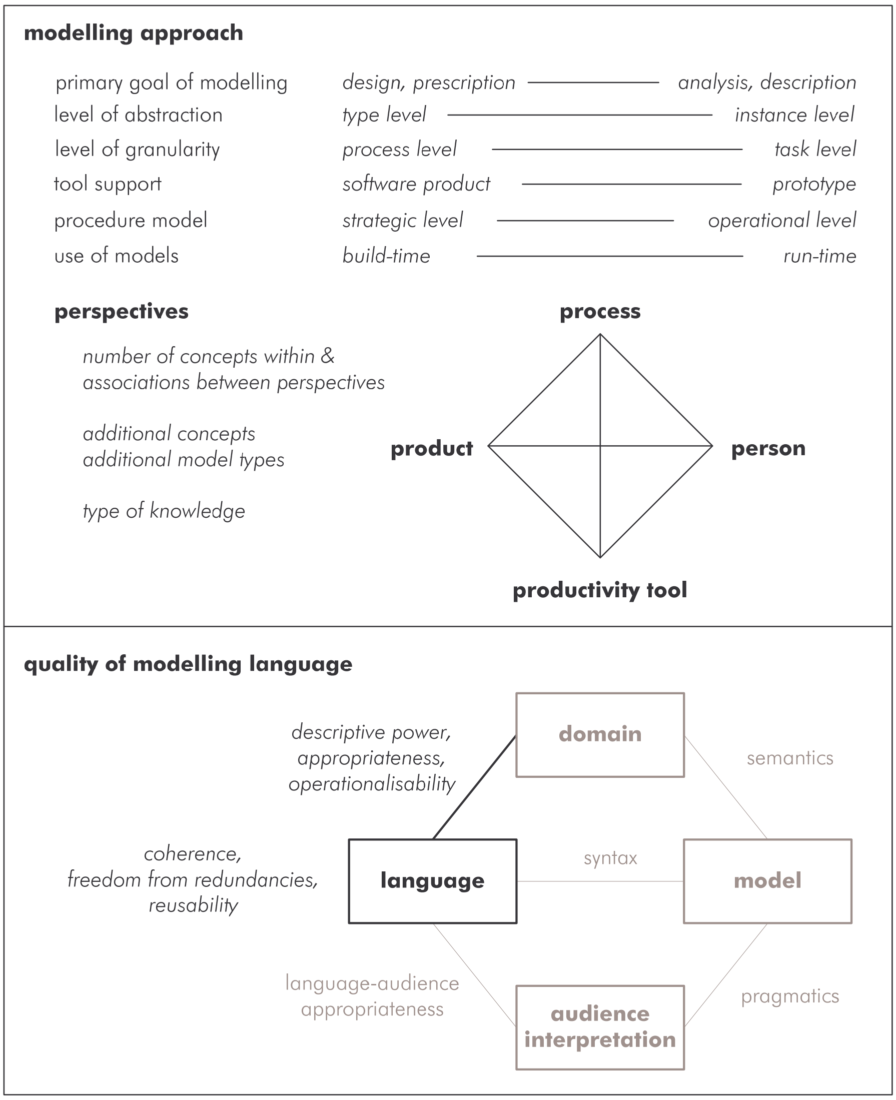

Figure 20. Overview of criteria for the evaluation of modelling approaches

4.5 Modelling approaches

This section presents the approaches for knowledge-oriented modelling of business processes selected based on the criteria described in section 4.4. Each approach is introduced shortly, a meta-model of the corresponding modelling language or the framework of concepts proposed is created and the quality criteria selected are discussed. UML 2.0 class diagrams are applied in order to structure the concepts of the modelling languages described.[42] A concept is represented by the UML symbol for class. The concepts are categorized into one of the perspectives described in section 4.3, i.e. product, process, person or productivity tool. Within the meta-models, different shades of grey as depicted in Figure 21 are assigned in order to indicate this classification. The relation between concepts is represented by means of associations between classes. If not further specified, multiplicity on both ends of associations is zero or more (0..*). For the sake of brevity, aspects irrelevant in relation to the object of investigation are excluded, e.g., start/end points, connectors, decisions and self-reflexive associations within the process perspective. In some cases, abstract classes with class names in italics are introduced in order to group similar concepts and to reduce the number of associations.

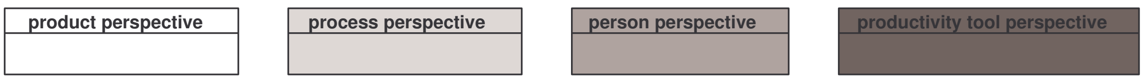

Figure 21. Visualization of concepts

4.5.1 ARIS-KM

Allweyer (1997; 1998) proposes a set of extensions to the Architecture of Integrated Information Systems (ARIS) (Scheer 1992; 2002). ARIS offers a variety of concepts and model types in order to represent five perspectives on an organisation: Functions within the function perspective transform input into output. They are governed by goals also included within this perspective just as application systems that incorporate rules defined based on the goals. Organizational units, machine resources and computational resources each summarize entities that conduct functions and together represent the so-called organisation perspective. Events are messages that trigger functions or are produced by them. Together with concepts

[42] The diagrams have been created with the tool Visual Paradigm for UML that has been provided to the author based on an academic partners program, see URL: http://www.visual-paradigm.com, last accessed: 2007-12-02.

used in order to model structured data such as entities and data clusters, they compose the data perspective. The so-called performance perspective contains all relevant material and immaterial inputs and outputs. Finally, elements from all four other perspectives are interrelated within the process perspective that arranges events and functions to process chains and relates elements from other perspectives to functions.

ARIS offers a variety of model types that can be used in order to model the perspectives described. The most important ones are organisation charts that show the relationships between different types of organisational units, function trees that hierarchically decompose single functions, entity relationship diagrams that structure data and extended event-driven process chains that describe business processes. Figure 22 depicts the meta-model of the modelling language. It does not include all concepts of ARIS but focuses those related to the knowledge-oriented extensions. These are knowledge structure diagrams, knowledge maps and communication diagrams all subsumed under the ARIS process perspective.

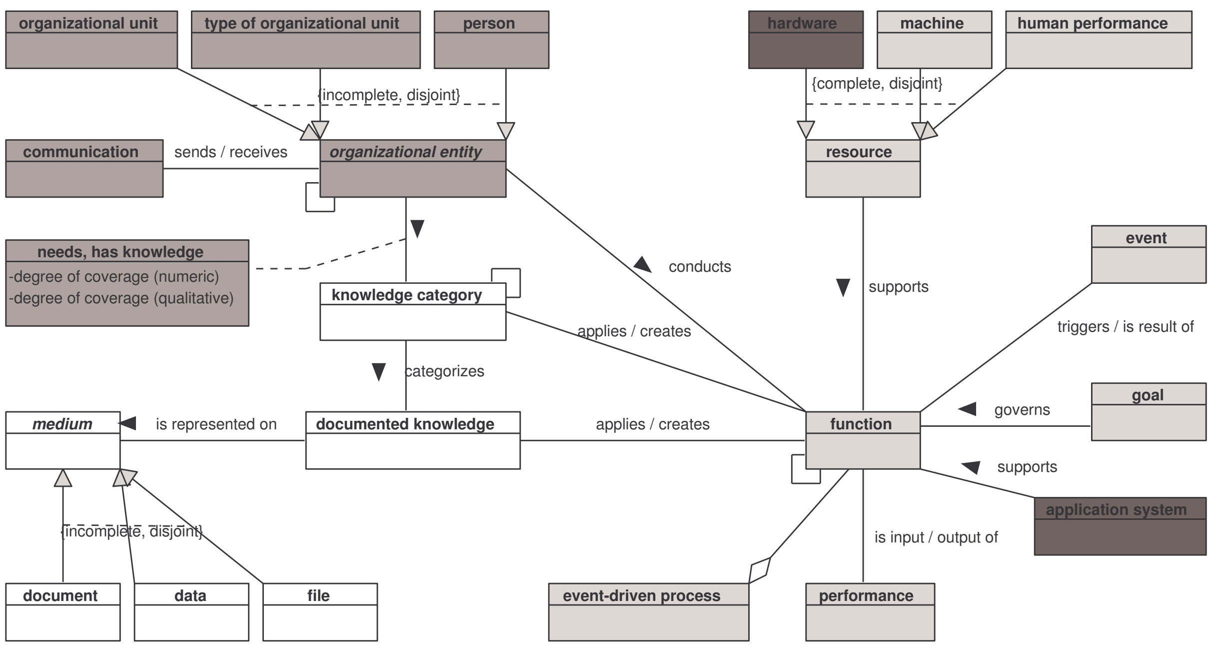

Figure 22. Meta-model of the ARIS-KM approach

Knowledge categories, documented knowledge and media can be related within a knowledge structure diagram in order to give an overview of the knowledge applied or created in the context of business processes. Knowledge categories are general categories of implicit or explicit knowledge that in turn can be detailed by further knowledge categories. Documented knowledge is defined as explicit knowledge that can be represented on various media such as documents, card files, electronic data files and protocols. The knowledge map includes a subset of concepts available within the organisation perspective, i.e. the concepts organisational unit, organisational unit type, position, position type, internal person, external person, location and group. These can be related to knowledge categories or to documented knowledge to indicate the possession of or need for knowledge. This association is rated with respect to a degree of coverage, e.g., to express how much knowledge an organisational entity has. In process diagrams, directed edges between functions, knowledge categories and documented knowledge indicate application or creation of knowledge. Communication diagrams are simple models that link organisational units by means of a communication symbol in order to visualize communicative relationships. In ARIS, IS are modelled on a high level of granularity, e.g., by including data, types of software systems and hardware within the control perspective. Allweyer suggests describing knowledge processing by explicitly modelling knowledge processes with event-driven processes.

The procedure model of the approach targets knowledge process redesign. It starts on strategic level and consists of the steps (1) strategic knowledge planning, (2) description of knowledge processing with the respective model types, (3) analysis and identification of problems and potentials for improvement, (4) creation of a target plan for knowledge processing and (5) of implementation plans for organisation and ICT followed by (6) their subsequent implementation. It includes no specific guidelines for the identification of challenges, potentials or knowledge-intensive functions or the modelling of unstructured processes with ARIS.

Discussion

ARIS-KM models are suited to give a general overview of the knowledge used and created by business processes. Event-driven process chains can be applied in order to represent KM processes that are (to be) formally established. Principally, they also can be used to model individual tasks on a more fine-grained level. However, modelling is accomplished mainly on process level and thus ARIS-KM is suited to identify general challenges. Support of individual tasks, e.g., by KM instruments or IS, is not included. The approach only offers rudimentary guidelines or concepts for identification of knowledge-related challenges or potentials. As an extension, Remus (2002b, 271f) categorizes functions of event-driven process chains based on the classes of KM-activities generate, store, distribute, search and apply in order to support the analysis of business processes with regard to missing or weakly supported steps.

Knowledge structure maps model taxonomies based on hierarchical aggregation or generalization relationships. They are applicable for structuring the knowledge related to business processes roughly. Though the need for visualizing the relationships between knowledge domains and people, roles or organisational units is frequently discussed in the context of visual representations in KM (Eppler 2003a; Eppler & Burkhard 2006), model types such as ARIS knowledge maps can only be scarcely found in other modelling approaches. Modelling is accomplished on type level though some instance-level concepts are included that nevertheless always have a counterpart on type level, e.g., organisational unit and person on instance level are corresponded by type of organisational unit and person type on type level. The approach is supported by the ARIS platform that offers comprehensive functionality, e.g., for run-time use of process models by export of processes in the Web Services Business Process Execution Language (WS-BPEL) or for simulation tasks.[43]

Coherence of the modelling language is rated low because the two concepts knowledge category and documented knowledge are only vaguely described and do partially overlap as both of them may be used to describe explicit knowledge. Consequently, freedom from redundancies is rated medium. Reusability is rated medium because the knowledge structure diagram at least allows modelling generalization/aggregation relationships and single process functions can be detailed by more fine-grained processes. Descriptive power is rated medium because no relationships between the perspectives product and productivity tool as well as person and productivity tool can be expressed though all perspectives are taken into account (Figure 22). Models only allow for general overview and thus appropriateness is rated medium. Operationalisability is rated low because knowledge-oriented models cannot easily be used for other KM tasks except visualisation due to their high level of abstraction.

4.5.2 GPO-WM

GPO-WM was developed at the Fraunhofer IPK is based on the method Integrated Enterprise Modelling (in German: Integrierte Unternehmensmodellierung, IUM) (Mertins & Jochem 2000; Spur, Mertins & Jochem 1993). It targets the description, analysis and design of business processes (Heisig 2002; 2003; Heisig & Mertins 2003). IUM is an object-oriented approach that distinguishes the three generic classes product, order and resource. These are

[43] URL: http://www.ids-scheer.com/en/Software/ARIS_Software/ARIS_Design_Platform/6926.html, last accessed: 2007-12-02

interlinked by actions within a so-called activity-oriented perspective used to represent business processes. These classes can be further specified during modelling and may inherit attributes from super-classes. GPO-WM extends them and also adds a KM-oriented procedure model. The meta-model of GPO-WM is depicted in Figure 23.

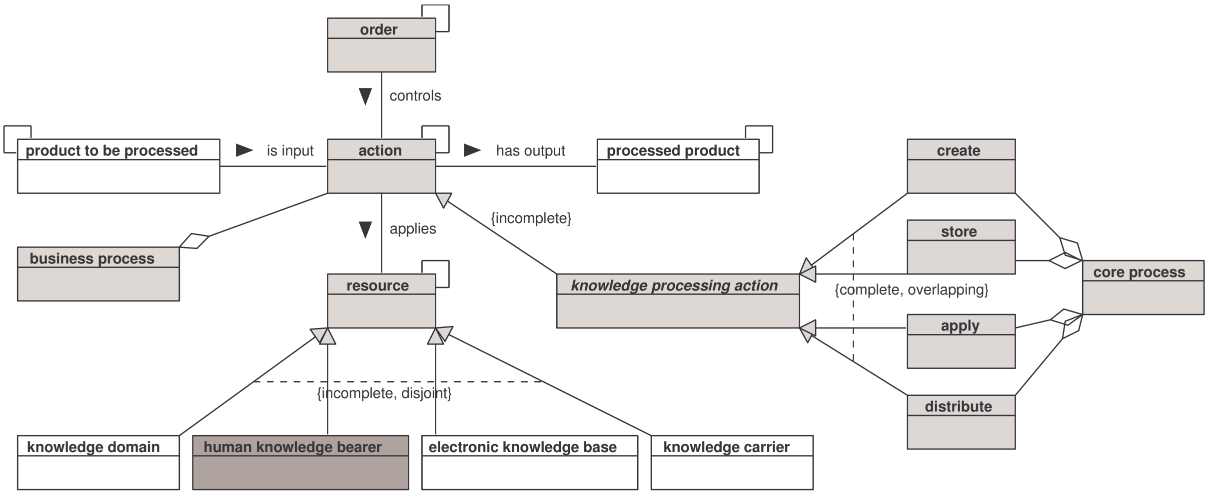

Figure 23. Meta-model of the GPO-WM approach

Knowledge is represented by objects and processes. Knowledge as an object is represented by four types of resources: knowledge domain, i.e. generic topics, knowledge bearers, i.e. knowledge of human experts or of organisational units, electronic knowledge bases, i.e. knowledge represented in IS, and knowledge carriers, i.e. other representations of knowledge such as paper-based documents. Furthermore, knowledge is embedded or might be represented by products that are the result of knowledge processing. Knowledge as a process is represented by sequences of actions in the context of business processes referred to as process-knowledge and by knowledge processing actions that belong to one of the four generic classes creation, storage, distribution and application of knowledge. Together, they constitute a so-called core process that orders these actions into the fixed sequence as they were listed. Knowledge-processing actions embed knowledge in objects or produce objects that represent explicit knowledge. The third generic class called order implicitly includes demands for knowledge processing and can be used to specify knowledge goals. The organisational structure is represented by resources that also comprise roles and organisational units.

The procedure model of GPO-WM concentrates on the operational level and consists of the steps (1) specification of organisational area, (2) selection of knowledge-intensive business processes, (3) KM audit based on the Fraunhofer IPK reference model[44], (4) analysis of knowledge-intensive business processes, (5) development of solution scenarios based on KM building blocks, (6) detailed planning of KM measures and implementation processes, (7) pilot implementation and (8) evaluation. The knowledge-intensity of processes is judged based on a set of characteristics such as weak predictability and standardization, high variability as well as need for high qualification and expertise.

Models are the foundation for the assessment of business processes during step four. It focuses on two main areas: Firstly, each action of a specific knowledge-intensive business process is analysed based on the core process. As a result, those knowledge processing actions of the core process that are not covered can be identified, e.g., knowledge needed for a specific action might not be available electronically because it has not been stored beforehand. The approach is based on the hypothesis that ideally all of the knowledge processing actions create, store, distribute and apply are covered. This assessment is undertaken separately for each knowledge domain linked with the process and results in a knowledge-oriented activity profile of the business process. Secondly, the quality of resources, products and actions is judged based on a set of pre-defined criteria, e.g., reusability, validity and relevance of knowledge domains or reliability and goal-orientation of knowledge processing actions.

The approach suggests the inclusion of additional KM activities and resources in case quality deficiencies or missing actions are discovered, which concerns the steps five to seven of the procedure model. Improvements are based on a set of KM building blocks, e.g., yellow pages and Communities of Practice, that represent successful KM practices identified in benchmarking studies on KM by the authors of the approach. Some of them include ICT support. Modelling is assisted by the tool MO^{2}GO developed in the context of IUM. It allows structuring products, orders and resources in a hierarchical manner as well as their combination within the activity-oriented perspective. It is also possible to generate reports by means of a macro language. Strohmaier (2005) based on this approach presents a framework and a software tool that supports the knowledge-oriented survey and analysis of business processes.

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[44] This model aims at surveying the current state of knowledge utilization in an organisation, focuses on business processes and analyses the six areas controlling, process organisation, IT, managerial systems, organizational culture, personnel management (Mertins et al. 2003).

Discussion

Advantages of GPO-WM are the provision of explicit guidelines and criteria for the selection of business processes to be modelled, actions to be analysed and for the identification of KM-oriented challenges. Strength of the modelling language is its flexibility due to a consequent implementation of object-oriented principles and the clear and simple relationships of the concepts. Nevertheless, a small set of generic concepts may limit the expressiveness and thus the suitability of the modelling language (Hommes & van Reijswoud 2000, 3f).

The requirement that all knowledge processing actions that make up a core processes need to be completely covered by each business process is questionable and even more the fixed sequence of the knowledge processing actions assumed by the approach. It is intuitively clear that knowledge created should also be applied somewhere and vice versa. However, not all knowledge has to be stored before its distribution and distribution of knowledge does not always need to be formally organised as an explicit process step. For example, a lesson learnt or idea can also be communicated directly and then immediately applied without storage and formal distribution. Furthermore, the actions store and distribute are strongly focused on explicit knowledge. Communication and collaboration-oriented actions as well as optional, unspecified or less foreseeable ones are not taken into account. Despite this critique, the approach motivated a number of researchers to explicitly include the four knowledge processing actions within their suggestions (Papavassiliou & Mentzas 2003; Remus 2002b; Strohmaier 2005). GPO-WM focuses the task level. Modelling takes place on type level or instance level depending on whether concrete experts and organisational units are included.

The quality of the modelling language is rated as follows: Coherence is rated high because all concepts of the language are defined explicitly. Freedom from redundancies is rated medium because it is not always obvious how different types of knowledge should be represented. Particularly, it is not clear whether knowledge to be processed by an action should be represented as product or as resource. The resource class knowledge domain has the problem that it overlaps with other types of knowledge that represent concrete media of knowledge. Reusability is assessed to be high because the language is based on object-oriented principles and thus supports generalization-specialization relationships as well as information hiding. Descriptive power is rated low because the perspective productivity tool and the corresponding associations cannot be modelled and also relations between person and product are not included. Appropriateness is rated medium because models do not indicate concrete starting points. Operationalisability is rated high because the models can be used for the creation of different types of knowledge maps or are reused in navigation tools though this is described to be in a prototypical stage (Mertins, Heisig & Alwert 2003).

4.5.3 KMDL

The Knowledge Modeling and Description Language (KMDL®) aims at a holistic description of business processes in order to provide an informative basis for analysing provision, sharing and use of knowledge and information with a focus on the identification of weak points in business processes (Fröming, Gronau & Schmid 2006; Fröming, Korf & Fürstenau 2005; Gronau, Müller & Uslar 2004; Korf & Fröming 2006, 435f).[45] KMDL is based on the analysis of communication structures[46] that analyses information flows between tasks assigned to positions (Hoyer 1988). This approach does not include a comprehensive organisational redesign but rather focuses on a thorough analysis of the current state of organisational areas (Wyssusek 2001, 270).

The meta-model of KMDL is depicted in Figure 24. It distinguishes between a process view and an activity view.[47] The process view contains business processes composed of tasks that are accomplished by roles. Process interfaces connect multiple business processes. Information systems represent ICT applied within the process in order to create or manage information objects. They can be further detailed with respect to the functions they offer. The remaining concepts constitute the activity view. A person can adopt one or multiple roles. Knowledge objects represent the competences of a person or of teams and can be of the types professional skill, methodological skill, social skill or a capacity to act. Competences are broadly defined to comprise knowledge, skills and attitudes. The concept unspecified person is used when it is unclear at the time of modelling whether knowledge or tasks are linked to a person or to a team. Information objects represent explicit knowledge that can be supported with IS and stored on various media types and in different formats.

[45] Version 1.1 of the modelling language has been applied in modelling projects as part of a practical university course. This section is based on the revised versions of KMDL published in (Gronau & Fröming 2006; Korf & Fröming 2006). The main extensions are complex, abstract and unspecified conversions as well as the distinction between a process-oriented and an activity-oriented perspective.

[46] in German: Kommunikationsstrukturanalyse

[47] The authors unfortunately offer no motivation or explanation for the distinction between these two views.

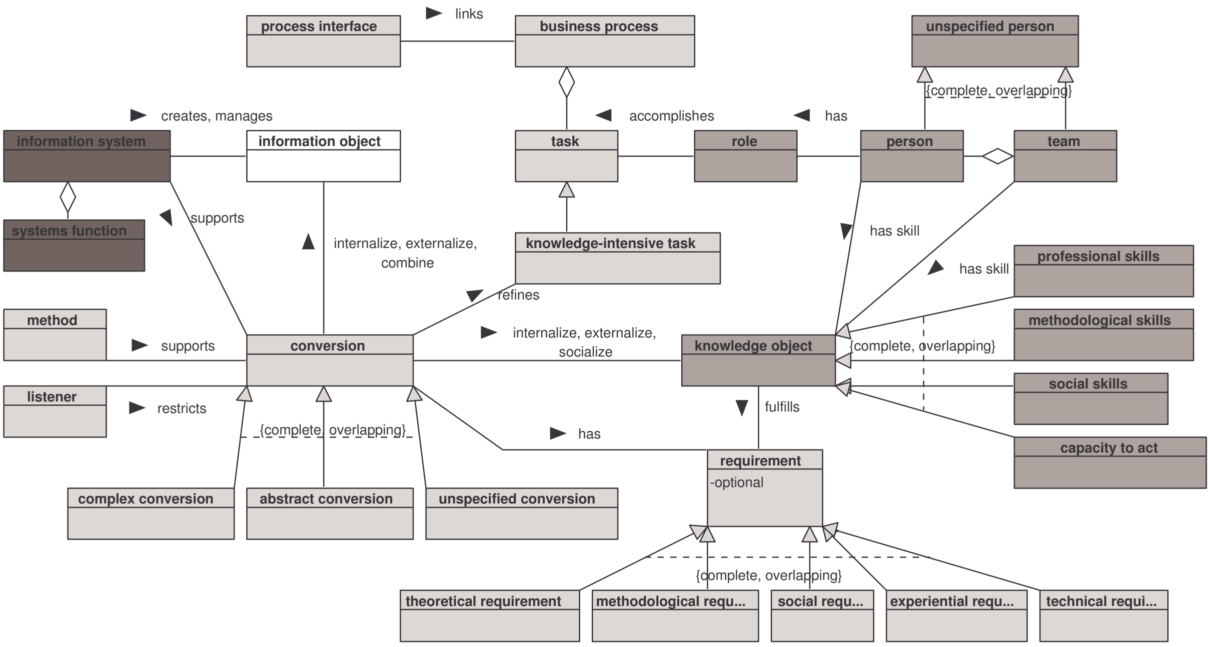

Figure 24. Meta-model of the KMDL approach[48]

Atomic, complex, abstract and undetermined conversion processes and related objects are used to detail knowledge-intensive tasks. Atomic conversations are classified based on Nonaka & Takeuchi's SECI[49] model (Nonaka & Takeuchi 1995) and thus describe direct sharing of experiences through socialization, externalization of subjective knowledge into explicit knowledge, combination of explicit knowledge to new explicit knowledge and individual learning by internalization of explicit knowledge. Each of them is supported by a set of methods, e.g., metaphors, analogies and models are applied in the context of externalization.

Complex and abstract conversions describe processes that involve multiple ones of these atomic processes as well as information or knowledge objects. The former have a maximum of one input object or of one output object. The latter are characterized by multiple input and multiple output objects. The unspecified type is modelled if not enough information is available for an accurate specification. Theoretical, methodical, social, experiential and technical requirements describe preconditions that need to be fulfilled in order to perform a conversation process. Examples for technical requirements are the availability of email as a communi-

[48] The diagram is based on recent publications (Gronau & Fröming 2006; Korf & Fröming 2006, 16). The meta-model presented by the authors contains some additional concepts such as role, position, group of people, domain, and agent that stem from older versions of KMDL. These are not included in the newest notation and thus are not further described here.

[49] SECI stands for the four conversation processes socialization, externalization, combination and internalization.

cation channel or of text processing software. So-called listeners can be used in order to specify conditions related to input and output that cannot be modelled otherwise, e.g., if it should be specified that the quality of information objects is required to have a defined level.

Modelling with KMDL is accomplished on instance level as well as on type level. The approach starts with instance level models that later on are generalized to the type level. The procedure model of KMDL consists of the steps (1) project initiation, (2) identification and (3) iterative description of knowledge-intensive processes, (4) analysis and evaluation of processes, (5) definition of target processes and measures, (6) implementation and (7) evaluation of measures. It thus can be categorized to primarily address the operational level.

A set of pre-defined anti-patterns are proposed to assist the process analyst during the identification of weaknesses within the captured processes. Examples are so-called knowledge monopolies, Chinese whispers or dependencies on specific knowledge (Bahrs, Bogen & Schmid 2005; Gronau & Fröming 2006, 356ff; Gronau & Uslar 2004). Modelling is supported by the software prototype K-Modeler[50]. Views on the model filter selected objects and help to reduce complexity. Simple reports about the models can be generated, e.g., all information objects externalized within a selected process or a competency profile for a person. A hope expressed in this context is that it will be possible to automatically identify knowledge-related problems such as unwanted knowledge flows, e.g., by applying reasoning and inferencing techniques to the knowledge conversion processes as formalized by the models (Gronau, Kopecny & Kratzke 2006).

Discussion

KMDL is suited to describe general relationships between individuals, tasks and knowledge. Specifics of knowledge work are conceptualized by including the modes of knowledge conversion based on Nonaka & Takeuchi's theory. It explains knowledge creation as a dynamic process that is amplified by a continuous succession of the four conversion modes described with respect to its ontological dimension, i.e. the organisational levels individual, group and organisation, and its epistemological dimension, i.e. type, depth and scope of knowledge (Nonaka & Takeuchi 1995). The theory is about a general understanding of knowledge crea-

[50] URL: http://www.k-modeler.de, last accessed: 2007-12-02

tion and thus the modes are broadly defined to comprise a large variety of different activities.

Hence, it is questionable whether they are specific enough to express what is needed to understand and to enhance business processes from a knowledge-oriented perspective. Though intuitively comprehensible, they may involve a large variety of activities on different organisational levels and involving different types of media and knowledge. Externalization for example may comprise dialogue, discussion and structuring of ideas during a team meeting just as individual authoring of documents and their subsequent distribution to colleagues. Each activity has different challenges and possibilities of enhancement and ICT support. This argument holds for the atomic type of conversion processes and even more for the complex types. KMDL thus runs the risk of treating knowledge work as a black box where just input and output objects are described. Other ideas of the knowledge creation theory are not included within the approach e.g., the consideration of conversion processes on different organisational levels or the view on knowledge creation as a synthesizing process (Nonaka & Toyama 2003). The hope to automatically identify knowledge-related problems appears as very optimistic because techniques are applied that combine the knowledge conversion processes in an inappropriate way.

Another issue is that some of the concepts included in the language refer to the instance level and cannot be easily generalized to the type level, particularly the concepts person and team. For example, a concrete person "Mr Miller" who is a software developer that explicates knowledge about implementation of software design patterns in C# (instance level), has to be generalized to a "person A" explicating knowledge about software design patterns. This is problematic because relevant information is lost, e.g., responsibilities and privileges of the individuals, and remaining information is very unspecific. Older versions of KMDL lacked operators such as OR, XOR and AND and thus were not applicable for process modelling. Business process models in KMDL fast get large and complex. The approach lacks concepts or models for complexity reduction, e.g., knowledge maps that can be used for the generalization of knowledge objects or the definition of person types or roles that (need to) have specific competencies.

Quality of the modelling language is rated as follows: Coherence and freedom from redundancies are both rated high: all concepts are described and none of them overlap. Reusability is rated low as no means of abstraction are included. Descriptive power is rated medium.

Though all perspectives are covered, no relationships between the perspectives person and product as well as person and productivity tool can be expressed. Models at least allow for a description and an overview and thus the appropriateness of the language is rated medium. Operationalisability is rated medium because besides the creation of models, the tool K-Modeler allows to generate simple reports and models are applied for automatic analysis.

4.5.4 Knowledge Modelling

Papavassiliou et al. present an approach that extends traditional workflow management in order to support knowledge-intensive business processes (Papavassiliou & Mentzas 2003; Papavassiliou, Mentzas & Abecker 2002; Papavassiliou et al. 2002; Papavassiliou et al. 2003). This includes definition of a general workflow meta-model, a modelling language and an implementation based on the DECOR[51] toolkit (Abecker et al. 2002). Figure 25 depicts the meta-model of this approach.

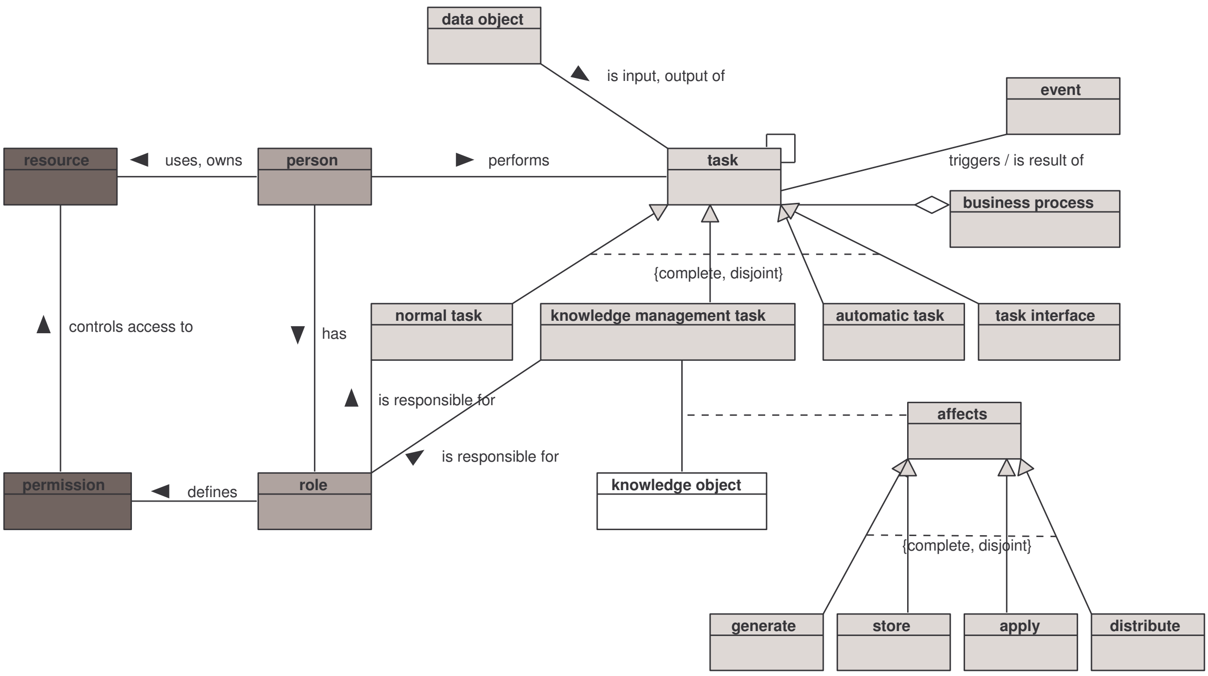

Figure 25. Meta-model of the Knowledge Modelling approach

Main extension is the inclusion of KM tasks as opposed to normal, operative or automatic tasks. KM tasks describe activities dealing with explicit knowledge that is represented by knowledge objects. Motivated by the generic KM tasks of GPO-WM (section 4.5.2), the four

[51] DECOR stands for delivery of context-sensitive organizational knowledge.

types of relationships generate, store, distribute and apply between KM tasks and knowledge objects are distinguished. Main goal of the inclusion of this type of tasks is the provision of specific functionality to the user on the execution of workflows. This comprises automatic information queries based on context-variables linked to tasks as well as support for the storage of information. Normal tasks represent the actions accomplished by people as a part of the business process. Automatic tasks are activities executed without user interaction. Task interfaces are used to connect multiple workflow models. Tasks and KM tasks are performed by roles. Users are described by means of the concept person. They are assigned to roles that are used to delegate tasks and to define permissions that control the access and use of resources. Data objects describe inputs and outputs of a task.

The approach is strongly oriented towards the provision and implementation of technical support by workflows. Knowledge objects are structured by means of an ontology that is used to enhance queries for information based on context-information linked to KM tasks. Constructs suited to model ontologies are not included within the modelling language. The approach builds on the idea of weak workflows, i.e. users are able to change workflow instances during run-time. Tasks also can be hierarchically decomposed into several alternative subtasks during build-time which adds further flexibility to workflow enactment. The prototypical implementation is based on models of processes created with Microsoft Visio and on the repository CognoVision that contains a collection of knowledge objects managed based on meta-data structured by the ontology.

The procedure model of the approach starts out at operational level and consists of the steps (1) identification of knowledge-intensive business processes based on the criteria knowledge-intensity and process complexity, (2) analysis and description of business processes with respect to tasks, roles, key people and resources, (3) task analysis, i.e. a detailed description of individual tasks including input and output objects and the classification into one of the mentioned tasks types, (4) business process design, i.e. modelling the workflow that implements the business process, (5) ontology creation, i.e. creation of the knowledge structure and (6) ontology refinement.

Discussion

The approach pragmatically focuses on technical support of knowledge work by means of workflows. All elements introduced are directly related to the provision of ICT functionality.

The technical solution proposed includes elements such as an ontology or meta-data specifying information needs of KM tasks that are not included in the modelling language. Due to its pragmatic focus on explicit knowledge and the enhancement of the flexibility of workflow support, other aspects are underrepresented such as individual skills or the support of collaboration and communication. It is not clear how the small set of types of KM tasks helps to assign technical support, especially how generation and distribution of knowledge should be supported.

The coherence of the modelling language is rated high because all concepts of the approach are defined clearly and all relationships are clarified. Freedom of redundancies is classified to be high because no redundant concepts exist. Reusability is classified as low because no means for abstraction are offered though the hierarchical decomposition of tasks might support the reuse of task models. Descriptive power is rated medium because relationships between perspectives product and person, product and productivity tool as well as process and productivity tool cannot be modelled. Appropriateness is rated high: KM tasks provide clear starting points for KM interventions and models provide an overview of at least the information or explicit knowledge used and generated by the process. Operationalisability is rated high because models are also used during run-time for workflow execution.

4.5.5 PROMOTE

PROMOTE© is presented as a comprehensive approach for process-oriented KM (BOC 2004; Hinkelmann, Karagiannis & Telesko 2002; Woitsch & Karagiannis 2002; 2005)[52]. Main goals are the design of a technical infrastructure in order to support business processes with a focus on the definition of workflows. PROMOTE is based on the business process modelling approach ADONIS©[53]. ADONIS originally includes a business process model, a work environment model, a process map and a document model (Hinkelmann 2001). PROMOTE offers ten additional model types, many additional concepts and a KM-oriented procedure model. Figure 26 depicts the meta-model of the language. Due to the large number of concepts, they are grouped based on the perspectives product, process, person and productivity tool.

[52] This description is based version 1.3 of PROMOTE and version 3.8.1 of the ADONIS modelling environment.

[53] URL: http://www.boc-eu.com, last accessed: 2007-12-02

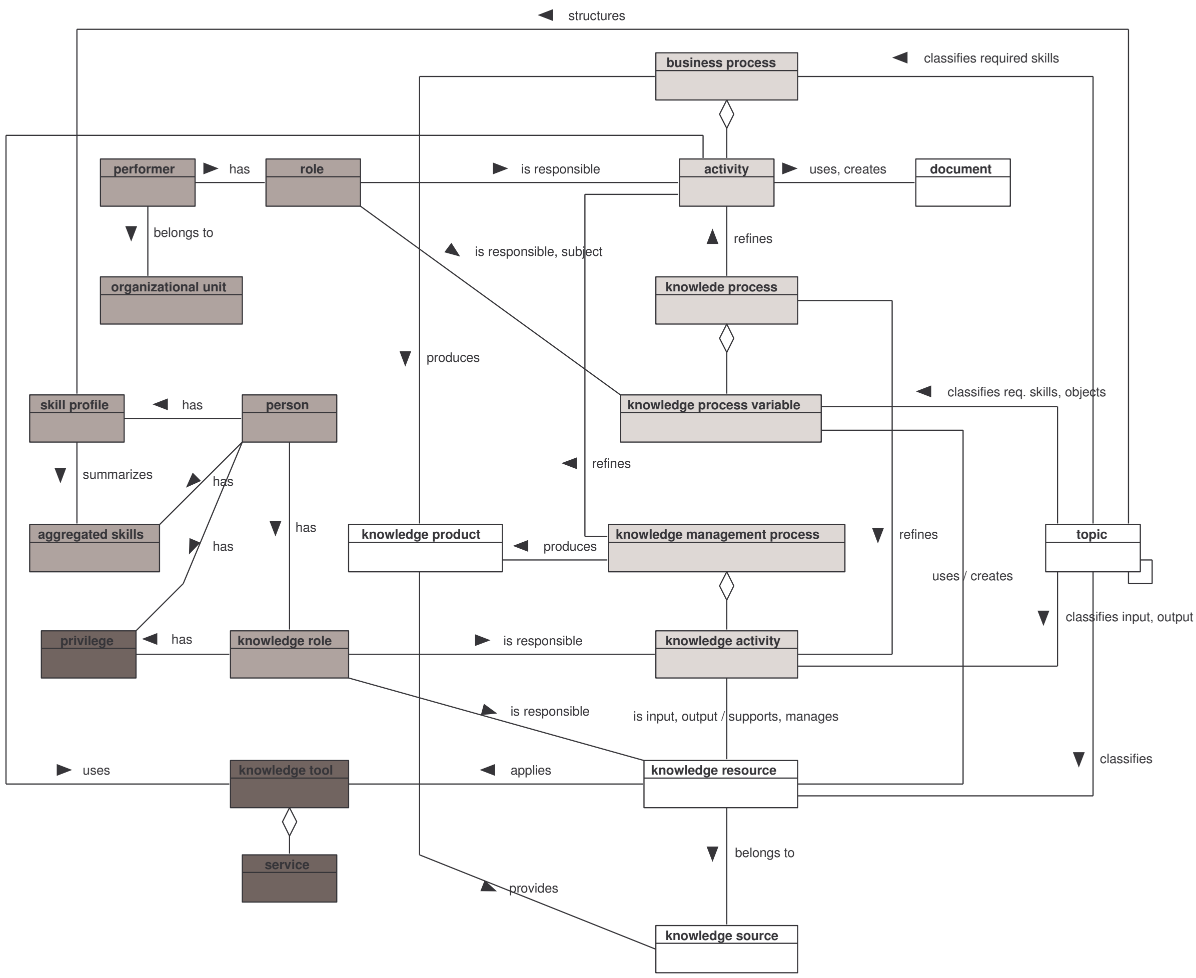

Figure 26. Meta-model of the PROMOTE approach[54]

Process perspective. Activities in the context of business processes can be classified as knowledge intensive tasks (KIT) that are the major starting points for KM interventions. KIT can be detailed with knowledge management process (KMP) models that later on might be executed with a workflow engine. KMP describe the dynamic interaction with the organisational knowledge base. They connect business processes with knowledge resources and describe formally established flows of information. Just as activities in business process, steps of KMP can also be categorized to be of the type KIT. They may also trigger or are refined by

[54] In order to reduce the number of associations in the diagram, concepts aggregating other elements were excluded, i.e. process group that aggregates other types of processes and service group that represents tools and services both from the skill environment model, subject from the team landscape that groups performers, roles, knowledge roles, and organizational units, topic category and topic aggregation that both group topics from the knowledge structure model and process from the process landscape that aggregates other types of processes.

knowledge processes (KP) that consist of sequences or groups of so-called KP variables.[55] Each KP variable represents a sentence consisting of subject, i.e. someone who accomplishes the task such as a knowledge role or person, a predicate from a list of pre-defined verbs such as think, design or consult and an object, i.e. a knowledge resource, topic or process. They are aimed at the representation of the unstructured processes of knowledge work. KP variables can either be related with the link types *is successor* or more loosely with *has relation with* or they are grouped in so-called KP pools. Business processes, KMP and KP each are modelled in separate diagrams. Process landscapes extend ADONIS process maps and give an overview by summarizing business processes, KMP and knowledge processes on a high level of granularity.

Person. The perspective person is represented by skill environment models that consist of the elements person, skill profile, aggregated profile, knowledge role, privilege and service group. People are modelled on instance level and are assigned skill profiles describing interests, abilities, management skills or product-related skills. Multiple skill profiles are combined by means of the aggregated skills element. Privileges indicate the right to access or manage a group of services and tools. The concept person corresponds to the concept performer in the ADNOIS work environment model. Just as a performer in ADONIS can have roles in business processes, a person in PROMOTE may fulfil knowledge roles in KMP. The second model type within this perspective is team landscape that represents hierarchical and non-hierarchical relationships between individuals or groups.

Product. The product perspective is represented by a knowledge structure model which is composed of topics, topic aggregations and topic categories. These elements have hierarchical and non-hierarchical relationships and are used to structure knowledge resources, skill profiles and required skills for business process activities and for KP variables as well as inputs and outputs of KMP activities. Knowledge resource models depict knowledge resources such as experts, databases or documents that have several relations with other concepts: Knowledge tools, KMP and KP apply them and roles or knowledge roles are responsible for them. The knowledge product model is similar to the knowledge structure model but is used to structure knowledge products offered by knowledge sources. Explicit knowledge

[55] Within the diagram, associations of the type “refine”, e.g., between KMP and KP, denote a loose connection that is defined only as general relationship between two concepts. Aggregation relationships instead are applied if a concept is defined with the help of other concepts, e.g., a KMP is modelled based on a series of knowledge activities.

is represented in documents grouped by the document model already introduced with ADONIS. The knowledge landscape relates subjects, i.e. performers, organisational units, roles, persons or knowledge roles, with knowledge resources, knowledge tools, topics and topic categories by means of the connectors *belongs to* and *has relation with*.

Productivity tool. Knowledge tools and the services they offer are represented in the knowledge tool model. Examples are micro article generators or search engines. Activities of business process or KMP can be linked with knowledge tools or services in order to indicate support. Their input and output is represented by knowledge resources.

The PROMOTE procedure model is based on the business process management systems method (Karagiannis, Junginger & Strobl 1996) that comprises the steps (1) strategic decision about goals and products, (2) re-engineering of products, processes and organisation, (3) resource allocation and assignment specifically of IS to processes, (4) execution of business processes with workflows and (5) performance control and evaluation. These steps are paralleled by the KM activities (1) aware enterprise knowledge which includes the definition of goals, core competencies and risks, (2) discover knowledge processes and define KM instruments, (3) model knowledge processes, (4) make knowledge processes and organisational memory operational and (5) evaluate enterprise knowledge. As can be seen, the procedure model emphasises support by workflows.

PROMOTE is based on the ADONIS tool, a professional software product for process modelling (Junginger et al. 2000). It supports the definition of additional language constructs and thus can be extended by new model types and concepts such as that of PROMOTE. Vision of the PROMOTE approach is the integrated definition of a comprehensive technological infrastructure. The modelling environment is viewed as an integrated part of this infrastructure and used for tasks such as monitoring processes, management and assessment of tools or services to process steps and evaluation of organisational memory contents. Long-term goal is the seamless instantiation and use of all types of models during run-time. This has been demonstrated with a prototypical implementation (Hinkelmann, Karagiannis & Telesko 2002, 84).

Discussion

In terms of its procedure model and the perspectives included, PROMOTE is a very comprehensive approach that offers a large variety of concepts and models. It pragmatically focuses support of individual knowledge-intensive tasks as starting points for KM interventions. Though PROMOTE acknowledges some characteristics of knowledge work, modelling of, automation of and support based on workflows is the main approach for enhancing productivity of knowledge work. However, they are only suited for a limited share of knowledge-intensive tasks. KIT are a good starting point but need to be further specified with respect to, e.g., conditions that trigger KMP and types of information required or created. Modelling generally takes place on type level except if individuals and their competences are represented included based on the concepts performer, person, aggregated skills and skill profile. For some of them, PROMOTE includes no congruent concepts on type level such as person types or competency types as well as sets of (required) competencies. The approach and its modelling language offer large degrees of freedom due to the large number of model types and concepts that the modeller can choose from. However, there is no guidance concerning the aspects that should be described and particularly the relationships between concepts that should be specified.

The quality of the modelling language suffers from a lack of clear definitions and the high number of concepts and links between them. Concepts of ADONIS and PROMOTE are not thoroughly integrated: The difference between the ADONIS concepts performer and the PROMOTE concepts person and knowledge role is not clear and documents from ADONIS have not been integrated into PROMOTE. Some PROMOTE concepts do partially overlap, e.g., process from the process landscape and process group from the skill environment model as well as the knowledge tool element that groups services and the service group element that groups knowledge tools and services. The approach also lacks guidelines in which case of the processes types business process, KMP and KP should be selected during modelling. Hence, coherence and freedom from redundancies are both rated low. Reusability is rated medium because topic maps allow specifying generalization-specialization relationships and single process tasks can be detailed. Descriptive power is rated high because all perspectives and all general relationships between perspectives can be expressed with the modelling language. However, some relationships that are relevant from the perspective of KM are still missing, e.g., the link between knowledge roles and skill profiles that can be used to indicate required competencies. Appropriateness is rated high because the focus on KIT is pragmatic and provides clear starting points. Operationalisability is rated high because models are explicitly targeted at run-time use, e.g., they are used for the execution of workflows as well as for visualization and simulation.

4.5.6 PROMET I-NET

PROMET® I-NET is designed to support execution of enterprise-wide Intranet and Internet ("I-NET") projects (Kaiser et al. 1999). It belongs to the PROMET family of methods developed with the goal to formalize and guide the transformation of organisations based on a comprehensive business engineering perspective (Österle 2000). A modelling notation for this method has not yet been published. The business engineering approach advises the usage of modelling approaches such as ARIS. The approach is discussed here because it includes a formal meta-model with concepts and extensions comparable to other approaches discussed. Figure 27 depicts this meta-model as it is visualized by the authors.

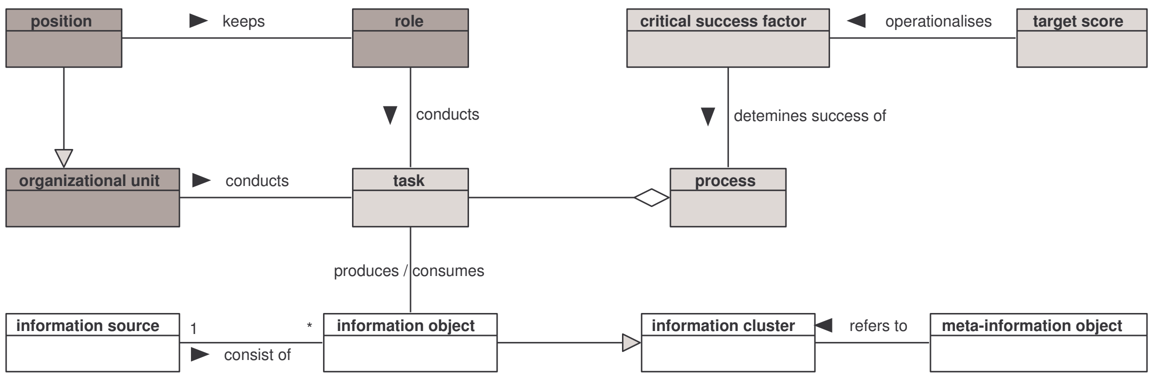

Figure 27. Meta-model of the PROMET I-NET approach[56]

PROMET I-NET concentrates on four design areas: business processes, information architecture, Intranet systems architecture and information processes. (1) *Business processes* and tasks firstly are selected based on the organisation's Intranet strategy. (2) The *information architecture* concerns the structuring and analysis of information objects. These objects are further described by meta-information and grouped to information clusters in order to enable flexible selection of and navigation based on information objects. A set of information objects constitutes an information source. (3) The *Intranet systems architecture* specifies the technical functionality required such as mechanisms for the classification of information objects, navigation and personalization. This also comprises the selection of software components and tools to be applied as well as the planning of their integration. (4) Especially important is the establishment of *processes* for the creation, distribution, maintenance and deletion of informa-

[56] based on Kaiser et al. (1999, 97)

tion objects and their linkage to the business processes involved. Tasks that are part of these processes are assigned to roles such as author, webmaster or content manager.

PROMET I-NET includes a procedure model that mainly focuses on the creation of an Intranet system. It starts on an enterprise-wide level with the (1) analysis and planning of the Internet or Intranet strategy and then turns to the (2) planning of operations, (3) IS architecture development and (4) security planning. This is paralleled by the process-specific steps (1) information (need) analysis, (2) information structuring including the definition and assignment of meta-data, (3) establishment of content management processes, (4) design and implementation of applications and (5) fine-grained security planning.

This method is referred to in the context of the business knowledge management framework (BKM) (Kaiser & Vogler 1999). It distinguishes between the three levels knowledge base, knowledge structure and business processes (Bach 1999). The *knowledge base* comprises all roles, processes and systems relevant from the perspective of KM and thus includes information architecture, system architecture as well as processes and roles defined based on the PROMET I-NET method. The *knowledge structure* includes all topics and categories of relevant knowledge and their relationships and thus corresponds to the meta-level of the information architecture. However, it is not specified in more detail within the framework presented by the authors (Kaiser et al. 1999, 97). The *business process level* describes the business processes focused by KM and thus mirrors the steps definition of the Internet or Intranet strategy and information needs analysis as part of the PROMET I-NET method. BKM framework and PROMET I-NET are not supported by a modelling tool.

Discussion

The BKM framework aims at establishing a general frame of reference for KM. However, except re-labelling concepts from information objects to knowledge objects, from roles to knowledge roles and from information flows to knowledge flows, it adds no substantial extensions to the PROMET I-NET method. Information and knowledge flows are not yet included explicitly within the meta-model of the method. Just as PROMET I-NET, the BKM framework calls for the definition of formal processes for the maintenance of the knowledge base referred to as knowledge management processes. Framework and method emphasize the role of the knowledge structure as a mediator between business processes, KM processes, knowledge roles and ICT systems. It is suggested here that guidelines, procedures and criteria should be detailed and extended in order to appreciate KM specifics. Specifically, the relation and the differences between knowledge and information objects as well as of knowledge and information flows should be defined and further guidance should be offered concerning how to identify and support flows of knowledge between tasks and how to exactly assess information needs, which are starting points for analysis and design.

Quality of the modelling language is rated based on the reference model presented by Kaiser et al. (1999, 97) and depicted in Figure 27. Coherence is rated medium: Though the formal reference model specifies concepts and their relations on a general level, some concepts remain unclear, e.g., information clusters and meta-information objects. None of the concepts overlap and thus freedom from redundancies is rated high. Generalization relationships are possible for organisational units and for information objects and thus reusability is rated medium. Descriptive power is rated medium because the productivity tool perspective and all associated relationships are not included just as no relationships between the perspectives person and product can be expressed. Appropriateness is rated low because the reference model does not conceptualize any KM specifics and the areas pointed out as the main starting points of the method, i.e. the analysis of information needs and flows, are not included in the reference model. The criterion operationalisability is omitted since the approach does not include a modelling language.

4.5.7 Reference Model of KM

The Reference Model of KM targets the proposition of a general framework suited to structure KM interventions (Warnecke, Gissler & Stammwitz 1998). It consists of an object model that formalizes the concepts focused, namely system elements and activities, a process model defining sequences of activities and a general procedure model. Main goal is the provision of a meta-structure for the redesign of the organisational structure and particularly the design of resources with a focus on ICT. Warnecke et al. (1998) do not define a modelling notation and advise using that of other approaches. The object model builds on some of the principles of object orientation, i.e. all concepts are defined as classes, may have attributes and are part of generalization-specialization relationships. The classes and relationships defined by the object model are depicted in Figure 28.

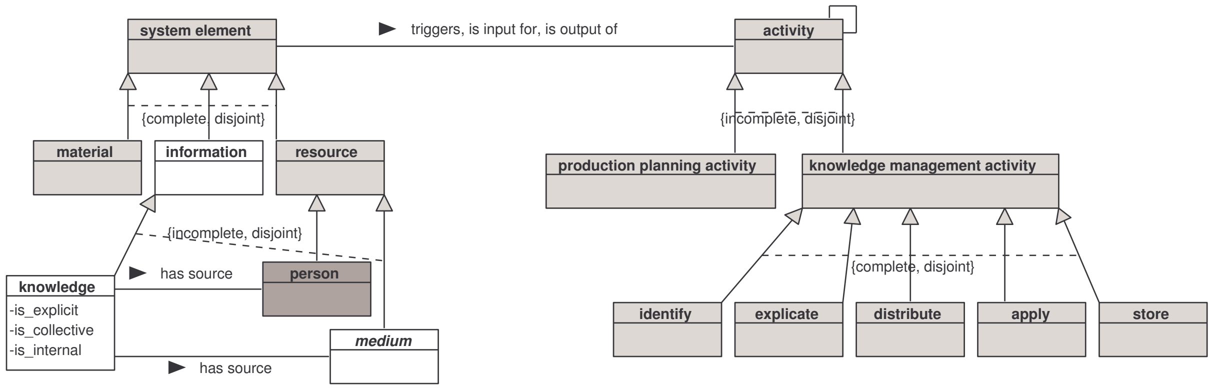

Figure 28. Meta-model of the KM Reference Model approach

Knowledge is defined as a subclass of information based on the argument that it could be understood as "information plus comprehension" (Warnecke, Gissler & Stammwitz 1998, 26). The approach distinguishes explicit and implicit, individual and collective as well as internal and external knowledge. Information about this differentiation is assigned as Boolean attributes to the class knowledge. Knowledge sources are either people or media such as documents or electronic systems. They are represented as specializations of the class resource and have an association with the class knowledge. Resources, information and material all are specializations of the class system element. All system elements may be input for or output of activities or they may trigger them. Other examples for system elements are resources such as operating supplies, real estates or materials.

The reference model distinguishes sets of general activity classes for different areas such as production planning, quality management or KM. For the field of KM, these are the five generic activities identify, explicate, distribute, apply and store. Based on experiences with industry sector companies, the authors argue that these generic activities always have the sequence in that they are listed here. The procedure model primarily addresses the operational level and consists of the steps (1) situation analysis, i.e. identification of processes and activities with a high potential for improvement, (2) definition of goals such as enhancement of product quality or of flexibility, (3) modelling of the current state with common modelling languages, (4) definition of an implementation model and (5) implementation.

Discussion

The approach structures KM from a production-oriented perspective. Knowledge is classified as a specialization of the class information which overly simplifies the relationship between these two concepts. The approach also has a conceptual problem with regard to the relationship of system elements and activities. Humans and also technical systems may be modelled as input and output of activities, which seems as a too generic conceptualization. Another issue is the pre-defined sequence of KM activities. It is not based on empirical or theoretical evidence and very questionable in terms of its general validity, particularly for other types than explicit knowledge.

Due to the lack of an own modelling language, the quality of the modelling language is rated here based on the object model and without the criterion operationalisability of models. Coherence is rated medium because the KM activities are not clearly defined and delimited from each other. This also leads to a medium rating for freedom of redundancies. The perspective productivity tool and its relationships to the other perspectives are not included and thus descriptive power is rated medium. The appropriateness of this approach is rated low as it is not clear how the models created are suited as a foundation for the identification of starting points for KM interventions.

4.5.8 Other approaches

This section summarizes CommonKADS, INCOME and Knowledge MEMO which are other approaches related to knowledge-oriented modelling of business processes. They are shortly outlined here as they are sometimes cited in this context IS (Maier 2004, 204; Papavassiliou & Mentzas 2003, 29; Remus 2002b, 222). However, they are not included within the detailed comparison because they do not formulate explicit concepts but only offer a common procedure and frame of analysis (CommonKADS), are a foundation for knowledge-oriented extensions but do not include specific extensions for KM (INCOME) or could not be analysed in detail due to the lack of published literature (Knowledge-MEMO).

CommonKADS. The CommonKADS approach is rooted in the method Knowledge Acquisition and Documentation Structuring (KADS) that aims at structuring the development of knowledge-based systems and specifically of expert systems (Schreiber et al. 2000). CommonKADS emphasizes the requirement analysis stage and offers six general model types: organisation, task, agent, knowledge, communication and design. The first three models describe the organisational environment and corresponding critical success factors. They are also referred to as context models of the knowledge system.[57] They provide information for

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[57] The term model in this case is used in a broad sense for any structured descriptions, e.g., in the form of lists or concise notes. For example, the organisation model proposes the focus areas structure, process, people, resources,

the knowledge model and the communication model that describes the structure of knowledge used to conduct a task and how knowledge is communicated between agents. The knowledge model consists of structured statements, may also comprise definitions for rules used in order to infer new facts as well as an UML class diagram-like visualization of the knowledge structure. The design model describes the implementation details of the knowledge system by specifying requirements to be fulfilled.

The method provides no means to describe business processes and related resources in a formalized way though they are explicitly regarded by CommonKADS. Knowledge, communication and implementation models are more strongly formalized. Though the creation of the task model includes the analysis of knowledge-intensive tasks, no detailed guidelines are established that indicate aspects relevant to be captured. Gardner (1995) uses some of the principles of the CommonKADS approach in order to model problem-solving templates that visualize cognitive tasks and their inputs and outputs. Bera et al. (2005, 817) propose an extension of CommonKADS based on the event-driven processes[58] method. However, these applications and extensions remain on an abstract level and do not discuss specifics of knowledge work.

INCOME. The Interactive Netbased Conceptual Modelling Environment (INCOME) was developed between 1985 and 1990 by the institute AIFB of the University of Karlsruhe in Germany (Jaeschke 1996, 55). Method and corresponding software tool INCOME Suite are marketed by PROMATIS[59] in cooperation with the company get process[60]. INCOME offers three types of models: process, organisational and object model. Process models are based on a Petri Net approach. The organisation model structures organisational units responsible for process tasks. Data used or created by the process is structured into attributes that are grouped to object types included in the object model. INCOME is one of the more well-known process modelling approaches in research and practice and this might be one reason why its application is also discussed in the context of KM (e.g., in Gronau 2004). However, it

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knowledge and culture & power that represent a general frame of reference. Visual representations may complement the documentation, e.g., UML activity diagrams are proposed to be used in order to sketch the layout of business processes on a high level of granularity.

[58] This method should not be confused with the model type event-driven process chain known from the ARIS approach (section 4.5.1).

[59] URL: http://www.promatis.com, last accessed: 2007-12-02

[60] URL: http://www.get-process.com, last accessed: 2007-12-02

does not provide any knowledge-oriented extensions though the object model is principally flexible enough to describe, e.g., skill trees or categories of explicit knowledge. The knowledge browser as an additional component of the INCOME Suite can be used to visualize different perspectives on processes and objects. The software tool also includes a DMS called document centre and means to simulate processes.

Knowledge-MEMO.[61] Schauer (2007) proposes an extension of the Multi-Perspective Enterprise Modelling Framework (MEMO) (Frank 1994; 2002). MEMO distinguishes the three general perspectives strategy, organisation and IS that each are structured into the five aspects structure, processes, resources, goals and environment. Special purpose models allow for a detailed representation of one or more of the resulting 15 elements. Knowledge-MEMO targets the extension of this framework by knowledge-oriented aspects. Examples for enhancements from a KM perspective are intangible assets and core competencies within the perspective strategy, abilities and skills within the perspective organisation as well as explicit knowledge within the perspective IS (Maier 2004, 204f). The approach also includes the representation of secondary organisational structures such as projects or communities, their link to strategic goals and their support by IS. It also proposes an evolution model similar to the KM Maturity Model©[62] (Ehms & Langen 2000) that aims at assessing the current state of KM in order to guide the selection of appropriate elements within the framework.

4.6 Comparison of modelling approaches

Table 8 gives an overview of the approaches discussed in section 4.5 and structures them according to the criteria applied. Results of the evaluation and comparison can be used in order to discuss enhancements and suggestions for further research. The approaches in the following will be compared based on goals and starting points, levels of modelling, tool support and procedure model. The comparison of KM-oriented extensions is structured according to the perspectives product, process, person and productivity tool. Subsequently, the approaches will be compared with regard to their ability to express relationships between these perspectives. The quality of the modelling languages is contrasted afterwards. The

[61] Knowledge-MEMO was in preparation at the time of writing and therefore appropriate material for a detailed analysis was not accessible.

[62] URL: http://www.kmmm.org, last accessed: 2007-12-02

requirements for modelling approaches applied in the context of PKM formulated throughout this section finally are summarized.

Goals and starting points. Though all approaches are rooted in business process modelling and thus include a management-oriented perspective on the design of knowledge infrastructures, differences can be identified between those approaches that predominantly target business process analysis and re-design (ARIS-KM, GPO-WM, KMDL, PROMET I-NET, Reference Model of KM) and workflow-oriented approaches that more strongly emphasize design of ICT support, particularly of workflow systems (Knowledge Modelling, PROMOTE). Whereas the former address process enhancement and reengineering based on identification of problems of knowledge processing, i.e. they all use models primarily for analysis and description, the latter focus on the support with IT and treat models as a specification that in subsequent design steps can be detailed and used during run-time. PKM modelling approaches are ideally applicable for both, the knowledge-oriented analysis and enhancement of business processes as well as for the specification of technical solutions. However, this might represent a stretch that cannot be overcome.

Levels of modelling. Modelling needs to be accomplished on type level in order to guide analysis and design beyond single cases. KMDL is the only approach that places its primary focus on the creation of instance level models that later on are generalized to the type level. As discussed in section 4.5.3, this is associated with information loss if no appropriate type level concepts are available. Nevertheless, the description of existing business processes should be possible with an approach and thus PKM modelling approaches should include both levels. ARIS-KM focuses on process-level models though principally also task-level models can be created based on the language. PROMOTE takes into account both levels. Process level models are only suited to give a general overview and are not appropriate to design the support of concrete individual tasks. PKM modelling approaches thus should be based on task level modelling.

Tool support. Tool support for creation and management of visual models is a constitutional requirement for modelling to be economically feasible. All approaches that formulate an explicit modelling notation are based on a modelling tool that either has the status of a software prototype (GPO-WM, KMDL)[63] or of a professional software product (ARIS-KM, PROMOTE). The Knowledge Modelling approach extends and integrates standard tools such as Microsoft Visio for modelling and CognoVision for the management of documented knowledge. A modelling tool should offer specific functionality that differentiates it from graphical editors. For example, syntactic and semantic rules should be included in order to support the creation of valid models. It is proposed that PKM modelling approaches should generally be based on such a tool. As stated, two tools were available for evaluation, the ARIS platform and the ADONIS tool including the PROMOTE modelling definitions. They both offer multi-user support, model management and visual creation of models.

Procedure model. Every approach described includes a procedure model. Three of them address KM holistically and start out on a strategic level (ARIS-KM, PROMOTE, PROMET I-NET). Though the inclusion of a strategic level does not seem to be generally necessary, at least the general focus of KM (section 2.4) and ideally specific KM goals should be taken into account by an approach. Only GPO-WM, KMDL and PROMOTE include an evaluation stage and only the Knowledge Modelling approach proposes a refinement stage, in this case for the detailing of ontologies. Based on an aggregation of the procedure models described above, the requirement is stated that the procedure proposed by PKM modelling approaches should include the selection of the intervention area, the knowledge-oriented analysis of business processes as well as the design, implementation, evaluation and refinement of interventions. Guidelines and criteria that allow for a systematic procedure within these stages should be included. All approaches propose a sequential ordering of activities, following the basic structure of the waterfall model in software engineering (Balzert 1998). A strict sequential ordering of activities has been criticised in this context and alternative models have been developed that take the iterative nature of this process and the need for the continuous participation of system users into account (Fowler 2005). The procedure model of PKM approaches thus should include cycles or review phases in order to take the necessity of the repeated refinement and revision of models into account. The only procedure model that includes a cycle at least on a general level is that of the PROMOTE approach.

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[63] GPO-WM and KMDL both also provide a set of so-called *shapes* for the vector-based design tool Microsoft Visio representing the notation so that this software alternatively can be used as a simple graphical modelling tool.

	ARIS-KM	GPO-WM	KMDL	Knowledge modelling	PROMOTE	PROMET I-NET	Reference Model of KM
modelling approach							
foundation	ARIS	IUM	KSA	workflow modelling	ADONIS	PROMET	none
primary goal of modelling	knowledge process reengineering	introduction of best practice KM instruments	identification of knowledge problems	definition of workflows for knowledge work	selection of ICT services, definition of workflows (analysis, *design*)	design of an Internet/Intranet system	re-design of organisation structure
(*main orientation*)	(*analysis*, design)	(*analysis*, design)	(analysis)	(design)		(design)	(analysis, *design*)
primary starting points	problems / potentials for improvement	incomplete core process	knowledge problems	KM tasks	knowledge-intensive tasks	information / knowledge deficits	incomplete KM reference process
level of abstraction (*main focus*)	instance level, *type level*	instance level, *type level*	*instance level*, type level	instance level, *type level*	instance level, *type level*	type level	type level
level of granularity	task, process level	task level	task level	task level	task, process level	task level	task level
tool support (category)	ARIS platform (software product)	MO²GO (prototype)	K-Modeler (prototype)	Visio+CognoVision (software products)	ADONIS tool (software product)	none	none
procedure model	strategic	operational	operational	operational	strategic	strategic	operational
number of concepts per perspective[64]	product: 3, process: 7, person: 2, prod. tool: 2	product: 5, process: 9, person: 1, prod. tool: 0	product: 1, process: 14, person: 9, prod. tool: 2	product: 1, process: 11, person: 2, productivity tool: 2	product: 5, process: 6, person: 7, prod. tool: 3	product: 4, process: 4, person: 3, prod. tool: 0	product: 3, process: 7, person: 1, prod. tool: 0
perspective on knowledge	product, skill	product, process, skill	product, skill	product	product, process, skill	product	product, person

Table 8. Comparison of the modelling approaches selected

[64] This criterion focuses on the *distinct* concepts that can be used for modelling. Un-systematic specialisations and variations that can be read as examples rather than separate concepts thus are not counted separately. For example, document, data and file can be used in order to describe different media of knowledge within the product perspective of ARIS-KM. Here, they are subsumed under the concept media which is counted only once. Abstract classes introduced in order to reduce the number of associations are not counted as well.

	ARIS-KM	GPO-WM	KMDL	Knowledge modelling	PROMOTE	PROMET I-NET	Reference Model of KM
additional concepts	knowledge category, documented knowl-edge	knowledge core process, resources: knowledge domain, human knowledge bearer, electronic knowledge base, knowledge carrier	atomic, complex, abstract, unspecified conversion process, knowledge object, information object	KM task (generate, store, apply, distrib-ute), knowledge object, person	kn.-int. task, kn. activity, - role, - tool, - product, - resource, - source, service, - group, process group, person, subject, (aggr.) skill profile, topic, - category, - aggregation	information / knowledge source, information / knowledge object, KM process	resource class knowledge, KM reference process
additional model types	knowledge map, knowledge structure diagram, communi-cation diagram	none	none	none	KM process, kn. process, - structure, - resource, - product, - landscape, - tools, process land-scape, team -, skill environment	none	none
quality of modelling language							
coherence	low	high	high	high	low	medium	medium
freedom from redundancies	medium	medium	high	high	low	high	medium
reusability	medium	high	low	low	medium	medium	high
descriptive power	medium	low	medium	medium	high	medium	medium
appropriateness	medium	medium	medium	high	high	low	low
operationalisability (stage)	low (build-time)	high (build-, run-time)	medium (build-time)	high (build-, run-time)	high (build-, run-time)	-[65]	-[65]

Table 8. *(continued)*

[65] PROMET I-NET and the Reference model of KM do not specify a modelling language but a reference model that structures the concepts focused. Critera judging the quality of the modelling language are applied to this model.

Product perspective. The inclusion of the product perspective by modelling the structure of knowledge as well as artefacts representing documented knowledge is one of the main KM-oriented extensions of most approaches. Explicit knowledge is conceptualized by additional object types such as documented knowledge, knowledge carrier and information or knowledge object. However, this is not always clearly differentiated from already existing concepts used to represent different types of information. GPO-WM and PROMOTE offer the most concepts within this perspective. Other approaches such as KMDL and Knowledge Modelling include only one explicit concept. Only ARIS-KM and PROMOTE provide separate model types for the representation of knowledge structures. These mainly represent taxonomies suited to give a general overview of the knowledge created. Though the Knowledge Modelling approach refers to ontologies used during implementation, they are not explicitly included as a model type. The application of ontologies yet is an extension explicitly discussed in the context of KM (Staab 2002; Staab & Studer 2004). It should thus be included in PKM modelling approaches.

Process perspective. Most approaches are rooted in business process or in workflow modelling and thus it is trivial to conclude that they all choose the process perspective as the main focus. This is reflected by the fact that the largest number of different concepts is offered for the process perspective. Knowledge Modelling and PROMOTE on a more fine-grained level propose the usage of workflows in order to support knowledge work, particularly for selected knowledge-oriented actions. Though the workflow metaphor is not generally suited to model knowledge actions, it may be appropriate for a restricted set of actions that are characterized by a recurring course of steps (section 3.4). The view on knowledge as represented by processes as outlined in section 2.2 is taken only rudimentarily into account by the approaches, e.g., by modelling conversion processes or generic knowledge processes. It is argued here that PKM modelling approaches should be able to model flexible patterns and sequences of knowledge actions without imposing the metaphor of structured processes on them.

A common extension within the process perspective is the classification of selected steps or complete processes as knowledge-intensive or not (section 2.6). GPO-WM provides the most concrete criteria for judging the knowledge intensity of processes. Most common addition is the introduction of generic types of knowledge-oriented activities deemed relevant for analysis and design. The four generic tasks generate, store, apply and distribute as defined by

GPO-WM inspired other approaches, e.g., Knowledge Modelling. KMDL alternatively suggests focusing on the four processes socialization, externalization, combination and internalization. Inclusion of typical knowledge actions appears as a fruitful idea. However, a meaningful set of actions has not been found yet that is specific enough to guide the design of technical infrastructures.

Person perspective. KMDL and PROMOTE offer the largest number of different concepts within the person perspective. Most common extension is the inclusion of concrete individuals. In some cases, they are linked to the product perspective in order to describe concrete skills (ARIS-KM, GPO-WM, KMDL, PROMOTE). However, this concept relates to the instance level. A consistent approach needs an appropriate equivalent on type level, e.g., roles that have defined skill requirements and may have selected KM responsibilities. None of the discussed approaches solves this challenge. PROMOTE suggests the inclusion of knowledge roles but the concept is not further specified and delimited from traditional roles. ARIS-KM also models selected types of relationships between people by including a basic communication diagram. PROMOTE uses the skill environment model to relate individuals to skills and knowledge roles. Structural organisation of KM, the view on knowledge as a skill as well as communication-oriented and collaborative aspects of knowledge work otherwise in many cases are only superficially included within or even disregarded completely by the approaches.

Productivity tool perspective. This perspective is not included in three of the seven approaches compared. If at all, tools are modelled on a very general level by including application systems or general ICT services. Only PROMOTE offers a knowledge tool model that structures tools and applications. Generally, when concerned with technical support of knowledge work, PKM modelling approaches should be able to describe functions or services offered by the technical infrastructure.

Relationships between perspectives. Table 9 indicates the number of different types of direct associations that are offered in order to express the relation between concepts categorized into the same or into different perspectives. This was analysed based on the meta-models depicted in section 4.5. The main diagonal (cells I, V, VIII and X) refers to relationships between concepts within a specific perspective. Generalization/specialization and aggregation relationships that can explicitly be modelled with an approach as well as recursive associations are also counted. Generalisations to abstract concepts that were merely introduced to reduce the complexity of the diagrams are excluded as well as associations within the process perspective common for every approach such as predecessor-successor relationships of tasks or functions.

	product	process	person	productivity tool
product	*(I) taxonomy, ontology*	*(II) resource, result*	*(III) interest, skill, authorship*	*(IV) occurrence*
ARIS-KM	3	2	1	0
GPO-WM	1	3	0	0
KMDL	0	3	0	2
Kn. Modelling	0	4	0	0
PROMOTE	4	5	2	1
PROMET I-NET	2	1	0	0
Ref. Model	1	3	1	0
no. of approaches	5	7	3	2
process		*(V) business proc., knowledge proc. / actions*	*(VI) responsibility*	*(VII) support, control*
ARIS-KM		6	1	1
GPO-WM		6	1	0
KMDL		6	5	1
Kn. Modelling		5	3	0
PROMOTE		6	3	1
PROMET I-NET		3	2	0
Ref. Model		4	3	0
no. of approaches		7	7	3
person			*(VIII) relationships, organisational structure*	*(IX) identity, profile, privilege*
ARIS-KM			2	0
GPO-WM			0	0
KMDL			4	0
Kn. Modelling			1	3
PROMOTE			6	2
PROMET I-NET			1	0
Ref. Model			0	0
no. of approaches			5	2
productivity tool				*(X) architecture, interaction, services*
ARIS-KM				0
GPO-WM				0
KMDL				1
Kn. Modelling				1
PROMOTE				1
PROMET I-NET				0
Ref. Model				0
no. of approaches				3

Table 9. Number of relationships between the modelling perspectives

In the following, firstly the relationships within the four perspective are discussed and afterwards the associations between the perspectives. Concerning the main diagonal, most approaches are able to express relationships within the product, process and person perspective. Exceptions are KMDL and the Knowledge Modelling approach which do not include associations within the product perspective as well as GPO-WM and the Reference Model for KM which do not offer associations within the person perspective. Most types of relationships can be found within the process perspective which reflects the fact that the largest number of different types of concepts is offered here. Links between productivity tools are only included by KMDL, the Knowledge Modelling approach and PROMOTE. This is consistent with the observance that in each case only one type of association is available and supported by the fact that all approaches use the smallest share of their concepts for the description of this perspective.

Processes or actions can be further specified with regard to their relations to explicit knowledge which concerns the link between *the product and the process perspectives* (cell II). It is taken into account by all seven approaches. PROMOTE offers the largest number of associations between these perspectives. From the perspective of KM, links between *the product and the person perspectives* (cell III) are relevant in order to indicate interests, skills or authorship. It is addressed only by three approaches and if this is the case only either by one or by two types of associations. Furthermore, the challenge of describing this relationship on type level in many cases remains unresolved. PKM modelling approaches need to conceptualize this relationship systematically in order to include authorship, required skills and typical sets of skills or interests. The product perspective may act as an integration layer on a semantic level. It allows linking knowledge products to processes independently of their occurrence in concrete systems. PKM modelling approaches nevertheless should be able to express in which systems specific contents occur or at least with which services they are typically handled. This concerns links between *the product and the productivity tool perspectives* (cell IV). So far, this relation can only be expressed with PROMOTE and KMDL.

Relationships between *the process and the person perspectives* (cell VI) refer to the responsibilities of individuals in the context of processes and are included in all approaches. Though informal networks and communities are frequently discussed in the context of KM (section 2.4), none of the approaches provides means to establish links between processes and groups. For example, shared tasks or practices can be used as starting points for the introduction or support of process communities that link process steps or processes within or beyond the boundaries of an organisation (section 2.6). Links between the *process and the productivity tool perspective* (cell VII) are particularly important for the design of technical infrastructures. This relationship is only weakly supported as it can only be expressed with three approaches and in each case only by one type of association. As a general requirement, PKM modelling approaches should offer the possibility to specify this relationship in more detail. Associations between *the person and the productivity tool perspective* (cell IX) refer to privileges and identities of individuals and are taken into account only by two of the analysed approaches. This reflects the comparably low relevance assigned to the productivity tool perspective. In this case, PROMOTE and Knowledge modelling approach both offer basic means to indicate access privileges.

Quality of the modelling language. An overall evaluation and comparison of modelling languages faces two challenges: Firstly, criteria partly may have conflicting relationships and thus cannot be judged in isolation but rather require the appropriate interpretation of trade-offs (Frank 1994, 80). Secondly, models need to serve a large variety of different goals, tasks, roles and individual preferences. Hence, it is not easy to draw a general conclusion regarding the quality of the modelling languages. The set is characterized by diverse ratings. No language can be judged to be generally better than all others. Those languages with a high number of concepts and associations face the danger of a lower coherence and a low freedom from redundancies. A high number of concepts does not necessarily result in a high descriptive power as this criterion also takes the degree into account to which all four perspectives are covered. Some of the approaches lack a clearly defined meta-model which may lead to a low coherence and redundant concepts. Thus, the requirement is posed that PKM modelling approaches always need to define a clear meta-model that adheres to the quality criteria discussed. This particularly includes clear definitions for all concepts and their associations. Furthermore, they are required to offer concepts appropriate for the domain of PKM and thus need to take specifics of knowledge and of knowledge work into account. Ideally, PKM modelling approaches should enable the automatic translation of build-time models to the run-time of a system in order to ensure that the concepts of description are consistently used throughout all design phases and in order to link modelling efforts as directly as possible to the design and use of a system. This also supports iterative systems development because run-time models may be used as a foundation for the re-design of systems in subsequent build-time steps.

In conclusion, the approaches offer some starting points but none of them fully acknowledges the aspects that are characteristic for knowledge work, particularly the need for flexible support by knowledge infrastructures and the fact that knowledge work is not only limited to a process perspective that focuses on knowledge exploitation but also has a strong learning orientation. Table 10 summarizes the requirements for PKM modelling approaches as described before. They can be used in order to specify a new modelling approach for PKM or to enhance existing modelling approaches. They are also relevant for the definition of a meta-model that includes the KWS concept in the last chapter of this work (section 8.3).

Area	**Requirements**: PKM modelling approaches …
starting points and use of models	… are applicable either for the knowledge-oriented analysis and enhancement of business processes or for the specification of technical solutions.
levels of modelling	… offer appropriate concepts for instance-level and type-level modelling.
	…are based on task-level models.
tool support	… include a modelling tool that incorporates the specifics of an approach, i.e. syntactic and semantic rules suited to guide the modelling process.
procedure model	… take KM goals or at least the general orientation of KM into account.
	… provide clear criteria and guidelines for a systematic procedure.
	… explicitly include a procedure model that takes the selection of the intervention area, the knowledge-oriented analysis of business processes as well as the design, implementation, evaluation and refinement of interventions into account.
	… overcome a strict sequential ordering of modelling activities and includes cycles or review phases.
process perspective	… takes flexible patterns or sequences of knowledge actions into account.
product perspective	… offer means to represent knowledge structures, ideally based on ontologies.
person perspective	… are able to represent individuals and their competencies on instance and on type level.
productivity tool perspective	… provide ways for the representation of services offered by the technical infrastructure.
relationships between perspectives	… address all relationships between the perspectives product, process, person and productivity tool.
modelling language	… are based on models that can be translated automatically from the build-time to the run-time of a system.

Table 10. Summary of requirements for PKM modelling approaches

4.7 Summary

This section has provided an overview and comparison of approaches for knowledge-oriented modelling of business processes. Based on the literature on modelling and on KM, criteria have been derived that allow classifying modelling approaches in KM. Concepts of description and extensions can be analysed according to the four perspectives product, process, person and productivity tool and their relationships. Furthermore, criteria have been identified that address the formal quality of the language and its language-domain appropriateness.

Seven approaches for knowledge-oriented business process modelling approaches have been described and discussed in detail, namely ARIS-KM, GPO-WM, KMDL, Knowledge Modelling, PROMOTE, PROMOTE I-NET and the Reference Model of KM. They have been discussed in detail with regard to their characteristics, their suitability in the context of process-oriented KM and the quality of their associated modelling language. PROMOTE appears to be the most advanced modelling approach as it offers many concepts and ideas for the description and support of knowledge work. However, it suffers from high complexity of its meta-model. While GPO-WM makes the most concrete suggestions for knowledge-oriented analysis of business processes, the idea of the closed core process and the generic knowledge-oriented activities create, store, apply and distribute can be easily criticised. KMDL experiments with representation of conversation processes but yet fails to show how this approach can be used to specify supportive KM interventions. ARIS-KM supports modelling processes on a high level of abstraction and thus is rather suited to provide an overview than for the design of EKI. The Knowledge Modelling approach pragmatically focuses on the provision of information resources for workflow steps. PROMET I-NET and the Reference model of KM lack the definition of an own modelling language and share a limitation with many other approaches: the dominant view on knowledge as an object.

Summing up, though relevant extensions for KM are suggested, all approaches fail to conceptualize especially the unstructured, creative, learning-oriented aspects of knowledge work that deal with exploration rather than exploitation of knowledge as well as the need for flexible support by IS. As a consequence, a set of requirements for PKM modelling approaches has been defined. Insights from this chapter amongst others motivate the definition of a meta-model in section 8.3.

5 Enterprise knowledge infrastructures

After dealing with the levels of concepts and of modelling, the third level of technical systems is focused by this chapter. Goal here is to outline possible ways of technical support of knowledge work in general and of KWS in particular. KWS offer three general starting points for technical support: occasions, context and knowledge actions. This chapter primarily focuses on the support of knowledge actions by software services.

5.1 Overview

Figure 29 gives an overview of the chapter structure. Service-orientation is discussed more recently as an approach for the design of software architectures. Concepts and characteristics discussed in this context are suited to conceptualize the flexible support of knowledge actions. Principles of service-orientation and a classification of services therefore are outlined firstly (section 5.2) before the chapter turns to the foundations of service composition as an aspect of SOA specifically is relevant (section 5.3). Then, the chapter turns to technologies and systems applied in order to support knowledge work subsumed under the topic EKI (section 5.4). They are presented and discussed based on a service-oriented perspective. Knowledge services are an important part of EKI. Hence, an overview of the current state-of-the art of the technical functionality that can be used to implement knowledge services is provided (section 5.5). The chapter is concluded with a summary of results (section 5.6).

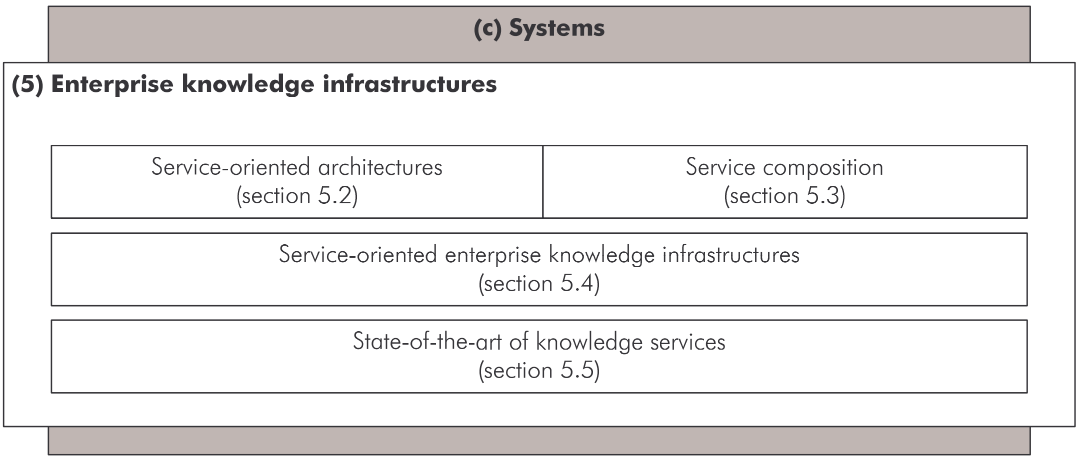

Figure 29. Overview of the chapter *Enterprise knowledge infrastructures*

5.2 Service-oriented architectures

Business processes today change with a faster pace and cost-efficient adoption of IT-support thus is an increasingly high challenge (Richter, Haller & Schrey 2005, 413). SOA more recently are intensively discussed in relation to the enterprise-wide design of application infrastructures as they may help to tackle this challenge They are not a concrete technique or method but rather represent an abstracted view of an enterprise application landscape that highlights selected aspects (Dostal et al. 2005, 8), particularly basic reusable building blocks and their interaction. Major software vendors offer corresponding technological platforms on the market, e.g., SAP promotes the Netweaver platform[66] based on the Enterprise Services Architecture (ESA) framework, IBM has extended its WebSphere platform[67] by an enterprise service bus and Microsoft offers the BizTalk server[68] and includes service-oriented concepts in its .NET platform (Richter, Haller & Schrey 2005, 414f). SOA are driven by open standards and sometimes are even equated with Web services (WS) and associated technologies (Richter, Haller & Schrey 2005, 413). This is not correct, though the WS family of standards is very relevant and most widely used in this context. In the following, the term SOA will be defined and its main characteristics will be outlined (section 5.2.1). This is complemented by a classification of typical services (section 5.2.2).

5.2.1 Definition and characteristics

SOA currently do not pinpoint a standardized architecture or a clearly defined set of terms (Dostal et al. 2005, 11). A SOA is defined as an architecture pattern that describes the structure of an application landscape in the form of abstracted building blocks that each fulfil a well-defined task from a professional view, i.e. tasks from a of business-oriented perspective (Marks & Bell 2006, 1; Richter, Haller & Schrey 2005, 413). Generally, software architectures describe the structure of software systems by means of its components and their relationships (Balzert 2001, 696). Other definitions accentuate specific SOA characteristics, e.g., reusability of and open access to services and independence of platforms or programming languages (Dostal et al. 2005, 11), emphasize selected parts of SOA, e.g., service, service repository and service bus (Krafzig, Banke & Slama 2005, 57) or explicitly link them to related tech-

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[66] URL: http://www.sap.com/netweaver/, last accessed: 2007-12-02

[67] URL: http://www-306.ibm.com/software/websphere/, last accessed: 2007-12-02

[68] URL: http://www.microsoft.com/biztalk/, last accessed: 2007-12-02

nologies such as WS (Erl 2005, 54). Most of them include that SOA are concerned with the architecture of an enterprise's application infrastructure, i.e. they represent the technical structure, constraints and characteristics of components and their interfaces (Krafzig, Banke & Slama 2005, 55f).

The traditional software architecture is focused on the structure of single applications, e.g., their separation into different software tiers. SOA in contrast are targeted at the design of flexible software systems on an enterprise level independent of concrete technologies, e.g., of hosts or of monolithic software systems (Hess, Humm & Voß 2006, 399; Krafzig, Banke & Slama 2005, 82ff). An important feature thus is the abstraction from concrete technical conditions or prerequisites. Main task during implementation of a SOA is the development of an architecture that provides a framework for the design and (re-)use of technical services (Richter, Haller & Schrey 2005, 415). This is followed by the definition and implementation of software services. Comprehensiveness and complexity of this process represents a substantial professional and organisational challenge (ibid.).

A central term for SOA and for this work is *service*. Generally and concisely it can be defined as "a helpful act" (Merriam-Webster 2003, 1137). For a more detailed definition that is related to technical infrastructures, the term component will be outlined firstly. Software components are basic units for the design, implementation and planning of an application infrastructure (Hess, Humm & Voß 2006, 396). They can be used in order to comprehensively structure an application landscape and also single applications down to a fine-grained level. Main goal is the reuse of software. Consequently, components are defined as "… self-contained, clearly identifiable artefacts that describe and/or perform specific functions and have clear interfaces, appropriate documentation and a defined reuse status" (Sametinger 1997, 68ff). *Self-containedness* concerns the ability for reuse without the need to include other components. *Clear identification* requires that a component must not be spread over multiple locations or is intermixed with other artefacts. The requirement of *specific functions* refers to a clear definition of a component's functionality. A *defined reuse status* means that information about the maintenance status and the owners of a component is provided.

A *service* is defined as a distinctive, reusable functionality of a component that typically encapsulates a high-level business concept (Krafzig, Banke & Slama 2005, 59; Marks & Bell 2006, 1; Richter, Haller & Schrey 2005, 413). As can be seen, reusability is also emphasized as a central characteristic of services. It represents an abstracted view on a software component, more specifically its interfaces, and hides details of its implementation (Hess, Humm & Voß 2006, 396). This allows for complexity reduction and higher flexibility. Services are defined based on the business processes of an organisation and tend to be coarse-grained (Richter, Haller & Schrey 2005, 415). A conceptual reason for not choosing a fine-grained level is that otherwise, reuse of existing software components would fast become too complex (Krafzig, Banke & Slama 2005, 112). A technical reason is that the number of interactions between components has to be minimized in order to avoid performance problems experienced with past distributed architectures such as the Common Request Broker Architecture (CORBA). A service may either be implemented within an organisation or alternatively may be offered by an external service provider (Papazoglou & Georgakopoulos 2003, 26). Describing systems in terms of services introduces a different perspective that emphasizes the work performed by an IT system for its user – regardless whether this is a human or another IT system. In other words, it is emphasized how an IT system can serve its user. This view will be helpful for identifying services in the context of the empirical study (chapters 6 and 7).

SOA and related technologies ultimately are means to realize the integrated processing of information. The coupling of business processes requires the integration of the involved application systems (Holten 2003, 41). According to Mertens (2004, 1ff), the objects of integration can be *data*, i.e. data is consolidated on a logical level, *organisational functions*, i.e. tasks are integrated that are fulfilled by different organisational functions, *processes*, i.e. business processes are harmonized, *methods*, i.e. different methods and procedures are aligned, and *software programs*, i.e. software applications and components are consolidated. SOA can be classified based on this as an approach for the integration of software programs with a special focus on the support of process integration by explicitly taking the easy adoption of changes in business processes into account.

Integration of IS is not a new challenge and has been approached for years by a number of approaches and technologies summarized under the term EAI (Kaib 2002). EAI is an umbrella term that denotes the integration of applications across different technical and logical infrastructures (Buhl, Christ & Pape 2001, 7ff). Common practice for the integration of IS is to separate them into layers, e.g., into the three-tier architecture consisting of data level, application logic level and presentation level (Alonso et al. 2004, 16ff; Balzert 2001, 697). Integration principally can be implemented on all three levels. The choice depends on the requirements of the specific scenario. In many cases, an additional so-called *middleware* layer that abstracts from the underlying infrastructure is necessary that enables communication between distributed applications (Bernstein 1996, 88). Common forms of middleware are remote procedure call-based systems, transaction processing monitors and object brokers such as CORBA (Alonso et al. 2004, 33). These approaches and technologies share many characteristics with SOA outlined so far, e.g., messaging between services and abstraction from implementation platforms. Differences can be found in the principles that govern the design of SOA, which are platform-independent service descriptions, loose coupling and dynamic binding of services and service repositories (Erl 2005, 37). They are outlined in the following:

Platform-independent service descriptions. Services are described by one or more formal or informal service descriptions (Erl 2005, 37). They represent a communication agreement also referred to as *service contract*. It establishes a formal definition of the service's communication interface. At least, it specifies service name and the so-called signature that describes possible input and output parameters of service operations that incorporate the functionality of a service. The Web Services Description Language (WSDL)[69] is a standard defined by the World Wide Web Consortium (W3C) that structures the interface specification within a WSDL document and defines a basic service model. It is fundamental for many other Internet standards related to service-orientation. Independency of concrete technical platforms is enabled by including additional information within the interface description, specifically the network location of services as well as data transport protocols used such as the Hypertext Transfer Protocol (HTTP) or Simple Object Access Protocol (SOAP) (Alonso et al. 2004, 166). Other parts of the interface specification are the determination of the way of interaction and the definition of groups of operations. A service contract may also provide formal or informal information about the purpose, functionality, constraints and usage of a service (Krafzig, Banke & Slama 2005, 59). Its definition can be characterized as a formal contract between service provider and service user and thus as a part of a service-level agreement (SLA) (Hess, Humm & Voß 2006, 397). Service descriptions also are a means for the discovery and interaction of services and thus the foundation of loose coupling (Erl 2005, 35).

Loose coupling of services. Loose coupling enables higher flexibility to adapt an application landscape to changing business processes and also fosters software reuse. Coupling refers to the degree of mutual dependency of software components and can affect a number of different properties (Krafzig, Banke & Slama 2005, 46ff). It is characterized as loose if the relations

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[69] URL: http://www.w3.org/TR/wsdl20/, last accessed: 2007-12-02

between components are implemented indirectly by means of intermediaries instead of establishing direct connections, if the components are also able to communicate asynchronously instead of only synchronously and if the interaction of components is independent of operating systems and programming languages (ibid.). Loose coupling is one of the foundations for the dynamic binding of services.

Dynamic binding of services. Binding refers to the identification of services and the usage of their functionality. During build-time, this can be supported by service repositories that are used in order to identify appropriate services and to retrieve their interface description. Run-time binding refers to the automatic selection of services and their application during software execution. Three increasingly advanced levels of run-time binding can be distinguished (Krafzig, Banke & Slama 2005, 63f): (1) Services are looked-up based on their names in a specific directory, e.g., a client application selects printer services based on the printer name chosen by the user. (2) Services are looked-up based on their properties, e.g., printing services based on the printer location and paper format. In these two cases, the service definition is already known during build-time and their usage is implemented correspondingly. (3) Services may also be discovered based on properties without knowledge about their interfaces, e.g., a printing service with the right properties is selected without knowledge of the printing interface. In this case, mechanisms need to be implemented on the client side that enable the client to dynamically adapt to the interface and to create valid requests. This can be a complex challenge. Although service look-up and binding during development time is a far simpler model, it already is sufficient for most purposes and supports the reuse of services (Krafzig, Banke & Slama 2005, 62). Run-time binding should always be implemented as simply as possible because complexity rises fast (Krafzig, Banke & Slama 2005, 64).

Service repositories. As noted, service repositories enable the dynamic binding of services by offering the facilities for service discovery and the information necessary for their use (Krafzig, Banke & Slama 2005, 60ff). They can be used in the context of one or of multiple organisations, e.g., for cross-organisational application integration.[70] A common standard is the Universal Description, Discovery and Integration (UDDI) specification that defines a framework for description and discovery of WS (Alonso et al. 2004, 174f).

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[70] An example for a publicly available directory that provides examples of Web services can be found under the URL: http://www.xmethods.org, last accessed: 2007-12-02.

SOA offer some starting points for the description and implementation of technical support of KWS. Service descriptions, loose coupling, dynamic binding of services and service repositories are foundations for service composition that is relevant for the integrated, platform-independent and flexible support of knowledge actions. This will be discussed in more detail in section 5.3 after an overview of different types of services.

5.2.2 Types of services

Different types of services are distinguished based on the function they fulfil within a SOA. The service types may differ fundamentally with regard to reusability, implementation complexity, maintainability and frequency of change (Krafzig, Banke & Slama 2005, 67ff). The literature distinguishes different types based on the traditional three-tier-architecture into data, function and access layer services with an additional process layer that focuses the composition of services in order to support the business processes of an organisation (Hess, Humm & Voß 2006, 398; Krafzig, Banke & Slama 2005, 67ff; Marks & Bell 2006, 51; Woods 2003, 29ff). However, the analogy between tiers and service layers should be used with caution. SOA are about abstraction from single software applications and thus the layers of a SOA play a different role than that in application systems (Krafzig, Banke & Slama 2005, 82ff). Consequently, the four general types of infrastructure, integration, composition and access services are distinguished here, which does not suggest a direct relationship to the three-tier-architecture (Hess, Humm & Voß 2006, 399; Krafzig, Banke & Slama 2005, 67ff). These general types of services in the following will be detailed by more specific services. Nevertheless, the idea of hierarchically ordered tiers is reflected by the fact that they are structured based on a layered architecture (Figure 30). A service on a particular layer is based on other services from lower layers and provides functionality for higher layers.

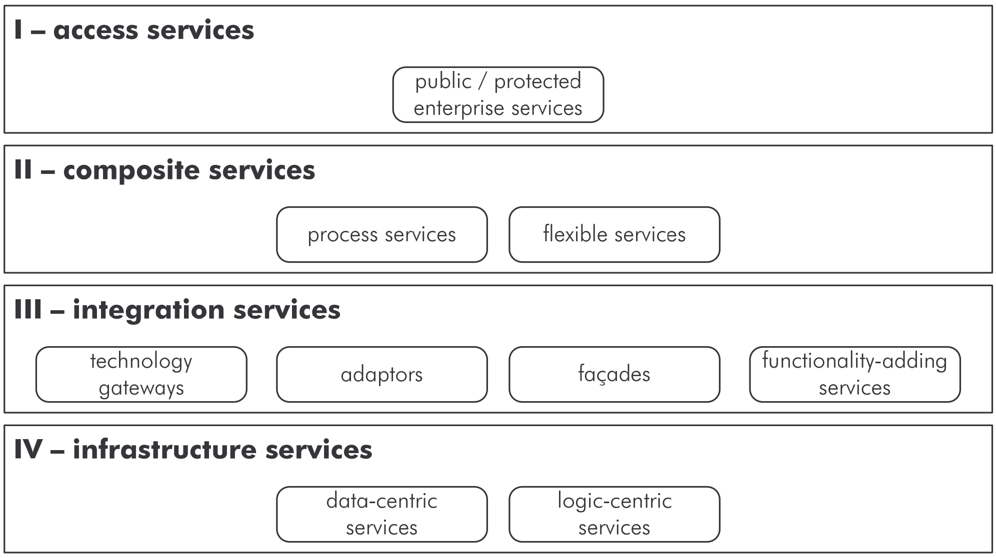

Figure 30. SOA layers and types of services[71]

Infrastructure services. The foundation of a SOA is provided by two types of infrastructure services: data-centric and logic-centric services. *Data-centric services* encapsulate data as well as the logic for their modification and access which ensures data consistency. They also implement transaction management, locking mechanisms and persistent storage. Data services ideally are delimited according to the major business entities of an organisation, e.g., a separate service is responsible for customer data and one for employee data (Krafzig, Banke & Slama 2005, 70). However, this is at the cost of performance because many transactions span multiple business entities and thus a significant overhead would be introduced into the overall system (Krafzig, Banke & Slama 2005, 71f). In practice, compromises thus will have to be found. *Logic-centric services* encapsulate business logic such as calculation algorithms. In traditional applications, it is contained in software libraries or business frameworks. An insurance product service that computes fees, payments or refunds is an example of this type of service (Krafzig, Banke & Slama 2005, 72f).

Integration services. Integration services of this type bridge design gaps or technological incompatibilities and provide abstractions from infrastructure services. They can be further distinguished into four types: *Technology gateways* translate between different technologies and are helpful for the integration of legacy systems, e.g., by providing an abstracted view on functions offered by these systems that later on can be exchanged without the introduction of changes on the user's side. *Adaptors* map signatures and message formats to client

[71] based on Krafzig et al. (2005, 67ff)

requirements. *Façades* are the pendant to the design pattern of the same name (Gamma et al. 1995, 185ff) and provide alternative views on one or more existing services, e.g., in order to restrict access for an external client. *Functionality-adding* services complement other services with additional functions without changing them. They are required, e.g., when source code of third-party services is not available or when responsibilities and tasks of different development teams need to be disentangled.

Composite services. A composite service is a service implemented by combining the functionality offered by other services (Alonso et al. 2004, 245). Composite services themselves are represented as services and in turn can be invoked by or included as a part of other services. Service composition thus can be iterated and allows for the definition of increasingly complex applications by the stepwise aggregation of services (Alonso et al. 2004, 247). This type of service can be detailed into process services and flexible services. *Process services*, also called orchestrated services, specify the order and the conditions that govern how services are invoked and thus represent a means to separate the process logic of an organisation from the logic implemented in other layers, e.g., from the business logic contained by infrastructure services (Krafzig, Banke & Slama 2005, 113). This idea is not new as it represents one of the foundations of workflow management (Oberweis 2005, 21). New or changed business processes ideally can be supported by (re-)defining process services which enables for more flexible reactions to changes (Richter, Haller & Schrey 2005, 414). The main difference compared to the traditional composition of application functions is that the components that provide services remain programmatically unaltered (Erl 2005, 200). Integration takes place solely on the level of component interfaces (Alonso et al. 2004, 247). Though the type of *flexible services* is not explicitly discussed in relation to SOA, it is highlighted here in order to acknowledge the specifics of knowledge work. The reason is that process services at best are suited to support routinized knowledge actions. Otherwise, they typically do not follow a structured sequence (section 3.4.4). Furthermore, process services currently focus on application-to-application interaction but knowledge actions frequently require the collaboration between people. These two types of composite services will be described in more detail in the next section (section 5.3).

Access services. The end-points used to access a SOA are subsumed by access services. It is specifically referred to *public* or *protected enterprise services* that offer interfaces for users outside the boundaries of an organisation (Krafzig, Banke & Slama 2005, 81f). They are pointed out due to special requirements concerning decoupling from business partners, implementation of security mechanisms, billing and SLA. From a user perspective, services of all layers are initiated and their results are received by means of *application front-ends*. Examples are Web interfaces and office applications.

5.3 Service composition

Service composition concerns the definition of composite services, i.e. the process of how services are composed into a coherent whole. Though the need to link EKI to knowledge actions is recognized, e.g., in relation to architectures that structure their functionality, so far it has not been detailed how this could be achieved (Bach 1999, 68ff; Riempp 2004, 126). It is highly probable that the knowledge actions described in section 3.4.4 will be supported by more than one service. For example, expert search may require the application of an Intranet search engine in order to identify the author of a document as well as a contact directory in order to look up his email address. Users then need to manually transfer information from one service or system to another. Service composition addresses the combination of services in order to support more complex tasks and thus represents a possible starting point to resolve this challenge. This section thus describes the state-of-practice of the creation of process services in more detail (section 5.3.1) and ways for the flexible composition of services which is specifically relevant in this context (section 5.3.2).

5.3.1 Process services

WS-BPEL is an industry specification that standardizes the creation of process services and represents the current state-of-practice. WS-BPEL (or short: BPEL) was called Business Process Execution Language for WS (BPEL4WS) before it was approved by the OASIS Open standardization committee.[72] BPEL is layered on top of the service model defined by WSDL (OASIS 2007, 11). BPEL is designed for the specification of abstract as well as of executable processes (Khalaf et al. 2005, 319). Abstract processes are business protocols that specify the flow of interactions a service may have with other services. Executable processes define the implementation logic of a service (Khalaf et al. 2005, 319). The former corresponds to the external behaviour of a service and thus concerns coordination (Alonso et al. 2004, 284). In

[72] The description is based on the current version WS-BPEL 2.0. Its specification can be found at URL: http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.html, last accessed: 2007-12-02.

the context of this work, mainly executable processes are relevant. They are published and accessed just as WS.

BPEL distinguishes between two types of activities: basic activities and structured activities. *Basic activities* describe elemental steps of the process behaviour (OASIS 2007, 84ff). These are combined by nesting in structured activities that represent control semantics. Three types of basic activities are used to specify interactions with its partners (OASIS 2007, 24ff): *Receive* is used if the process should wait until a matching message arrives. They are used for starting the process or to wait for results of method invocations by the process. *Invoke* is applied either for one-way communication between process and a WS or if it should wait until the response of a WS invoked before is received. *Reply* is used if messages should be sent out by the process in response to operations invoked by clients. Other basic activities are *assign* for manipulation of process data, *wait* used in order to delay the process for a specified time interval, *throw* for signalling user-defined faults, *terminate* applied in order to stop the process and *empty* to do nothing for a step, e.g., in order to catch and suppress faults or for synchronization purposes.

Structured activities prescribe the order in which other actions are executed (OASIS 2007, 98ff). They either may contain basic activities and other structured activities. *Sequences* structure activities in a sequential order. *If activities* provide conditional behaviour. They consist of one or more branches that are executed upon specified conditions. *While activities* execute activities they contain as long as a Boolean condition is evaluated to be true. *RepeatUntil activities* execute contained activities until a condition is assessed as true. *Pick* waits until one out of a set of specified events occur and executes the corresponding activities. *Flow* does not complete unless all contained activities are fully executed and thus can be used for parallel execution and ensuring concurrency. *ForEach* is used in order to execute nested activities a specified number of times determined by a counter value.

Functionality offered and required by the process is specified by means of so-called *partnerLinks*. Roles are used in order to specify the interface required to exchange messages with the process. Messages are defined using WSDL and are composed of a set of named and typed parts based on the XML Schema[73] type system. Variables are used to define containers that

[73] XML Schema provides means for defining the structure, content, and semantics of XML documents. URL: http://www.w3.org/XML/Schema, last accessed: 2007-12-02

hold data. They allow BPEL processes to maintain a state (OASIS 2007, 45). The state includes messages exchanged as well as intermediate data used to compose messages or to steer the control flow. Variables are specified as reference to a WSDL message type, simple or complex XML Schema type or XML Schema element. Each variable is declared within a scope where it belongs to and is visible within. Scopes in BPEL provide the context which influences the execution behaviour of enclosed activities (OASIS 2007, 115). BPEL supports five types of expressions (OASIS 2007, 57): Boolean expressions, e.g., for the specification of conditions in *if* and *while* activities, deadline expressions to define endpoints in time, duration expressions to specify time lengths, unsigned integer expressions, e.g., in order to set values of BPEL elements, and general expressions, e.g., for the assignment of values to variables. Standard language for expressions and queries is XPath[74], a specification that defines how elements and attributes in XML documents are transformed and presented.

BPEL includes exception handling in order to compensate actions and to return into a valid state before an exception occurred (Alonso et al. 2004, 290). This is achieved by the definition of fault handlers that dictate the handling of exceptions within a defined scope. BPEL combines exception handling with transactional techniques (Alonso et al. 2004, 291). It is possible to define compensation handlers in order to undo the execution of activities within a specified scope. Compensation handling is a foundation for the support of long-running transactions (OASIS 2007, 118f). Compensation handlers are executed in the case a transaction needs to be rolled back. The ACID principle[75] in this context needs to be relaxed because long-running transactions access resources that cannot be locked for the whole time of a transaction (Alonso et al. 2004, 226ff). Furthermore, life-cycle management concerns the creation and destruction of processes as well as the routing of messages to the correct instance of a process (Khalaf et al. 2005, 330ff). Event handling concerns the definition of logic to manage events such as arrivals of messages by means of event handlers that can be assigned to every activity (Khalaf et al. 2005, 330ff).

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[74] URL: http://www.w3.org/Style/XSL/, last accessed: 2007-12-02

[75] ACID is an acronym used in the context of data management that summarizes four basic requirements for valid transactions (Gray 1981; Gray & Reuter 1993, 6; Kratzer 2001): (1) atomicity, i.e. a transaction is to be treated as a single logical unit that needs to be committed completely, (2) consistency, i.e. a database can only be transformed from a consistent state into another consistent state, (3) isolation, i.e. a transaction has to be committed separately and isolated from all other (potentially simultaneously) committed transactions, (4) and durability, i.e. the state reached as the result of a transaction has to be made persistent.

BPEL primarily is designed to support automated processes based on WS. Interaction with human users is currently not included. Since this is required in many settings, an extension of the standard under the working title BPEL4People has been proposed (Kloppmann et al. 2005a). It includes a set of generic human roles such as process initiator, process stakeholder or activity owner. *People links* are used to represent groups of people who participate in the process. Actual individuals are identified during runtime by means of queries to organisational directories assigned to the people links. BPEL4People proposes the introduction of a new type of basic activity called human activity that is realised by a human being. Their definition includes properties, states and defined operations for client applications. Other propositions for extensions comprise the inclusion of Java code under the title BPELJ (Blow et al. 2004), e.g., for the orchestration of long-running transactions with Java components or in order to support advanced transactional capabilities of sub-processes and the specification of sub-processes that can be reused within the same or across multiple BPEL processes referred to as BPEL-SPE (Kloppmann et al. 2005b).

There is no standardized modelling language defined for BPEL. Service orchestrations can be modelled with UML activity diagrams (Engels et al. 2005). More recently, BPMN has been proposed with the intention to support typical process modelling activities of both, business analysts and technical analysts, as well as to enable a straightforward mapping to BPEL (OMG 2006, 9). Use of only one modelling language in different stages such as process analysis, process design and implementation of workflows is desirable for frictionless support (Recker & Mendling 2006). However, translation of BPMN to BPEL implies challenges due to varying capabilities of the languages with regard to represent the modelling domain, discrepancies concerning the definition of the control flow and the different process representation paradigms, i.e. graph oriented vs. block-oriented description of processes (Recker & Mendling 2006). Translation algorithms proposed such as that by Ouyang et al. (2006) are limited to a subset of BPMN (Recker & Mendling 2006). This conclusion holds even more true for approaches that try to translate semi-formal process modelling languages such as event-driven process chains to BPEL. BPEL may also be modelled directly with graphical notations of tools such as Oracle BPEL Designer[76] or IBM WebSphere Business Modeler[77] that are mainly focused on the implementation stage.

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[76] URL: http://www.oracle.com/technology/products/ias/bpel/index.html, last accessed: 2007-12-02

The actual implementation of service composition requires a composition middleware that offers a composition model and language, i.e. ways to express the specification how services are combined, also referred to as composition schema, a development environment, i.e. a graphical user interface that supports the creation of composition schemes, and a run-time environment that executes the composition schema by invoking the respective service (Alonso et al. 2004, 249f). Examples for software products that offer such a middleware are SAP Netweaver[78] and JBoss jBPM[79].

WS-BPEL 2.0 has undergone major changes from version 1.1 to 2.0 (Sys-Con 2007). The partner concept that groups several partnerLinks is no longer available, some syntactic changes have been made to the XML Schema of BPEL, XML expressions are represented within XML elements instead of XML attributes in order to enable more complex query expressions, e.g., based on XPath 2.0, links used to specify synchronization dependencies between nested activities in a flow are more restricted with regard to their scope in order to simplify compensation handling, formerly unspecified aspects of messaging have been complemented, repeated invocation of compensation handlers has been specified as restricted and data manipulation has been changed significantly by the definition of a data model that represents BPEL variables as well as the description of mapping rules for other languages such as XPath. Migration thus will not be an easy task except for very simple processes.

5.3.2 Flexible services

Generally, flexibility can be defined as "… the capability to adapt to new, different, or changing requirements" (Merriam-Webster 2003, 478f). In the following, different classifications of PAIS will be outlined in order to establish a foundation of what could be understood under the type of flexible services. Different classes of PAIS will be described afterwards based on two selected classification dimensions. This also allows classifying the case handling approach that will be presented subsequently in more detail as it represents a suitable foundation for the definition of flexible services.

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[77] URL: http://www.ibm.com/software/integration/wbimodeler/, last accessed: 2007-12-02

[78] URL: http://www.sap.com/netweaver/, last accessed: 2007-12-02

[79] URL: http://www.jboss.com/products/jbpm, last accessed: 2007-12-02

Classification of process-aware information systems

PAIS are classified according to four dimensions: based on life-cycle phases, organisational boundaries, the nature of participants or resources and the structure and predictability of processes (Dumas, van der Aalst & ter Hofstede 2005, 11f):

PAIS life-cycle. The PAIS life-cycle can be distinguished into four phases (Dumas, van der Aalst & ter Hofstede 2005, 11f; Hammori, Herbst & Kleiner 2006, 42f; zur Mühlen & Hansmann 2002, 389ff): (1) During *analysis*, business processes are surveyed and evaluated for enhancements, which results in business process models and requirements for IT support. (2) In the subsequent *design phase*, processes are defined or redefined and enhanced based on these requirements. (3) A part of them are refined to workflows during an *implementation phase*. (4) They are executed in an *enactment phase*, e.g., by means of WfMS. Subsequent analysis of audit data may be used in order to generate knowledge about business processes that is applied within a new iteration of the life-cycle. Analysis and design typically are supported by business process modelling tools (sections 2.5 and 4.2). Audit data gained during workflow monitoring may be analysed using visualization and workflow mining techniques (Hammori, Herbst & Kleiner 2006; van der Aalst et al. 2003). The ProM framework integrates the functionality of several existing process mining tools and is an example of a recent approach in this area (van Dongen et al. 2005). Flexibility in terms of this classification concerns the easy transition from one phase into another and thus the integrated support of ideally all phases.

Organisational boundaries. Traditional PAIS are mainly oriented towards supporting processes within the boundaries of one organisation (Dumas, van der Aalst & ter Hofstede 2005, 15). During the last years, the automated support and integration of inter-organisational processes has been increasingly focused. Based on the number of interaction partners they can be distinguished to involve one-to-one, one-to-many and many-to-many interactions. The integration of inter-organisational processes in order to support electronic business-to-business transactions in the context of electronic business is an example of a typical application field (Corsten & Gössinger 2002, 205). Service-orientation promises to resolve some of the challenges of inter-organisational systems integration (section 5.2.1). Here, flexibility is understood as the ability to easily adapt and change technical infrastructures to business processes as well as to easily include new business partners.

Nature of participants and resources. PAIS can be distinguished to be human-oriented or systems-oriented (Georgakopoulos, Hornick & Seth 1995, 128) or more precisely, into supporting person-to-person, person-to-application and application-to-application processes (Dumas, van der Aalst & ter Hofstede 2005, 12f). *Person-to-person* processes involve tasks that require human intervention. *Application-to-application* processes consist of tasks that are only performed by software systems. *Person-to-application* processes include both types of tasks. Flexibility particularly is required if humans are involved and thus in this context understood as the ability to support human tasks.

Structure and predictability of processes. The degree of structure and predictability of processes determines the degree to which processes can be automated and ultimately the class of tools used for their support (Dumas, van der Aalst & ter Hofstede 2005, 12f). Picot & Reichwald (1987, 70ff) distinguish between one-time, regular and routine processes. Another classification differentiates ad hoc, administrative and routine processes (Georgakopoulos, Hornick & Seth 1995, 124ff). These taxonomies are based on multiple criteria, predominantly the complexity and task structure of processes. Other authors suggest to focus solely on the predictability of processes which is preferred here and distinguish between unframed, ad hoc framed, loosely framed and tightly framed processes (Dumas, van der Aalst & ter Hofstede 2005, 13f; van der Aalst, Stoffele & Wamelink 2003, 309). *Unframed* processes have no explicit process model associated with them. *Ad hoc-framed* processes are based on a priori defined models but they are subject to frequent changes. *Loosely-framed* processes are defined a priori but during execution allow deviations from their model within defined limits. *Tightly-framed* processes correspond to workflows that are defined a priori and leave no room to alter the process model defined. Flexibility in this context can be understood as the ability to adapt the process model to changing requirements upon execution.

Classes of process-aware information systems

When being concerned with the support of knowledge actions, then particularly processes with a low degree of predictability are relevant as well as the need to support not only application-to-application processes but also person-to-application and person-to-person processes. Hence, the corresponding criteria are used as dimensions within a classification of PAIS depicted in Figure 31. Nevertheless, flexibility in terms of the PAIS life-cycle is also relevant, e.g., in order to enable the refinement of routines by supporting users during analysis, definition and change of composite services. The system classes are described in the following in order to provide an overview.

Tracking systems help to distribute tasks between people and to keep on track about their activities (Dumas, van der Aalst & ter Hofstede 2005, 12f). *WfMS* integrate tasks conducted by people or technical systems and thus support people-to-application processes (zur Mühlen & Hansmann 2002, 388). *Service composition* based on the current BPEL specification is limited to application-to-application integration and tightly framed processes.

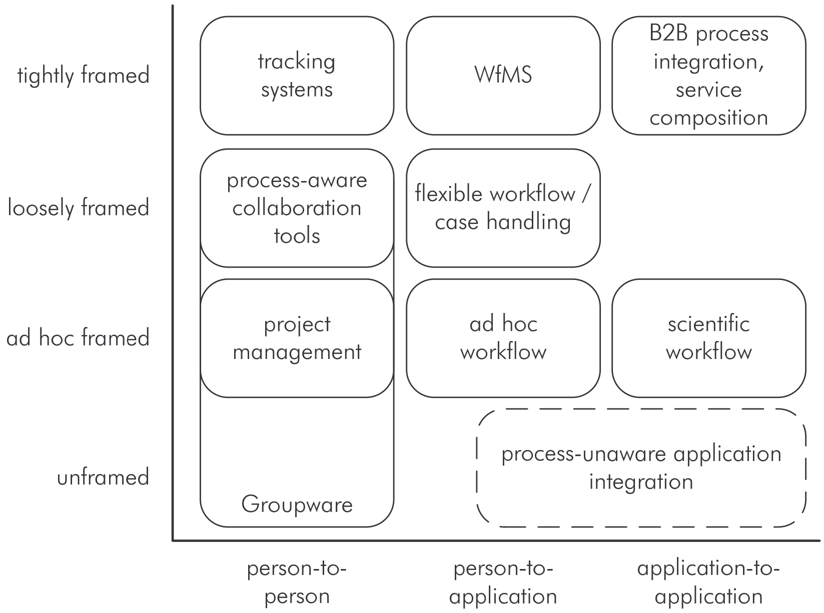

Figure 31. Classification of PAIS[80]

Some *collaboration tools* allow the definition of loosely framed processes and thus can be characterized as process-aware. Examples are Microsoft Leadline[81] that structures communication sessions and Caramba that supports pre-defined as well as ad hoc processes within a collaborative team environment (Dustdar 2004). *Flexible workflows* allow deviations from the process model upon execution (Dumas, van der Aalst & ter Hofstede 2005, 14). Flexibility can be introduced already during design-time on type level or during run-time on workflow instance level (Oberweis 2005, 33). The former can be implemented by anticipating alternative execution paths or leaving parts of the workflow unspecified until actual execution (Heinl et al. 1999, 80ff) and the latter by allowing modifications on workflow instances in

[80] based on Dumas, van der Aalst & ter Hofstede (2005, 15)

[81] URL: http://research.microsoft.com/research/scg/leadline.aspx, last accessed: 2007-12-02

order to incorporate unforeseen changes. Examples for related approaches and research prototypes are ADEPTflex (Reichert & Dadam 1998), METEOR (Luo et al. 2000) and WIDE (Casati et al. 1998). A software product that supports ad hoc as well as flexible workflows is the TIBCO iProcess Suite[82]. *Case handling* is another approach for supporting loosely framed processes that focuses on the case that a process deals with and its associated data rather than the control flow of the process. It is described in more detail below.

Project management tools help to structure the cooperation in teams, e.g., by the definition of project charts. *Ad hoc workflows* are defined instantly by users before they are executed (Heinl et al. 1999, 82) and thus are a typical example of support of ad hoc framed processes. Just as other types of workflows, they may contain tasks performed by humans as well as automated tasks. *Scientific workflows* or grid workflows structure the processing of large data sets and the execution of scientific experiments on distributed resources (Yu & Buyya 2005, 44) and thus are concerned with the coordination of automated tasks. *Groupware* focuses on the support of unframed collaborative processes but also ad hoc framed and loosely framed processes and thus may comprise process-aware collaboration tools and project management applications. It is discussed in more detail in section 5.5.3. *Process-unaware application integration* is the residual category that contains all systems that do not separate between process-logic and application logic.

Case handling

When being concerned with the support of knowledge actions by composite services, person-to-application processes are relevant because many steps of knowledge actions require human intervention, e.g., related to direct communication between experts, and others can be automated by appropriate services, e.g., the identification of individuals based on a structured competency directory. Furthermore, the class of loosely framed processes is relevant here as knowledge actions cannot be planned completely in advance though it may be possible to describe the general steps required to accomplish them. Hence, flexible workflows and case handling are particularly relevant. The case handling approach in the following will be described in more detail as it offers starting points for the support of knowledge actions.

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[82] URL: http://www.tibco.com/software/business_process_management/iprocess_suite/, last accessed: 2007-12-02

The underlying assumption of case handling is to focus on *what can be done* instead on *what should be done* as it is defined with control flow-oriented workflows (van der Aalst & Berens 2001, 41). The approach has three important characteristics that make it particularly relevant for support of knowledge actions: the focus is on the case, the process is driven by data and the model implies implicit routing (van der Aalst & Berens 2001).

The focus is on the case. Workflow descriptions comprise five main aspects: (1) function, i.e. the single activities to be performed, (2) behaviour, i.e. the way and particularly the sequence in that activities are conducted, (3) data, i.e. the structure and type of data changed by a workflow, (4) actors, i.e. the entities that perform activities in workflows, and (5) support, i.e. the tools and technologies applied to conduct activities (Jablonski 2001, 99ff).[83] In order to enhance the flexibility of workflows, the case handling approach shifts the emphasis of control flow-oriented workflows from function and behaviour to the data aspect, i.e. from the activities to be performed to the objects or in other words, the case a workflow deals with (van der Aalst, Weske & Grünbauer 2005, 134ff). Cases have a structure and a state and are represented by data objects. Users are not only confronted with the workflow tasks they are required to do as usual in traditional WfMS but rather they are supported in getting a more comprehensive picture of the case that a workflow handles by presenting all data objects they are allowed to access. Hence, instead of offering a fragmentary, task-centred view on parts of a case, the approach seeks to provide as much information about a case as possible.

The process is driven by data. A case is not primarily determined by the status of the control-flow but rather by that of its data objects. All data objects are linked to activities and can be represented by means of electronic forms to the user. Mandatory data objects need to be entered in order to complete a corresponding activity. Restricted data objects can only be entered within a set of specified activities. Free data objects are not linked to specific activities and may be changed at any time during the process. The actual progression of a case ultimately is determined by available information because the activities to be executed are derived based on the state of data objects. Case handling thus sometimes is characterized as being context-aware. The activities are executed by actors that are grouped by means of roles. Roles are used to flexibly query all activities that require attention and that a user is

[83] Oberweis (2005, 24ff) offers a comparable classification that includes business rules and exception handling.

allowed to access. An actor is able to execute multiple activities at once by filling out multiple data objects.

The model implies implicit routing. In traditional WfMS, the execution of a workflow is fully controlled by the workflow schema defined in advance. The case handling approach allows users to deviate from the pre-defined schema, i.e. they may alter the actual control flow by means of specific operations offered by the case handling system. This is referred to as implicit routing. Whereas other types of workflows route cases along control flows and thus prescribe a way of conduct, case handling regards processes only as a general recipe for handling cases. Therefore, three types of roles are specified for every activity: the execute role carries out activities or starts a process, the redo role is able to undo activities and the skip role may pass over activities. Activities have a corresponding status, which can either be initial, ready, running, (by-)passed, completed or skipped. Besides introducing more flexibility into workflow execution, these principles make the workflow models substantially simpler. The redo role for example allows realizing loops easily by having the right to return an activity from passed, skipped or completed state back to initial state and the skip role eases passing over activities which otherwise would need to be explicitly modelled. The approach also includes further roles in order to avoid undesirable effects, include responsibilities for cases and model the authorization to access and change cases. Case handling separates roles used for distribution of work and those used to determine the authorization to access an activity.

The approach is supported by the system FLOWer (Berens 2005; van der Aalst, Weske & Grünbauer 2005, 147ff). Van der Aalst et al. (2005, 148ff) illustrate case handling with the treatment of claims by an insurance company. Here, a case corresponds to a claim for the financial compensation of a damage. It needs to be registered, data from all involved parties needs to be collected, e.g., medical reports, police reports and witness statements, its compensation needs to be decided and finally it is closed. Several ones of these activities can be completed at once by, e.g., by entering data concerning medical or police reports available already during the registration step. If changes occur, e.g., the amount of the estimated financial damage changes, then activities may be redone by users possessing the redo role. If no information from witnesses needs to be collected due to an only marginal damage this activity can be left out by someone owning the skip role.

The case handling approach can be used to enhance the flexibility of composite services targeted at the support of knowledge actions, e.g., by executing multiple steps of knowledge actions at once based on context data available and by especially by introducing more flexibility by allowing skipping or redoing steps of a knowledge action. Consequently, process services in order to denote the control flow-oriented composition of services and case handling services as a specialization of flexible composite services will be distinguished in the following.

5.4 Service-oriented enterprise knowledge infrastructures

During the last years, a large number of approaches and software systems have been developed that target the support of knowledge work, e.g., DMS (Forquer, Jeliniski & Jenkins 2005; Gulbins, Seyfried & Strack-Zimmermann 2002; Kampffmeyer & Merkel 1997; Sutton 1996), CMS (Boiko 2002; Zschau, Traub & Zahradka 2002), WfMS (Jablonski 2001; Jablonski, Böhm & Schulze 1997; van der Aalst & Berens 2001; Wargitsch, Wewers & Theisinger 1998), Groupware (Ellis, Gibbs & Rein 1991; Grudin 1994; Johansen 1988), data warehouses (Chamoni & Gluchowski 1998; Inmon 2002), group support systems (Dennis 1994; Zigurs & Buckland 1998), search engines (Baeza-Yates & Ribeiro-Neto 1999; Lahme 2004), communication systems (Hansen & Neumann 2001, 434ff; Tanenbaum 2003, 588ff) and artificial intelligence technologies (Haverkamp & Gauch 1998; Kerschberg et al. 2004; Resnick & Varian 1997). The diversity is reflected by different terms such as knowledge infrastructure, knowledge management system, knowledge-based information system, knowledge-oriented software, knowledge warehouse or organisational memory (information) system (Maier 2004, 79). Another group of software systems relevant in this context targets the support of learning and comprises, e.g., e-learning suites and learning management platforms, portals or systems (Baumgartner, Häfele & Maier-Häfele 2004; Dittler 2003; Hettrich & Koroleva 2003; IEEE 2001; Paulsen 2003; Röder 2002; Schulmeister 1997; Wolpers & Grohmann 2005).

EKI is used as an umbrella term for organisation-wide platforms that offer services for publication, discovery and retrieval of information and knowledge, collaboration and learning in order to support knowledge work (Maier, Hädrich & Peinl 2005, 71). They integrate functionality from the aforementioned large variety of root systems. The term emphasizes the need for the integration of systems to an enterprise-wide platform. In the following, EKI will be described from a service-oriented perspective. The main extension is the inclusion of service composition as described before in order to support knowledge actions. Furthermore, service-orientation enables the automatic selection of EKI services based on a set of given requirements independent of their concrete technical implementation (Woitsch & Karagiannis 2005). Firstly, the main characteristics of EKI are described as a foundation for the definition of the term (section 5.4.1). Its architecture and related types of services are outlined subsequently (section 5.4.2).

5.4.1 Definition and characteristics

In the following, the main characteristics of EKI will be summarized briefly (Maier & Hädrich 2006, 48ff; Maier, Hädrich & Peinl 2005, 71ff).[84] They imply requirements that need to be fulfilled by EKI and can be used to decide whether an infrastructure can be denoted as a knowledge infrastructure or not.

Goals. Primary goal of EKI is to enhance the organisational effectiveness by a systematic management of knowledge. The design of an EKI is part of an initiative that also comprises establishment of person-oriented and organisational instruments for improving the productivity of knowledge work (Maier 2004, 55).

Comprehensive platform. EKI are ideally used throughout the whole organisation. They are not targeted at support of a single KM initiative but rather represent a platform that can either be realized as an integrating base system on that specific KM applications are built or based on a comprehensive software product, e.g., a KM suite such as Open Text Livelink Enterprise[85], that is used as is or with customizations and extensions. The platform needs to enable the integration of data, participants, software functions as well as processes and has to offer security mechanisms.

Specifics of knowledge. EKI are used for handling explicit knowledge from an ICT perspective (section 2.2). It is represented by electronic contents complemented with meta-data that represents context information (section 2.2). Ontologies can be used in order to structure and integrate terms and their relations included within the meta-data. EKI also support sharing of implicit knowledge by aiding the identification of experts and communication between

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[84] The textbook by Maier, Hädrich & Peinl (2005) gives a comprehensive overview of technologies, standards, and systems relevant for EKI. It is based on the ideas of Maier's habilitation thesis (Maier 2004) and two years of joint teaching experience in bachelor-level and master-level courses about KM and technologies relevant in its context.

[85] URL: http://www.opentext.com, last accessed: 2007-12-02

participants. They ideally support all stages of the knowledge maturing processes from ideas, experiences, lessons learnt, best practices to manuals, rules, procedures and patents (Maier & Schmidt 2007). In these regards, they acknowledge the product and the person perspective on knowledge (section 2.2).

Knowledge services. EKI offer basic software services for the publication and discovery of knowledge, e.g., full-text search, storage of various types of knowledge and version control, for the support of collaboration among participants, e.g., synchronous and asynchronous communication channels, and for the facilitation of learning, e.g., by authoring functions and the provision of online courses (Maier 2004, 261ff). They also provide advanced functions for collaborative creation of contents, personalization, awareness, dynamic composition of learning objects and visualization of knowledge maps. All services need to be integrated and based on a common platform.

KM instruments. EKI support KM instruments such as person-oriented instruments, e.g., competence management and administration of personal experiences, product-oriented instruments, e.g., capturing and storing of lessons learnt and good or best practices, and process-oriented instruments, e.g., support of communities and knowledge networks as well as knowledge process reengineering (sections 2.4 and 2.6).

Processes. EKI are implemented with the goal to support and enhance (parts of) knowledge-intensive processes, tasks or projects, e.g., the generic knowledge life-cycle that comprises tasks such as knowledge creation, organisation, storage, retrieval, transfer, refinement and packaging, (re-)use, revision and feedback (Maier & Hädrich 2006, 48) or more specifically, selected knowledge actions such as co-authoring and expert search (section 3.4.4).

Participants. EKI foster active involvement and participation of users by provision of methods for easy contribution of knowledge, feedback and enhancement of the knowledge base as well as the participation in knowledge networks and communities. Establishment of semantic links and thus contextualization is not restricted to relationships between content items but also between contents and participants. In contrast to traditional IS, the simple container metaphor is extended to a network of artefacts and people, of memory and processing and thus can be compared with a distributed organisational memory (Ackerman & Halverson 1998, 47; Maier & Hädrich 2006, 49).

Summing up the characteristics described, EKI are defined as comprehensive ICT platforms for collaboration and knowledge sharing with knowledge services built on top that are contextualized, integrated on the basis of a shared ontology and personalized for participants networked in communities that fosters the integration of knowledge services and implementation of KM instruments in support of knowledge processes targeted at increasing the productivity of knowledge work (based on Maier, Hädrich & Peinl 2005, 73). EKI do not necessarily need to be implemented as a centralistic system following a client-server architecture. The peer-to-peer metaphor (Barkai 2001) promises to resolve some of the challenges related to, e.g., the substantial costs for design, implementation and maintenance of a centralized server, reduction of barriers for active participation in an EKI, integration of personal knowledge bases that contain individual messaging objects and seamless integration with the knowledge workers' individual workspaces (Maier & Hädrich 2004; 2006).

5.4.2 Architecture

Maier (2004, 250ff) presents an integrated architecture of EKI that amalgamates other theory-driven, vendor-specific and market-driven architectures. It can act as a frame of reference in order to categorize technical services, technologies and standards for their implementation. It is extended here to include ideas of service-orientation that help conceptualize support of knowledge processes and particularly knowledge actions by means of composite services (Figure 32). Alternative suggestions for architectures that synthesize frameworks and common functions of systems to support knowledge work are made by, e.g., Seifried & Eppler (2000, 29ff), Thiesse & Bach (1999, 89ff) and Riempp (2004, 124ff).

Infrastructure services. The infrastructure layer comprises the basic network and application infrastructure that implements mechanisms for storage by means of *data-centric services* and for data processing by means of *logic-centric services*. *Security-centric services* are included to highlight the relevance of functionality that protects the knowledge base from unauthorized access, e.g., by means of authentication services and restricted views for external participants. The infrastructure also includes an environment for the integration of software functions. The dependence on one centralized software bus or hub was a pitfall for many EAI projects in the past (Krafzig, Banke & Slama 2005, 110). The infrastructure thus includes an *enterprise service bus* as part of the infrastructure that enables the invocation of services and the routing of messages (Dostal et al. 2005, 19f; Krafzig, Banke & Slama 2005, 64f, 159ff). It abstracts from different technologies and systems embraced by an EKI and connects systems that are based on different communication modes and protocols, storage systems, programming languages, operating systems and run-time environments. The infrastructure also exposes administrative services for auditing, logging, security, message transformation and handling of transactions. Hence, it enables the creation of a comprehensive, enterprise-wide platform which is one of the central characteristics of EKI.

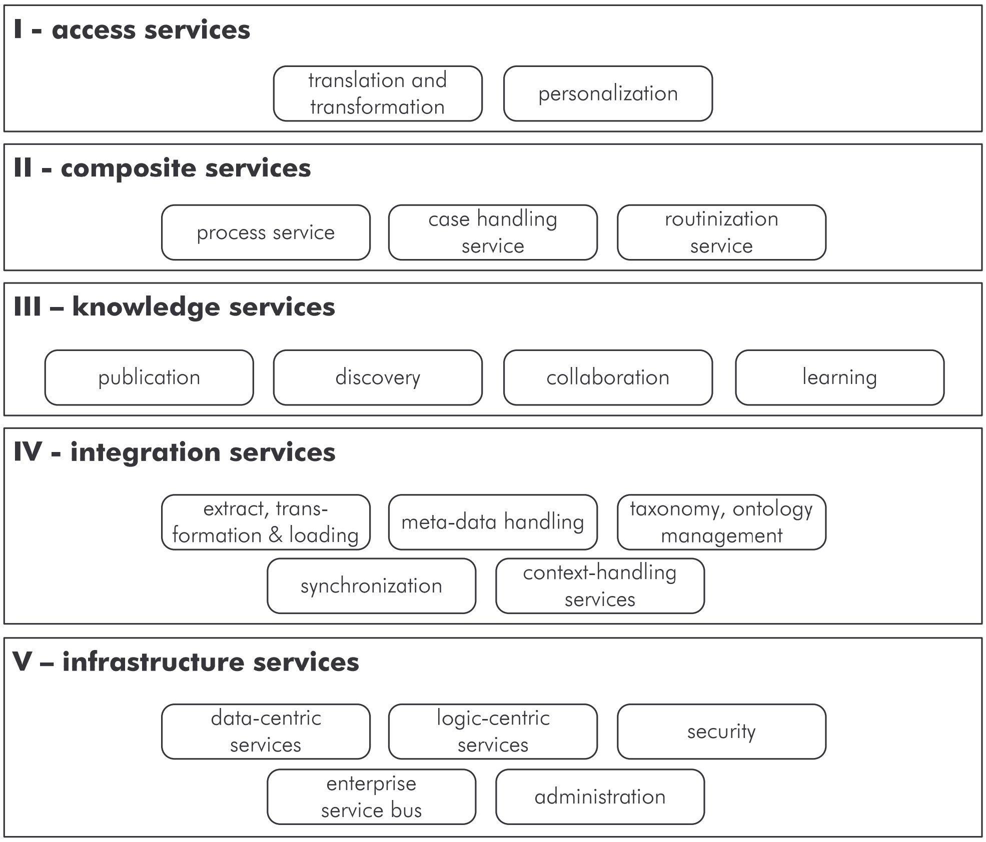

Figure 32. Architecture of service-oriented EKI[86]

Integration services. Integration services are concerned with the provision of the access to structured and particularly unstructured data of various types and from various sources used to represent knowledge (section 2.2). In contrast to integration services discussed in the context of SOA, they are concerned with semantic data integration and not with the bridging of technological gaps. This enables for a meaningful organisation and embedding of knowledge in a context as demanded by the EKI characteristic "specifics of knowledge". More specific integration services are (1) *extract*, *transformation and loading services* for the extraction and harmonization of data from different sources and in multiple formats, (2) *synchronization services* that support online and offline access to contents, (3) *meta-data handling services* used to create links on a semantic level and to store the context of creation and application of

[86] based on Maier (2004, 258ff) and Maier, Hädrich & Peinl (2005, 76ff)

knowledge and (4) *taxonomy and ontology management services* that concern the support of maintenance tasks, e.g., the management and creation of concepts, attributes, relations and rules of an ontology as well as the inference of facts as currently supported by specialized tools such as Ontoprise OntoStudio[87] (Maier & Hädrich 2006, 52; Maier & Peinl 2006, 87ff). Last but not least, (5) *context-handling services* provide means for the integration, representation, management and interpretation of context information that can be classified based on the dimensions product, process, person, productivity tool, time and location and has to be acquired from different sources (section 3.4.3).

Meta-data handling services can be further detailed into services for (1) the representation of meta-data in different structures and formats ideally based on common standards such as the Resource Description Framework (RDF)[88], Web Ontology language (OWL)[89] or micro formats (Kahre 2006), (2) storage of meta-data inline with contents or within separate databases and repositories, (3) manual or ideally semi-automatic extraction of meta-data based on the internal structure of contents or with the help of text-mining techniques, (4) querying meta-data based on, e.g., the structured query language (SQL) or by means of languages specifically designed for RDF-based standards, e.g., RDQL[90] or RDFQL[91], and (5) evaluation of meta-data based on pre-defined schemas, e.g., individually defined schemas, general standards such as Dublin Core[92], or domain-specific standards such as the Learning Object Model[93] (Maier & Peinl 2006, 87f).

Knowledge services. Integration layer services are the foundation for knowledge services. Four general categories can be distinguished: (1) *publication services* for creation, structuring, contextualization and storage of contents, (2) *discovery services* for discovery of contents and person-bound knowledge, (3) *collaboration services* that support collaboration of and communication between participants as well as coordination of joint work and (4) *learning services* that offer functionality in order to support the creation, management and use of learning

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[87] URL: http://www.ontoprise.de/content/e1171/e1249/index_ger.html, last accessed: 2007-12-02

[88] URL: http://www.w3.org/RDF/, last accessed: 2007-12-02

[89] URL: http://www.w3.org/2004/OWL/, last accessed: 2007-12-02

[90] URL: http://www.w3.org/Submission/2004/SUBM-RDQL-20040109/, last accessed: 2007-12-02

[91] RDFQL is a vendor-specific query language implemented in RDF Gateway by Intellidimension, URL: http://www.intellidimension.com, last accessed: 2007-12-02.

[92] URL: http://dublincore.org, last accessed: 2007-12-02

[93] URL: http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf, last accessed: 2007-12-02

resources as well as the conduct of examinations (Maier 2004, 259f). These services either offer basic or more advanced functions as described in relation to the EKI characteristic "knowledge services". The following section outlines typical functionality offered for every type of knowledge service (section 5.5).

Composite services. The layer of composite services is introduced here in order to acknowledge the requirement of EKI to support knowledge processes and particularly knowledge actions. So far, this is addressed only on a general level (Bach 1999, 68ff; Riempp 2004, 126). Composite services combine services of other EKI layers and specifically knowledge services and are distinguished into process services and case handling services as described in section 5.3. *Process services* target the support of knowledge routines by defining the sequence and the conditions of the invocation of EKI services from lower layers. *Case handling services* allow for a flexible combination of EKI services based on the case handling paradigm. Furthermore, *routinization services* offer means for the participants to identify, define and iteratively refine composite services that correspond to selected knowledge actions in order to explicitly support the process of routinization (section 3.2). Later in this work, process services and case handling services will be illustrated with the help of a more extensive example (section 8.4).

Access services. The access layer provides interfaces for participants external and internal to the organisation in order to enable them to access the EKI by means of different applications and devices. Access services include the *translation and transformation* of contents in order to enable multiple alternative ways of representation and *personalization services* that filter the output of other services based on information about the user context. Ideally, EKI services are integrated with the user's individual workspace as far as possible, e.g., with the personal desktop or with widespread used software such as text processing or spreadsheet applications. Currently, attempts are made for the semantic integration of information sources and related services within a so-called the Social Semantic Desktop[94] as well as for the enhancement of individual learning processes[95].

Alternatively, portals may offer a Web-based integrated access to knowledge infrastructures. Generally, they are defined as "… as an infrastructure providing secure, customizable, per-

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[94] See URL: http://nepomuk.semanticdesktop.org, last accessed: 2007-12-02 for the EU project NEPOMUK.

[95] See URL: http://www.aposdle.tugraz.at, last accessed: 2007-12-02 for the EU project APOSDLE.

sonalizable, integrated access to dynamic content from a variety of sources, in a variety of source formats, wherever it is needed" (Smith 2004, 94). Knowledge portals are characterized comprehensively to be goal-oriented towards knowledge production, knowledge acquisition, knowledge transmission and KM focused on business processes (Firestone 1999, 4). Here, the term portal is understood more narrowly as a part of the EKI access layer that bundles appropriate services and contents for roles, individual work processes, business processes or selected groups of people on the interface level (Collins 2003, 6ff). Knowledge portals principally comprise all layers of an EKI, emphasizing the integration of sources of documented knowledge on a semantic level (Maier 2006). Effective access to EKI is a prerequisite to actively involve participants. as addressed by the EKI characteristic "participants".

5.5 State-of-the-art of knowledge services

From the types of EKI services discussed in section 5.4.2, knowledge services will be detailed in the following as they represent the core functionality of EKI and are the primary foundation for the definition of composite services. This section outlines the current technological state-of-the-art related to all four classes of knowledge services, i.e. publication, discovery, collaboration and learning services. This represents a foundation for the identification of knowledge services in the context of the empirical study.

In the following, the term *function* instead of service will be used in order to denote the functionality offered by the software components relevant in this context. The reason is that the definition of services has to simultaneously take into account two perspectives, a business process perspective focusing on the tasks to be supported and a technical perspective that highlights the software components that might offer appropriate functions (Arsanjani & Allam 2006). It starts out with the tasks in business processes to be supported by means of ICT and then analyses existing software components for appropriate functions that might be defined and implemented as a service. This section exclusively focuses on the technical perspective and thus cannot generate a list of knowledge services. As a first step towards a business process-oriented perspective, a set of generic tasks typically supported by knowledge services is used in order to classify the functions outlined.

5.5.1 Publication

Typical systems that offer publication functions are file servers, CMS and DMS. A number of partly overlapping terms is used in this context. Content management is the systematic and structured management of content (Gersdorf 2002, 75), particularly its acquisition, creation, preparation, administration, presentation, processing, publication and reuse (Rothfuss & Ried 2003, 15). The term content has been defined in section 2.2 as any set of meaningfully arranged data that can be addressed and manipulated by a human or a system as a discrete entity. CMS are used for support of content management tasks in order to enable an economically feasible and flexible handling of information in organisations (Jablonski & Meiler 2002, 102). Web content management (WCM) is content management focused on the publication of Web contents, particularly of HTML pages on the organisational Intranet or on the Internet (Boiko 2002, 65f; Jablonski & Meiler 2002, 102). The terms CM and WCM are sometimes used synonymously. Systems used in the context of WCM are also referred to as Web CMS (WCMS). Code versioning systems (CVS) are specialized on the management of source code and share some functions with DMS and CMS.

Document management can be defined similar to content management as the systematic and structured management of documents. A document is a legally sanctioned record of a business transaction or decision that can be viewed as a single organised unit (Kampffmeyer & Merkel 1997, 20ff; Sutton 1996, 6f). Content management and document management and the functionality of the respective system classes overlap partially (Gulbins, Seyfried & Strack-Zimmermann 2002, 150f). The traditional focus of document management is records management, forms management, reports management, directives and manuals management as well as archives management (Sutton 1996, 8). An important concern is to guarantee the authenticity of documents. Content management in contrast advocates the separation of content and layout in order to enable its flexible transformation and presentation with different types of interfaces (Jablonski & Meiler 2002, 106f). This may be achieved by storing contents in XML documents and transforming them based on XSL stylesheets (Boiko 2002, 743ff; Jablonski & Meiler 2002, 108ff). The terms enterprise content management (ECM) and enterprise document management (EDM) are used to emphasize an enterprise-wide approach that embraces and integrates all relevant systems used in this context (Asprey & Middleton 2003, 21ff; Forquer, Jeliniski & Jenkins 2005, 312; Gulbins, Seyfried & Strack-Zimmermann 2002, 150). They rather stand for a vision that defines the long-term goals of content management and thus act as a foundation to determine short-term and medium-term goals and steps (Gulbins, Seyfried & Strack-Zimmermann 2002, 22).

Typical functions

Functions offered by DMS and CMS can be structured according to the tasks that are related to the life-cycle of contents. It consists of the phases creation, capturing, storage, review, retrieval and archiving as visualized in Figure 33 (Bach 2000; Blessing 2001, 100ff; Boiko 2002, 82ff; Christ 2001, 93; Gersdorf 2002, 76; Riempp 2004, 144ff; Walker, Foster & Banthorpe 1997, 75; Zschau, Traub & Zahradka 2002, 54ff). The knowledge action authoring may comprise multiple ones of these tasks (section 3.4.4). The sequence of tasks indicated within the figure visualizes common predecessor-successor relationships. The dashed line points to the fact that the cycle may be passed through multiple times until contents are archived or deleted. However, the sequence should not be interpreted as a predetermined flow of tasks as they principally can be conducted in varying sequences.

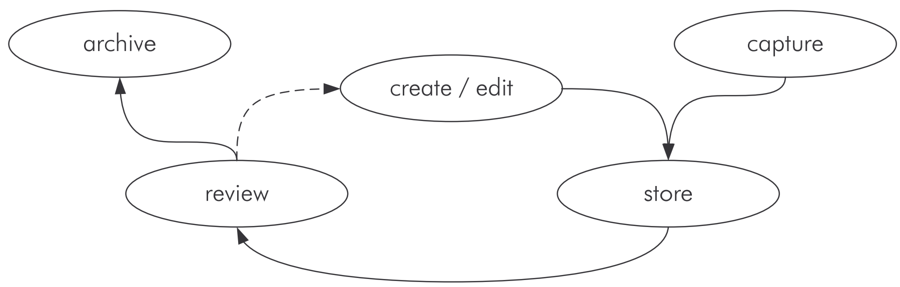

Figure 33. Generic tasks supported by publication functions

Create / edit. This task refers to the generation and change of electronic contents. `Creation`[96] of contents is either based on various end-user applications, e.g., text processing and spreadsheet software. Annotation and tracking functions enable for the `adding of comments` to contents and for `highlighting changes` (Gulbins, Seyfried & Strack-Zimmermann 2002, 56ff). Contents may also be created without specific applications installed on the user's personal computer based on a centralized system accessed with Web-based interfaces. Rules and templates are applied in order to `structure contents` consistently. Interaction of DMS and CMS with end-user applications is regulated by the standards Open Document Management Application Programming Interface (ODMA) 2.0 (AIIM 1997) and Web Distributed Authoring and Versioning (WebDAV) (Clemm et al. 2002; Clemm et al. 2004; Goland et al. 1999).

[96] In the following, the tasks supported are highlighted by means of `a separate typeface`.

Both define a set of general methods in order to access CMS and DMS, e.g., for retrieval, deletion, movement and locking of contents, and thus represent a technical starting point for the definition of service interfaces for publication and discovery services (section 5.5.2). One of the core support functions of WCMS is that they enable users that have no technical knowledge about the creation of Web pages to publish Web contents (Zschau, Traub & Zahradka 2002, 60f).

Capture. Capturing refers to the `scanning and digitizing` of potentially large volumes of paper-based documents and also to the `importing of electronic contents` in various formats such as text processing files or emails into a CMS or DMS (Gulbins, Seyfried & Strack-Zimmermann 2002, 30f; Zschau, Traub & Zahradka 2002, 237ff). Electronic signatures are used in this context to `assure authenticity`, `integrity and confidentiality` of contents (Götzer et al. 2004, 73ff). Capturing may include optical character recognition (OCR) applied to save storage space and to process contents further (Gulbins, Seyfried & Strack-Zimmermann 2002, 324ff) or their transformation to different formats such as Tagged Image File Format (TIFF) or Portable Document Format (PDF) in order to make them accessible independently of their native applications (Gulbins, Seyfried & Strack-Zimmermann 2002, 270). Syndications are sets of contents published for distribution and reuse (Boiko 2002, 86f). Originally, they were used to `integrate selected types of contents` into Web sites offered by specialized content providers such as press agencies. They are increasingly applied by end users that based on this technology subscribe information channels, e.g., news channels or Podcasts, in order to get notified about updates, e.g., based on the XML-based Really Simple Syndication (RSS)[97] standard that defines a basic format for syndications.

Store. Storing refers to the systematic filing of contents. After capturing or creating contents, they are `stored` with a system and potentially `moved` within or between different storage locations. They need to be `complemented by meta-data` in order to readily retrieve, manage and use them, which is also referred to as `annotation` of contents (Götzer et al. 2004, 19; Gulbins, Seyfried & Strack-Zimmermann 2002, 48ff) and particularly concerns their `classification` based on pre-defined types of meta-data (Gersdorf 2002, 77), e.g., in order to relate them to business processes or route them to selected roles. This can be done automatically based on barcode recognition or rule-based approaches that utilize typical characteristics of

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[97] The acronym RSS in earlier versions than the current specification 2.0 (URL: http://www.rssboard.org/rss-2-0, last accessed: 2007-12-02) is used for Rich Site Summary and RDF Site Summary.

document types such as the position of selected types of information within the layout of a document (Götzer et al. 2004, 21ff, 175ff). The term asset in this context is used in order to denote the subset of contents annotated with meta-data and to emphasize the value generated by this process (Zschau, Traub & Zahradka 2002, 40ff, 63ff). More recently, semantic annotations based on Semantic Web standards such as RDF are discussed in the context of content management, as a way to enhance the flexibility of the access to contents (Jablonski, Meiler & Petrov 2004, 99f). The term `tagging` denotes the assignment of freely definable keywords to resources such as bookmarks, Web pages and images by a large number of people which ultimately results in the creation of a user-generated taxonomy, also called folksonomy (Przepiorka 2006, 24).

Review. Review concerns the assurance of the quality of contents. Particularly Web contents need to be reviewed before they are published, e.g., concerning the correct the use of language and their general consistency (Boiko 2002, 91ff). Versioning mechanisms ease the `management of multiple versions` created, e.g., due to revisions or stepwise creation of contents, and help to audit the state and history of contents (Götzer et al. 2004, 21f). `Simultaneous access` by multiple authors is coordinated by means of check-in and check-out mechanisms that restrict the write access to selected users or groups.

Archive. Archiving is concerned with the `long-term storage` and ultimately the deletion of contents. Archival of potentially large amounts of contents is a core function of DMS that manage different storage media or have interfaces to storage systems such as storage area networks or hierarchical storage systems (Gulbins, Seyfried & Strack-Zimmermann 2002, 179ff). The types of contents to be archived, retention periods and requirements of the archiving systems are governed by a number of legal regulations (Gulbins, Seyfried & Strack-Zimmermann 2002, 375ff). `Deletion` of contents can be a complex process due to relationships between contents and potentially lacking information about the validity and use of contents (Gulbins, Seyfried & Strack-Zimmermann 2002, 109).

5.5.2 Discovery

The discovery of contents is discussed in the research field information retrieval (IR). It is the science of organising and searching of potentially large amounts of contents (Baeza-Yates & Ribeiro-Neto 1999, 1f; Lahme 2004, 59; Wedekind 2001, 235). Goal is to provide the user with easy access to information that fulfils his information needs. IR organises contents by linking descriptors to content items, i.e. meta-data used for classification and description of contents such as author, title, keywords and classification (Wedekind 2001, 236). These subsequently can be used and combined in search queries that specify the resources needed to satisfy an information need. IR traditionally focuses on documents and books that contain natural language. Research in IR has substantially broadened and also includes document classification and categorization, systems architecture, user interfaces, data visualization and filtering (Baeza-Yates & Ribeiro-Neto 1999, 2). Multimedia resources such as images and videos increasingly need to be taken into account due to their significantly increased amounts and the need to effectively retrieve them (Marques 2002, 1f). Systems discussed in the context of IR are Online Public Access Catalogues (OPAC) adopted by many libraries (Rasmussen 1999, 407), e.g., of the common library network GBV[98] or the Karlsruher Virtueller Katalog KVK[99] that both integrate multiple other OPAC systems, full-text databases such as Lexis-Nexis[100] or archives of newspapers and magazines such as the Electric Library[101] (Rasmussen 1999, 399) and Web search engines such as Google[102] and Alta Vista[103] (Glöggler 2003, 4ff).

Typical functions

There is no set of generic user-oriented tasks described within the IR literature such as the tasks related to the content life-cycle (section 5.5.1). Tasks referred to focus on internal tasks to be accomplished by IR systems, e.g., content preparation and indexing in order to enable efficient search (Baeza-Yates & Ribeiro-Neto 1999, 9f; Glöggler 2003, 45ff). Thus, the system functions will be structured based on tasks described in the context of information seeking behaviour that were already used to detail the knowledge actions acquisition and update (section 3.4.4). These are aggregated to the generic tasks browse, search and filter (Figure 34). Discovery also includes the retrieval of contents, i.e. the access to and the extracting of relevant information. The order of these tasks represents the general flow of actions accomplished for seeking information (Wilson 1999b, 256). The arrows within the figure again indicate general predecessor-successor relationships but they can also be accomplished in other

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[98] URL: http://www.gbv.de, last accessed: 2007-12-02

[99] URL: http://www.ubka.uni-karlsruhe.de/hylib/en/kvk.html, last accessed: 2007-12-02

[100] URL: http://www.lexisnexis.com, last accessed: 2007-12-02

[101] URL: http://www.elibrary.com, last accessed: 2007-12-02

[102] URL: http:///www.google.com, last accessed: 2007-12-02

[103] URL: http://www.altavista.com, last accessed: 2007-12-02

sequences. The arrangement of the tasks in a cycle indicates that search and retrieval is an iterative process and that results from prior searches influence subsequent iterations.

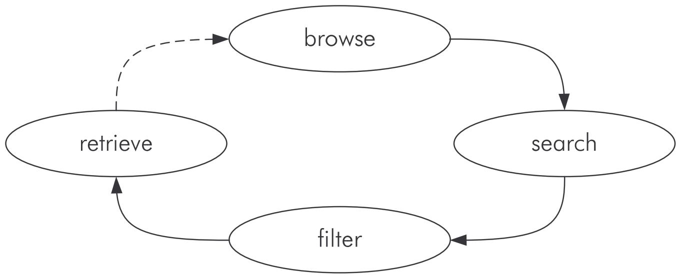

Figure 34. Generic tasks supported by discovery functions

Browse. Browsing was defined in relation to the knowledge action acquisition as a process of retrieving information whose main objectives are not clearly defined in the beginning and whose purpose might change during the interaction with a system (section 3.4.4). Knowledge maps can be used as a means to `identify` and to `gain an overview` of relevant knowledge (section 2.4). They are created manually, e.g., based on graphic tools such as Microsoft Visio[104], are implemented based on more specialized technologies such as interactive graphic visualizations generated from data bases and accessible by means of Web interfaces (Eppler 2003a, 190) or are generated with tools such as let's focus[105] that offer interactive visualizations applied in order to visually express and structure the results of group sessions (Eppler & Burkhard 2006, 522; 2007). Documented knowledge can be identified with the help of knowledge structure maps that visualize semantic relationships between single items (Eppler 2003a, 192f; Maier 2004). Examples for systems supporting visualization are Autonomy Visualization[106] and InXight SmartDiscovery VizServer[107]. Knowledge bound to individuals can be identified with the help of knowledge source maps that visualize the location of people having skills in relation to selected subjects (Eppler 2003a, 192). More recently, geographic maps are suggested as a means for the identification of relevant knowledge, e.g., by visualising expertise about a specific topic available at different locations (Amende, Maier & Peinl 2007; Tochtermann & Schwartz-Glaesker 2001). The usage of GoogleMaps to interac-

[104] URL: http://office.microsoft.com/visio, last accessed: 2007-12-02

[105] URL: http://www.reflact.com, last accessed: 2007-12-02

[106] URL: http://www.autonomy.com/content/Products/Visualization/index.en.html, last accessed: 2007-12-02

[107] URL: http://www.inxight.com/products/vizserver/, last accessed: 2007-12-02

tively visualize and provide access to all kinds of services and information became increasingly popular during the last years.[108]

Search. Searching refers to the specification and retrieval of required resources. Search engines are used widespread for the identification of resources based on a set of keywords that may be combined based on Boole's algebra with, e.g., AND, OR and NOT (Baeza-Yates & Ribeiro-Neto 1999, 4). Internet resources can be identified with the help of search engines that index parts of the World Wide Web. Indexing in this relation refers to the representation of resources in a way that enhances efficiency of the search (Baeza-Yates & Ribeiro-Neto 1999, 191ff). Google is an example of a widely-used Internet search engine that also offers additional functions such as an image search or a search specialized on academic resources. Meta-search engines such as metacrawler[109] do not index the Web themselves but aggregate the results from multiple other search engines and present them in a user friendly way (Glöggler 2003, 8f). Goal is to overcome the disadvantage of search engines that they index only a limited part of the Web. More recently, ontologies are applied in order to enable semantic searches which has the potential to significantly enhance the quality of search results (Berners-Lee, Hendler & Lassila 2001). Knowledge Sifter is an example of a prototype in this area (Kerschberg et al. 2004).

The analysis of search terms is a common approach for reasoning about Web usage behaviour (Jansen & Pooch 2001; Lewandowski 2006). Measures based on reports about the system usage can principally be used to identify areas where knowledge needs to be developed or should be offered to participants, e.g., based on popular search terms (Maier 2004, 264).[110] Other means of search support are thesauri that are used explicitly or implicitly in order to improve search terms, presentation of other potentially relevant information, e.g., new or unread items, and search assistants that offer context-specific help such as alternative search queries (Maier 2004, 262). In the context of KM, the provision of information about authors also is regarded to be important (Maier 2004, 357). Users also may navigate

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[108] An example is VeniVidiWiki (URL: http://www.venividiwiki.eu) where videos from YouTube (URL: http://www.youtube.com) can be accessed based on their geographical location. A number of further examples can be found at GoogleMapsMania (URL: http://googlemapsmania.blogspot.com). All URLs were last accessed on 2007-12-02.

[109] URL: http://www.metacrawler.com, last accessed: 2007-12-02

[110] An example for a report about search terms can be found under the URL: http://www.fireball.de/livesuche/, last accessed: 2007-12-02.

`through resources` with the help of hierarchical storage structures, links or pre-defined queries. Maier and Sametinger (2003; 2004) in this context propose the application of navigations known from online analytical processing (OLAP) such as slicing, dicing, drill-down, roll-up and ranging (Chamoni & Gluchowski 1998; Inmon 2002, 251ff). The Intergral Tornado Business Center[111] that allows creating multiple dynamic views for navigating contents stored in a so-called virtual object repository is another example.

Contact management functions facilitate the administration and `retrieval of contact information` as defined, e.g., by the vCard standard (versit 1996b). This task is supported by directory services such as Microsoft Active Directory that amongst others can be accessed by means of standards such as the Lightweight Directory Access Protocol (LDAP)[112]. LDAP specifies ways for the request and modification of information within a hierarchically structured directory. Search can also be supported based on an `information push` metaphor by delivering notifications, e.g., based on email or desktop windows, that inform about relevant events, e.g., changes within CMS such as the addition of new items, a new status of items on task lists or reminders about appointments within the calendar (Bafoutsou & Mentzas 2002, 285). Other approaches use autonomous search agents that notify users about changes, e.g., updated Web contents related to selected topics (Haverkamp & Gauch 1998).

Filter. This task is best described by the information behaviour of filtering identified by Ellis (1997, 399). It is characterized as the use of certain criteria or mechanisms in order to reduce search effort, e.g., periods of times or selected Internet domains. This includes functions that enhance the relevancy of search results and assist the user in refining his search. Search results are `ranked` according to their potential relevance, which may be based on the frequencies with which keywords appear, their position on a page and other criteria such as the number of links to a Web page (Gordon & Pathak 1999, 144f). This is also referred to as `content-based filtering` (Herlocker, Konstan & Riedl 2000). Recommender systems offer items to users based on their profile (Resnick & Varian 1997, 56). This may be based on a `collaborative filtering` approach that identifies users whose characteristics are similar, e.g., with regard to their taste concerning books or movies, and recommends items they have liked (Balbanovic & Shoham 1997). Examples for systems are GroupLens[113] and MovieL-

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[111] URL: http://www.intergral.com, last accessed: 2007-12-02

[112] URL: http://www.ietf.org/rfc/rfc4511.txt, last accessed: 2007-12-02

[113] URL: http://www.grouplens.org, last accessed: 2007-12-02

ens[114]. This approach is suggested to be advantageous compared to content-based filtering as it does not depend solely on a machine-based analysis of content but rather on human judgement (Herlocker, Konstan & Riedl 2000). Exalead[115] is an example of an Internet search engine that offers enhanced assistance for filtering and `refinement of prior search queries`, e.g., based on related terms that were automatically identified, content types, languages, visualizations of preview images of Web pages and generated suggestions for alternative search terms.

Retrieve. Retrieval refers to the process of identifying and obtaining contents. DMS and CMS include search mechanisms for the identification of and access to contents. Access privileges are used to `determine the actions permitted` for groups of users within a system (Götzer et al. 2004, 27). Contents may be `viewed` and used within native applications or by means of viewers. They also can be `transformed` for the representation on different media, e.g., paper or microfiche, depending on the actual requirements (Gulbins, Seyfried & Strack-Zimmermann 2002, 51ff).

5.5.3 Collaboration

Understanding group work and designing supportive ICT tools are researched under the topic of CSCW (Hasenkamp & Syring 1994; Teufel et al. 1995, 31ff). It is an interdisciplinary research field and was started as an effort by technologists to learn from members of other disciplines, e.g., economists, social psychologists, organisational theorists and educators (Grudin 1994, 19f). Technology discussed in the context of CSCW is referred to as Groupware, which is defined as "… computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment" (Ellis, Gibbs & Rein 1991, 40). Examples for Groupware servers are IBM Lotus Notes[116] and Microsoft Exchange[117]. A popular classification of Groupware systems is based on the general distinction whether group participants interact at the same time or at different times and whether they are located at the same place vs. at different places (Johansen 1988, 2), later on extended by Grudin (1994, 24f) who adds the predictability of time and place. Other criteria

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[114] URL: http://movielens.umn.edu, last accessed: 2007-12-02

[115] URL: http://www.exalead.com, last accessed: 2007-12-02

[116] URL: http://www.lotus.com, last accessed: 2007-12-02

[117] URL: http://www.microsoft.com/exchange, last accessed: 2007-12-02

used for classification are group size, group tasks, control models, application functionality, coordination processes and the type of the underlying technology (Bafoutsou & Mentzas 2002, 282ff).

Typical functions

Teufel et al. (1995, 26ff) distinguish the three general tasks communication, coordination and cooperation characterized by an increasing intensity of collaboration between individuals (Figure 35). The tasks will be used here in order to structure collaboration functions. A clear-cut classification is not always possible so that the generic processes should be regarded only as a first starting point for a task-oriented classification of system functions. Each category can be further refined based on the time-location taxonomy. In contrast to the other types of knowledge actions, no general sequence of actions can be identified.

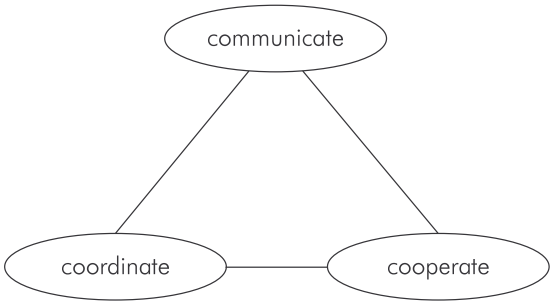

Figure 35. Generic tasks supported by collaboration functions

Communicate. From a technical perspective, communication can be defined as the exchange of information between communication partners (Teufel et al. 1995, 28).[118] Widely-used synchronous communication media are chat, instant messaging, telephony and teleconferencing. Chat enables two or more individuals for `text-based communication` (Hansen & Neumann 2001, 434ff). In the past, Internet Relay Chat (IRC)[119] was used widely but instant messaging based on clients such as ICQ[120] became more and more popular in recent years. It also allows `receiving presence information` about people on a so-called buddy list such as their online status. Telephony supports `voice-based communication` between two indi-

[118] This represents a simplistic view on communication. See Littlejohn & Foss (2005, 12f) for a more detailed discussion and alternative definitions.

[119] The original IRC standard is described in the Request for Comments (RFC) 1459 followed by four newer RFCs 2810-813, URL: http://www.irchelp.org/irchelp/rfc/, last accessed: 2007-12-02.

[120] URL: http://icq.com, last accessed: 2007-12-02. The acronym ICQ stands for “I seek you”.

viduals. Voice and data communication originally are based on two separate infrastructures that more and more grow together. Whereas the public switched telephone system earlier was used to convey digital information, e.g., by means of V.56bis[121] modems, packet-switched data networks in recent years are increasingly used in order to transfer voice communication data as in the case of Internet telephony based on the Voice over Internet Protocol (VoIP) specification (Tanenbaum 2003, 685ff). Teleconferencing can be distinguished into audio conferencing and video conferencing. Audio conferences support voice-based communication in groups of people (Hansen & Neumann 2001, 430f). Video conferencing systems additionally enable `visual communication` between participants. They are realized either as dedicated technical facilities or are based on extensions of each participant's personal computer, which is also called desktop video conferencing. Skype is an example of an Internet telephony peer that also includes videoconferencing functionality.[122]

Widely-used asynchronous communication media are email and newsgroups. Email is one of the most widespread used communication tools within the Internet (Tanenbaum 2003, 588ff). It allows for `asynchronous exchange of text-based messages`[123], potentially including additional content types as specified by the Multipurpose Internet Mail Extensions (MIME)[124] standard as well as attached files. Mailing lists are used in order to `distribute` copies of emails to multiple participants (Hansen & Neumann 2001; Tanenbaum 2003, 591). Newsgroups, in other contexts also called bulletin boards or discussions, are forums structured according to topics where participants can exchange messages (Hansen & Neumann 2001, 428ff; Tanenbaum 2003, 591). Examples are the traditional Usenet based on the standardized Network News Transfer Protocol[125] requiring a newsreader client to send end receive messages as well as Web-based forums that are accessed by means of Web browsers.

The `initiation of communication` is supported by social networking systems and social encounter systems. Social networking systems are subsumed under the term social software that in a broad sense can be defined closely to the term Groupware as software that supports

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[121] URL: http://www.itu.int/rec/T-REC-V.56bis-199508-I/en, last accessed: 2007-12-02

[122] URL: http://www.skype.com, last accessed: 2007-12-02

[123] The basic message format of emails, i.e. structure and contents of its parts envelope, header and body, is defined in RFC 822, URL: http://www.ietf.org/rfc/rfc0822.txt, last accessed: 2007-12-02.

[124] MIME is proposed in RFC 1341 and updated in the RFCs 2045 to 2049, URL: http://www.ietf.org/rfc.html, last accessed: 2007-12-02.

[125] URL: http://www.ietf.org/rfc/rfc3977.txt, last accessed: 2007-12-02

human communication and collaboration (Bächle 2006, 121) and in a narrow sense to facilitate the creation of social networks and the dissemination of information within their context (Hippner & Wilde 2005, 441). Examples are social networking sites such as XING[126] and Stayfriends[127]. Social Software emphasizes voluntary participation, self-organisation within groups and is related to the large base of Internet users (Hippner & Wilde 2005, 441). Social encounter systems offer advanced media spaces where geographically dislocated people can meet each other (Andriessen 2003, 11). Media Space is an example of an early prototype in this area (Bly, Harrison & Irwin 1993). Second Life[128] also belongs into this class of systems and is increasingly used in a business context.

Coordinate. Coordination in a narrow sense focuses on the arrangement of task-oriented activities and the allocation of resources in the best possible order (Borghoff & Schlichter 2000, 125). Planning systems support the `coordination the use of resources` available for a group, e.g., rooms and presentation facilities. They may be integrated with time scheduling systems, particularly electronic calendars that support `management of a group's time resources` and by this way represent a specialized class of planning systems (Teufel et al. 1995, 211). Group calendars make selected portions of individual calendars available to other members and by this facilitate joint time planning. Task lists are used for the systematic `management of individual or collective tasks` (Riempp 2004, 193). Calendar entries as well as task items are structured by the vCalendar specification (versit 1996a). Teleconferences may be coordinated with the help of conference management tools that are used to `moderate` group discussions, e.g., by managing contributions and access privileges (Maier 2004, 268f). Coordination of structured tasks is the original domain of WfMS (section 2.5). These may be integrated with a user's task list and also are applied for the `scheduling of meetings`. A less rigid approach in the sense that coordination is put into the hands of each individual group member is the support of `group awareness`, defined as the understanding of the activities of others which provides a context for individual activities (Dourish & Bellotti 1992, 107).[129] Awareness functions can have various forms. A simple example is informa-

[126] URL: http://www.xing.com, last accessed: 2007-12-02

[127] URL: http://www.stayfriends.de, last accessed: 2007-12-02

[128] URL: http://secondlife.com, last accessed: 2007-12-02

[129] Hoffmann (2004, 15) gives an overview of awareness definitions as well as mechanisms and possible ways for its support by ICT.

tion about the online status of communication partners provided by instant messaging clients.

Cooperate. Cooperation is the closest form of collaboration and characterized by shared goals and responsibilities (Teufel et al. 1995, 27). Those functions are categorized here that are directly related to the joint creation of results. Thus, they have links to publication services. Weblogs (Picot & Fischer 2006) and Wikis (Leuf & Cunningham 2004) are examples for specialized types of WCMS that enable to straightforwardly and `collaboratively publish contents on the Web` and thus for the asynchronous creation of joint contents. These either have the form of a jointly created set of topic-oriented Web pages, i.e. a Wiki book, or consist of a network of interlinked individual contributions and comments that as a whole are called blogosphere. Whereas Wikis and blogs support asynchronous co-authoring, other types of group editors discussed in the context of CSCW are targeted at the `concurrent creation of contents`, which requires sophisticated locking mechanisms and awareness functions (Borghoff & Schlichter 2000, 386ff). Application sharing or screen sharing can be regarded as special forms of teleconferencing (Maier 2004, 269) as they enable dislocated users to jointly view a computer interface. It is subsumed here as it can be used for the cooperative creation and review of electronic contents (Hansen & Neumann 2001, 431f), e.g., by the sharing of text processing applications or with the help of electronic whiteboards.

Support of meetings where participants are located at the same place is discussed in relation to electronic meeting support systems, also called group decision support systems or group support systems (Borghoff & Schlichter 2000, 374ff; Dennis 1994, 177ff; Zigurs & Buckland 1998). They are targeted at `enhancing the efficiency and effectiveness of meetings`, e.g., by removing communication barriers, providing decision techniques or supporting moderation and control of decision processes (DeSanctis & Gallupe 1987, 593ff). Some authors also subsume project management environments and particularly `management of project tasks` under Groupware (Dumas, van der Aalst & ter Hofstede 2005, 14).

Teufel et al. (1995, 26ff) define four classes of systems based on the degree of how strongly the support of each of the tasks communication, coordination and cooperation is focused: communication systems, shared information spaces, workflow management and workgroup computing. Overall, the categorization of systems presented here largely corresponds to this classification, i.e. conferencing systems mainly support communication tasks, workflow management is mainly related to coordination tasks and workgroup computing systems are mainly targeted at support of cooperation tasks. The class of systems called information spaces subsumes group workspaces that bundle communication, coordination and collaboration functions, e.g., community workspaces offering discussions, chat, awareness functions and a content repository (Borghoff & Schlichter 2000, 295ff; Riempp 2004, 194ff). However, taxonomies of Groupware systems always should be interpreted with caution. Even systems that at first sight can be categorized clearly may combine multiple other types of functions, e.g., conferencing systems may also include publication functions for the management of shared documents or group editors include functions to enhance awareness and to facilitate communication.

5.5.4 Learning

Learning that is supported or enabled by IT systems is discussed under the topics e-learning or technology-enhanced learning. E-learning is used as an umbrella term for many different forms of computer support (Bendel & Stoller-Schai 2001, 164). Just as in the case of CSCW (section 5.5.3), design of IT for learning is an interdisciplinary field that involves various aspects such as different principal approaches to designing e-learning environments, e.g., learner-centric, instructor-centric and directed environments, different forms of communication between participants, e.g., synchronous vs. asynchronous or one-to-one vs. one-to-many, and various pedagogical approaches such as objectivist, constructivist, collaborative approaches and situated learning (Sivakumar 2006, 152). Recent challenges are the integration of different system classes as well as the personalization and flexible adaptation of learning contents and functions. Technical support of learning requires some of the functions already discussed in relation to other types of knowledge services. This section concentrates on the systems and functions that are characteristic for IT-support of learning.

Typical functions

A starting point for identification of learning tasks that can be used to classify functions is the IEEE draft of Learning Technology Systems Architecture (LTSA), which defines a high-level architecture for IT-systems that support learning (IEEE 2001, 8). It consists of four so-called processes, i.e. learner entity, evaluation, coach and delivery, two so-called stores, i.e. learning resources and learner records as well as thirteen information flows between these components (IEEE 2001, 21). This represents an internal view on learning software systems. They are adapted here in order to reflect user-oriented tasks. The task author is added to include the creation of contents used as learning resources. Learner entity and delivery are subsumed under learn, which denotes the retrieval and usage of contents for learning. Evaluation and coach are included without changes. Author, learn and evaluate are ordered following the general predecessor-successor relationships indicated by the LTSA information flows (Figure 36). Coach is interrelated with each of these tasks which is indicated by the dashed lines.

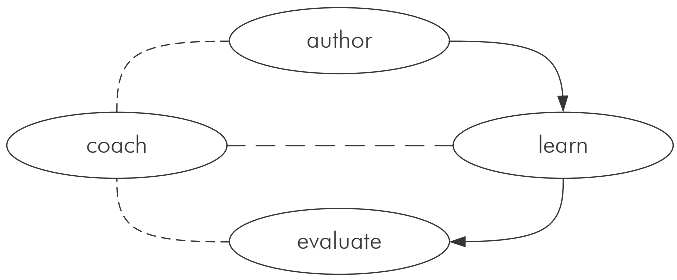

Figure 36. Generic tasks supported by learning functions

Author. The `creation of learning contents` is also referred to as authoring[130]. Software used for this task is labelled authoring system or courseware and may comprise a variety of different systems, e.g., professional authoring systems for the development of complex learning applications, rapid content development tools that offer templates for the fast and inexpensive creation of courses and specialized tools targeted at the creation of, e.g., audio and video files (Baumgartner, Häfele & Maier-Häfele 2004, 8f; Schulmeister 1997, 107). SumTotal ToolBook[131] is an example of the first class, Dynamic Media Dynamic Powertrainer[132] for the second class and Macromedia Director[133] for the third class. More recently, measures to `enhance the reuse of learning contents` have been discussed in relation to learning objects. The term is used to denote independent and self-standing electronic contents that can be used for learning, education and training and are predisposed to reuse in multiple instructional contexts (Baumgartner, Häfele & Maier-Häfele 2004, 9f; Hodgins 2000, 6ff; IEEE 2002, 5; Polsani 2003; Wiley 2001, 7). A foundation for reuse is their `description with meta-data`, e.g., based on the Learning Object Meta-Data (LOM) standard (IEEE 2002). Challenges related to learning objects are finding the right level of granularity (Baumgartner,

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[130] This task is different from the knowledge action authoring described in section 3.4.4 as it focuses on the creation of learning contents.

[131] URL: http://www.toolbook.com, last accessed: 2007-12-02

[132] URL: http://www.dynamicpowertrainer.com, last accessed: 2007-12-02

[133] URL: http://www.adobe.com/products/director/, last accessed: 2007-12-02

Häfele & Maier-Häfele 2004, 10f; Hodgins 2000, 8f; Wiley 2001, 12) and motivating and supporting authors to create and exchange learning objects (Liber 2005).

Learn. Learning refers to the use of learning contents. Established forms for `distribution of learning contents` are computer-based trainings (CBT) and WBT. CBT are autonomous applications delivered on a compact disc or digital versatile disc (Dittler 2003, 25). WBT are distributed over computer networks and based on Web technologies (Dittler 2003, 153f). An important advantage is that WBT may connect users and thus enable cooperative learning (Dittler 2003, 154). Learning management systems (LMS) support the `provision` and `administration of electronic learning contents` based on the level of courses as well as the `management and evaluation of users` (Hettrich & Koroleva 2003, 12f, 36ff; Paulsen 2003, 134). They also include means for asynchronous and synchronous communication such as chat and discussion forums (Hettrich & Koroleva 2003, 42f). Most LMS do not include any authoring functions but are able to import and export contents (Baumgartner, Häfele & Maier-Häfele 2004, 8). ILIAS open source[134] is an example of this type of system. Learning CMS (LCMS) in contrast include authoring functions, are based on the more fine-grained level of learning objects and thus principally enable the `adaptation of learning contents to user needs` (Baumgartner, Häfele & Maier-Häfele 2004, 9f, 11f; Hettrich & Koroleva 2003, 12f). SumTotal TotalLCMS[135] is an example of a software product.

Evaluate. Evaluation aims at gathering feedback about the learner's progress by `monitoring his behaviour` and `analysing results of assessments` (IEEE 2001, 27). Assessments are accomplished based on structured tests based on, e.g., single or multiple choice questions (Schulmeister 1997, 105) but may also be based on exercises to sort or relate items, games or simulations. Learning evaluation is strongly based on comparing the learner's behaviour to a pre-defined solution and thus mainly restricted to structured evaluations (Schulmeister 1997, 105). The evaluation may trigger changes in systems that `map the expertise` of individuals, which is a common function of EKI (Alavi & Leidner 2001, 114) and one of the tasks focused by competence management approaches (Baladi 1998; Lindgren, Henfridsson & Schultze 2004, 436). Competences technically are represented by ratings of a structured competence tree or less-structured descriptions of past experiences (Deiters, Lucas & Weber 2000, 55f; Gebert & Kutsch 2003, 228). Competence management systems also support related tasks

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[134] URL: http://www.ilias.de/ios/, last accessed: 2007-12-02

[135] URL: http://www.sumtotalsystems.com/products/stlcms.html, last accessed: 2007-12-02

such as the `creation and maintenance of competence profiles`, their `analysis and aggregation` as well as the `identification of competence gaps`, i.e. the difference between individual competences and a target profile (Riempp 2004, 182f). Furthermore, they can be used in order to `identify experts in a domain` characterized by a specific set of skills.

Coach. Coaching refers to the acquisition of learner preferences, evaluation of assessment information and selection of learning contents to be offered to the user (IEEE 2001, 29ff). As stated, LCMS target the adoption of learning contents to the user's needs. Therefore, they need to internally `maintain user information`, particularly his past actions and current competences. In this sense they have strong relationships to competence management systems. The Public and Private Information (PAPI)[136] standard specifies a learner model with elements such as relations to other users, security credentials and preferences. `Dynamic adaption` of learning contents to the user's situation on a finer level of granularity than that of whole WBT, e.g., based on learning style, available skills, individual preferences and past activities, up to now represents a vision that remains largely unfulfilled (Röder 2002; Wolpers & Grohmann 2005, 5ff).

5.6 Summary

Within this chapter, the foundations of SOA have been outlined. SOA have been characterized to describe the structure of an application landscape from a business-oriented perspective. Abstraction from concrete technical conditions and flexible reuse of software components have been pointed out as specific characteristics. They have been characterized as an approach for integration of software systems and have been delimited from traditional ways of software integration. As main differences, platform-independent service descriptions, loose coupling of services, dynamic binding of services and service discovery based on repositories have been described. Afterwards, two types of composite services have been described in more detail: process services and flexible services. BPEL has been described as it represents the current state of practice of the definition and implementation of process services. Possible types of flexibility have been discussed based on different classifications of PAIS. Case handling as an approach for the definition of flexible services has been described.

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[136] URL: http://edutool.com/papi/, last accessed: 2007-12-02

EKI have been defined based on their main characteristics. The architecture of EKI has been outlined from a service-oriented perspective. Services enable for a platform-independent general description of the EKI layers as well as their integration. Composite services have been suggested as starting point for the support knowledge actions, more specifically the two types of process services and of case handling services. Afterwards, this chapter turned to an overview of the current state-of-the-art of the technologies related to the four types of knowledge services publication, discovery, collaboration and learning. Generic tasks have been used to group relevant software functions with the goal to make a first step from a solely technical to a business process-oriented perspective. Table 11 summarizes the tasks outlined in each category. Altogether, it can be stated that a rich infrastructure of technical systems is available for the implementation of knowledge services. However, its success will depend on how good it can be tailored to the users needs and thus on procedures and concepts suited for this task.

publication functions	**discovery functions**	**collaboration functions**	**learning functions**
create / edit: create contents, add comments, highlight changes, structure contents *capture*: scan and digitize contents, import electronic contents, assure authenticity, integrity and confidentiality, syndicate selected types of contents *store*: move, complement by meta-data, annotate, classify *review*: manage versions, coordinate simultaneous access *archive*: long-term storage, delete	*browse*: identify or gain overview of relevant knowledge *search*: identify resources, index resources, aggregate resources, present search results, semantic search, analyse search terms, support search, navigate resources, retrieve contact information, information push *filter*: rank search results, content-based filtering, collaborative filtering, refine prior search queries *retrieve*: determine privileges, view contents, transform contents	*communicate*: synchronous / asynchronous text-based communication, voice-based communication, visual communication, receive presence information, distribute messages, initiate communication *coordinate*: coordinate use of resources, manage a group's time resources, manage individual or collective tasks, moderate discussions, schedule meetings, maintain group awareness *cooperate*: collaboratively publish contents, create contents concurrently, enhance efficiency and effectiveness of meetings, manage project tasks	*author*: create learning contents, enhance reuse of learning contents, describe learning contents with meta-data *learn*: distribute learning contents, provide and administer learning contents, manage and evaluate users, adapt learning contents to user needs *evaluate*: monitor learner behaviour, analyse results of assessments, map expertise, create and maintain competence profile, analyse and maintain competence profiles, identify competence gaps, identify experts in a domain *coach*: maintain user information, adapt learning contents (dynamically)

Table 11. Overview of tasks supported by knowledge services

6 Design of empirical study

Goal of this chapter is the development of a research design suited for the empirical investigation of the KWS concept. Together with the following chapter that presents the results of the study, it forms the empirical part of this work. It targets the exploration of the single parts of the KWS concept. The empirical study also contributes to the level of modelling as it investigates concepts applied within modelling languages. It also takes the technical support of KWS into account. Hence, the empirical part is concerned with all three of the levels concepts, models and systems.

6.1 Overview

Figure 37 gives an overview of this chapter. The development of a research design is a stepwise process starting with the decision for a general research approach and the definition of research goals (section 6.2) followed by the design of the way of data collection (section 6.3) as well as decisions concerning the analysis of the data collected (section 6.4). Methods and the concrete procedure are iteratively selected and focused based on the goals as well as the decisions placed in preceding steps. This chapter also includes a reflection of the quality of the research design (section 6.5). It is closed with a summary of the results (section 6.6).

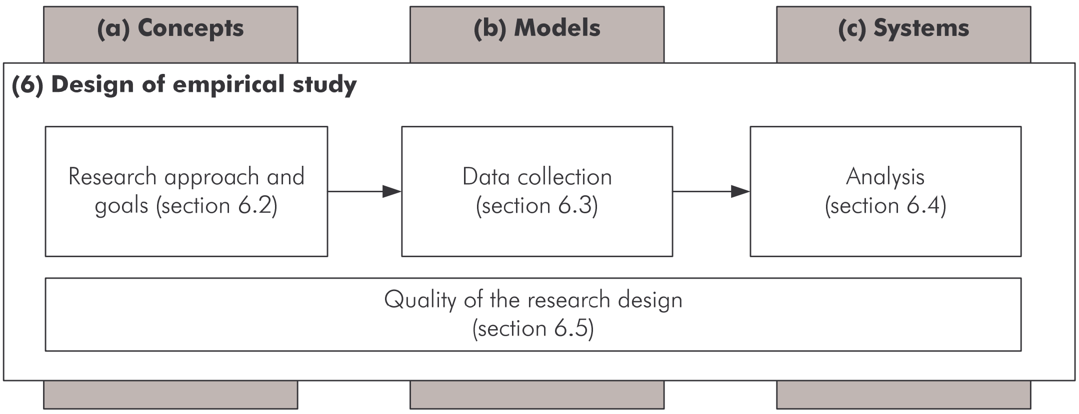

Figure 37. Overview of the chapter *Design of empirical study*

6.2 Research approach and goals

The main goal of this work is the development of a concept suited to structure the goal-oriented support of knowledge work with ICT. So far, the KWS concept has been proposed and detailed based on classifications of occasions, context dimensions and knowledge actions. However, it still remains on an abstract level. The further detailing of KWS can be achieved by means of an empirical exploration. The main goal of this study thus is the empirical investigation of selected components of KWS. This section firstly motivates the general research approach chosen and then formulates a set of propositions to be investigated.

Research approach

The general approach of this research is characterized with the help of two dimensions: the distinction between quantitative and qualitative research strategies and the stance of the research with regard to rigour and relevance. These are outlined in the following.

Quantitative and qualitative research strategy. It can be distinguished between quantitative and qualitative research strategies (Brymann & Bell 2003, 25f; Laatz 1993, 11). Superficially, one could state that quantitative approaches employ measurement and statistical methods and qualitative researchers do not but rely on words and identify and compare types. However, the distinction is not only based on the type of data and the procedures of analysis but rather stands for two general notions of empiricism and research (Brymann & Bell 2003, 25). Quantitative approaches entail a deductive relation between theory and research and accentuate the testing of theories. They are based on a natural scientific model and embody the view of social reality as external and objective. Qualitative approaches emphasize an inductive approach and focus on the generation of theories. They favour the investigation of how individuals interpret their social world. Social reality is regarded as a constantly shifting and emergent individual creation as assumed by constructivsm (section 2.2). The distinction between quantitative and qualitative approaches is applied in many textbooks for the classification of methods and approaches. Nevertheless, it should be used with caution because it is not as clear-cut at it seems at first sight and overburdened with a multitude of differentiations and conceptions of terms (Laatz 1993, 11).

Laatz (1993, 12) offers another classification. It is based on the degree of clarity of the research problem. He states that if the current and the target state of the research are clearly defined, then also the way of how it can be reached can be determined unambiguously. Bortz

& Döring (2002, 34f, 54) add that enough knowledge needs to exist in order to deductively define hypotheses that can be tested with quantitative approaches. A hypothesis is defined as an informed speculation about possible relationships between two or more variables set up to be tested (Brymann & Bell 2003, 570). If the desired state cannot be defined clearly in advance, e.g., if the goal is to gain insights into the social processes of some group, then a preliminary target state has to be defined, continuously evaluated and potentially re-defined. This type of approach is referred to as explorative research and characterized by the inductive creation of hypotheses. In this case, they represent the output rather than the starting point of research (Bortz & Döring 2002, 34f). Empirical methods do not have a value themselves but their choice is determined by the research questions (Bortz & Döring 2002, 34). A general confession to a quantitative or qualitative research stream does not make sense though researchers might tend to it.

This study has a clear orientation towards exploration as it is concerned with the detailing of the KWS concept. Apart from the general classification of KWS components proposed in section 3.4 as well as of technical functions as outlined in section 5.5, not enough knowledge is available in order to specify hypothesis about, e.g., single steps that knowledge actions are composed of and typical services used to support them. Consequently, a qualitative approach is appropriate here that starts out with the formulation of propositions that describe the main assumptions and determine the focus of the study. Goal is the refinement of these propositions to hypotheses that incorporate the results of the study and may be used as a foundation for a quantitative approach. A proposition is defined as a "… provisional hypothesis which could be tested out in the process of research" (Holloway 1997).

Rigor vs. relevance. There is an ongoing discussion within the research community about the right balance between rigor and relevance (Benbasat & Zmud 1999; Davenport & Markus 1999). Whereas the Anglo-American MIS community has a strong orientation towards the description and explanation of reality and sees its legitimation in the process of achieving and publishing respective results, the German-speaking MIS community more strongly focuses on the construction and design of IS and places a higher importance on the applicability of results in practice (Lange 2005; Schauer & Frank 2007). The former thus places a high value on rigorously achieved results and the latter on their relevancy in practice. An example for a rigour approach is Grounded Theory that starts without any pre-defined conceptions and emphasizes discovery of empirically grounded theories by means of a continuous interplay between data collection and analysis (Glaser & Strauss 1967; Strauss 1994).

The KWS concept is intended to represent a practically applicable means for the design of ICT that has an empirical grounding. The relevance of the results of the study will be ensured by using the KWS concept as a framework for data collection and analysis. This naturally does not exclude the application of rigour scientific methods for data collection and analysis.

Propositions

The KWS concept is too complex to be surveyed as a whole. Hence, it is decided to empirically investigate those parts that provide the best starting points for PKM to design effective technical support, i.e. knowledge actions that follow from KWS or more specifically, the steps they are composed of. Furthermore, the knowledge services accessed in their context are relevant here. These components are addressed by the three propositions made.

Proposition 0: Relevance of knowledge actions. As a constitutive proposition, it is suggested that the eight knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation described in section 3.4.4 can be used as a starting point for the study. They have been identified based on a theoretically well-grounded framework and technical functionality has been outlined that potentially is suited to support (parts of) them (section 5.5). Consequently, the proposition states that these actions are relevant when being concerned with the goal-oriented technical support of knowledge work:

(0) The knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation are relevant for PKM and specifically for the technical support of knowledge work.

Proposition 1: Steps. For each of the eight knowledge actions included in the first proposition, some steps already have been identified based on related literature (section 3.4.4). However, no results are available so far that are suited to list a comprehensive and empirically grounded set of steps that are conducted as a part of these actions. The goal of this study thus is to identify and characterize the steps associated with the eight knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation. The second proposition thus is formulated as follows:

(1) Typical steps can be identified for the knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation.

Proposition 2: Services. From the different types of services provided by an EKI, the four types of knowledge services are most relevant since they represent the core functionality of EKI to support knowledge work (section 5.4.2). Functionality related to administration, knowledge integration and personalization thus is excluded here. Second goal of this study is to find out which types of knowledge services are used in order to support the set of knowledge actions defined. It is also relevant how they are actually realized and whether there are differences with regard to the extent or quality of support between different settings such as the organisations surveyed. This can be used in order to estimate the current state-of-the-art of technical support of knowledge actions. The composition of services has been pointed out as being important for the integrated support of knowledge actions (sections 5.3 and 5.4.2). Thus, it should also be analysed how strongly the services identified in relation to a specific knowledge action are integrated. The third proposition is formulated as follows:

(2) Typical knowledge services of the types publication, discovery, collaboration and learning can be identified that are used in order to support the knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation.

Surveying knowledge actions and related services opens up the possibility to gain insights about the other parts of KWS, i.e. occasions and the KWS context. However, no propositions are made in this relation as they are not in the main focus of the study. Furthermore, they might be influenced by the research design which is the case in relation to *occasions*, which will be used as starting point for surveying knowledge actions. Hence, respective results should be interpreted cautiously and are not suited for the formulation of hypotheses. The *context of KWS* will only be investigated indirectly by gathering factors identified to influence knowledge actions and that are relevant for technical support.

The last two propositions include the requirement to identify *typical* steps and services. This refers to the generalizability of results. The most usual direction of generalization is the transfer of results to other populations (Brymann & Bell 2003, 288). For qualitative studies, this is not allowed since they analyse non-representative data in detail gathered based on small populations (Brymann & Bell 2003, 300). Questions such as whether steps of knowledge actions are typical for selected groups of people, organisations or industries can only be estimated based on a quantitative approach with a representative and significantly larger population. In qualitative studies, findings instead are generalized to theory rather than to other populations (Brymann & Bell 2003, 300f). The term typical is used here to refer to candidates for a generalization over populations. Quantitative measures, e.g., the frequencies with which concepts were observed, are primarily used in order to indicate the amount of empirical data that could be used to characterize a step or service.

The creation of hypotheses based on the analysis of qualitative data is characterized by an iterative process of refinement, evaluation and revision, which is typical for qualitative data analysis (Lamnek 2005, 91). Hypotheses generated this way have a different quality than the ones generated with the help of abstract theories. The reason is that they are already tested based on empirical data (Lamnek 2005, 93). Their context-dependence adds a specific explanatory power to the results (Flick 1999, 254). The criteria applied for disregarding or approving (preliminary) hypotheses are not always made explicit in contrast to quantitative research approaches (Lamnek 2005, 91). It is sometimes argued that the lack of such explicit criteria may limit research quality, particularly the reliability and validity of research. However, these criteria cannot be transferred directly to qualitative research due to its different orientation, i.e. the focus on exploration rather than evaluation of hypotheses (Brymann & Bell 2003, 286ff). Criteria for judging research quality will be discussed in more detail in section 6.5.

6.3 Data collection

Possible alternatives for data collection based on an explorative approach are (1) *unstructured and semi-structured interviews* applied in order to investigate subjective views of actors, e.g., concerning events, plans and opinions, (2) *field observation* which is appropriate to explore actors within their natural environment focusing on larger categories or questions and involving the active participation of the researcher, (3) *action research*, where researchers and participants jointly define problems, search for causes, formulate hypotheses and design interventions that subsequently are evaluated and lead to a modification of hypotheses and underlying theories, (4) *non-reactive measures* that conversely are characterized by having no influence on the people, events or processes by focusing only on traces, signs, media, symbols and documents and (5) *qualitative content analysis* to work out the main topics and matters of a selected set of texts or other objects (Bortz & Döring 2002, 54ff). The way of data collection is strongly but not solely determined by the research questions. Different approaches also might be combined to enhance confidence in findings, which is referred to as triangulation. More specifically, triangulation denotes the combination of different researchers, methods, populations, temporal and spatial settings or theoretical perspectives for the examination of phenomena (Flick 1999, 249).

Here, interviews are used for data collection. They are well-suited to explore a set of different knowledge actions on a feasible level of granularity. An alternative is the usage of observation for data collection, e.g., the creation and analysis of individual protocols of activities or the recording of computer sessions. However, it is suited better for a very fine-grained analysis of a lower number of actions. It also has the disadvantage that participants cannot be questioned regarding their reasoning and the other concepts that are of interest here (Brymann & Bell 2003, 362). Though the data collected is based on the reflection of interviewees, it can be expected that introspection leads to usable results. Aspects surveyed are not personal or sensitive. It also can be assumed that interviewees memorize the way how they act correctly because knowledge actions are assumed to represent usual and sometimes even daily accomplished activities of knowledge work. In contrast to other methods of data collection, interviews also offer the advantage that they can easily be recorded and subsequently analysed as frequent and intensively as desired (Lamnek 2005, 329f).

The following section outlines qualitative interviews and characterizes the approach chosen (section 6.3.1). The procedure of data collection with interviews on a general level can be structured into the steps preparation, conduct, and documentation (based on Bortz & Döring 2002, 309ff). As result of the preparation phase it is defined who will be interviewed about what topics (section 6.3.2). The conduct and way of documentation of the interviews are the concern of the last part (section 6.3.3).

6.3.1 Qualitative interviews

Interviews principally can be used as method of data collection in both, quantitative as well as qualitative approaches. Various types of qualitative interviews can be distinguished based on criteria such as who is consulted, the technique of questioning or the interview topics (Bortz & Döring 2002, 313ff; Lamnek 2005, 356ff). The type of interviews selected here can be characterized as expert interview because respondents will be viewed as competent to be questioned about the conduct and technical support of knowledge actions. The approach also shares some characteristics with problem-centred interviews in the sense that the occasions represent challenges or problems of knowledge work that need to be resolved. However, the focus is not on general problems relevant for society as typical for this class of interviews (Witzel 1989). An interview guideline is used to structure the interview process and in this respect the approach can be characterized as guideline interview (Bortz & Döring 2002, 315).

Lamnek (2005, 330ff) presents a classification of qualitative interviews based on seven criteria: (1) The *intention of interviews* can be informational, analytical or diagnostic. The objective here is to structure, analyse and describe statements which can be classified as analytical. This is the most frequently used interview type in social sciences. (2) In terms of the *standardisation of questions*, interviews are classified as structured, semi-structured and unstructured. This criterion can be used in order to differentiate quantitative and qualitative interviews. Semi-structured or unstructured questions are characteristic for qualitative interviews (Brymann & Bell 2003, 341f). They give interviewees the possibility to present their own perspective and also allow them going off on tangents and delving into aspects not determined in advance, whereas structured questions allow maximizing the reliability and validity of results. The flexibility of semi-structured interviews is required here as it is not known in advance what types of steps are accomplished and which classes of services are used in the context of a knowledge action. (3) Concerning the *structure of respondents*, it is distinguished between individual and group interviews. The individual procedure of accomplishing knowledge actions and thus individual interviews are relevant here. (4) Related to the *way of communication*, it can be distinguished between oral and written presentation and answering of questions. Here, questions are posed and answers are made verbally.

(5) The *communication style* can be characterized as soft, neutral or hard. A neutral style is used here in order to minimize influences of the interviewer. (6) *Openness of questions* again can be used to differentiate qualitative from quantitative interviews. Closed questions implicitly or explicitly predetermine a set of possible answers.[137] Qualitative approaches decline this type of questions as they impose the interviewer's perspective on the respondent (Lamnek 2005, 345). Open questions in contrast are answered simply with the structure and language desired by the interviewee. For this study, open questions are used. A set of closed, structured questions is included additionally for the characterization of the work tasks of the

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[137] More detailed classifications of questions can be found in Gläser & Laudel (2004, 118ff) who distinguish between questions targeted at facts vs. opinions, hypotheses vs. facts, motivation for narrations vs. focusing details as well as introduction, main, and inquiry questions. Bryman & Bell (2003, 349f) offer a similar but less structured classification into introducing, follow-up, probing, specifying, direct vs. indirect, structuring, and interpreting questions.

interviewees. (7) Qualitative interviews almost exclusively are conducted verbally and can be classified based on the *media* used into face-to-face interviews and phone interviews. Face-to-face interviews are preferred here. It was regarded feasible to also include phone interviews as a complement to other face-to-face interviews conducted within an organisation.

6.3.2 Preparation of data collection

During the preparation of data collection it is defined who will be interviewed about what topics. This relates to the sampling strategy of the study, i.e. the decisions about what groups should be focused and who from these groups should be interviewed (Flick 1999, 78). These two aspects will be discussed before turning to the contents of the interviews structured by means of an interview guideline.

Target group

KWS should be researched in a setting where individuals are likely to accomplish knowledge-intensive tasks. The knowledge actions focused are based on the work practice perspective on knowledge work (section 2.3). The occupation is used as a proxy in order to identify respondents that potentially accomplish knowledge work in general an the four types of informing practices used for the proposition of the knowledge actions to be researched in particular (section 3.4.4). This is typical for empirical studies about knowledge work from an economical perspective (Bredl 2005; Cully 2003; Schultze 2000; Wolff 2005; Wolff & Baumol 1989). The reason is that the selection of potential participants needs to be based on a criterion that can be determined easily in advance. In order to acknowledge the work practice perspective, further questions that should characterize the work tasks of the respondents are included and otherwise the actual activities that the respondents perform are focused.

Consultants can be regarded as a profession that is confronted with a high share of knowledge work as their work fundamentally is based on the offering and application of their expertise within different organisational settings. They are selected here as general target group. Walger (1995, 2ff) distinguishes the following four ideal types of increasingly comprehensive consulting activities: (1) *assessment* answers pre-defined questions, acquires appropriate information and appraises different alternatives, (2) *expert consultation* in cooperation with executive managers works towards more or less clearly defined organisational solutions, (3) *organisational development* is the coaching of individual members of an organisation in order to enable reflection and ultimately facilitate organisational learning and

(4) *systemic consulting* views organisations as autopoietic social systems and induces organisational measures that foster reflection on an organisational level. This study focuses consultants that act as experts for a specific topic and thus predominantly accomplish consulting activities that fall into the first category. More specifically, IT consultants are selected since they have access to a variety of technical systems and are able to describe them in more detail. This concerns IT consultants working for organisation-internal customers just as those employed by consulting companies and working for external customers.

Knowledge work is characterized to typically imply strong communication, coordination and cooperation needs (section 2.3). This characteristic can be used in order to further specify the profile of potential interview candidates. It is focused on those IT consultants that typically work on the interfaces between different disciplines and different organisational units. Typically, they should mediate between organisational units that apply IT and those that design, implement, administer and maintain respective systems. This intentionally excludes roles mainly concerned with implementation or system administration tasks and sets the focus on individuals consigned with conceptual tasks such as requirements specification and management tasks such as project management. Another characteristic of knowledge work that can be straightforwardly operationalised is that it requires a high level of education, training and experience. Hence, it is determined that participants of the study need to have a university degree and at least three years of work experience.

Potential interviewees should have access to a sophisticated technical infrastructure and a variety of different systems. Hence, it was decided that interviewees should be employed at large organisations. In the sense of § 267 of the German Commercial Code[138] an organisation is classified to be large if at least two of the following criteria are fulfilled: (1) On average it employed more than 250 employees during one year, (2) had more than € 27 500 000 of sales revenue in the twelve months before financial statement date and (3) a balance sheet total of more than € 13 750 000 discounted by a deficit reported in the assets (HGB 2003). This classification is applied here in order to select organisations.

Consequently, large organisations have been approached with the request whether employees working as internal or external IT consultants could act as interview partners that have a university degree, at least three years of work experience and typically mediate on the inter-

[138] In German: Handelsgesetzbuch, HGB

face between business and IT. Table 12 summarizes the profile of potential interviewees. Where possible, this profile was complemented with examples for typical tasks depending on the organisation approached.

characteristic	description
profession	IT consultant
work tasks	works at the interfaces between business and information technology
education	possesses a university degree
experience	has at least three years of work experience
affiliation	is employed at a large organisation according the § 267 of the German commercial code

Table 12. Profile of the target group

Selection and number of interview partners

Convenience samples, i.e. samples available to the researcher by virtue of its accessibility, are not unusual in qualitative research (Brymann & Bell 2003, 105f, 356f). The reason is that qualitative studies are not about generalization to other populations but rather about generalizations to theory (section 6.2). For this study, a convenience sample is used. Carefulness was invested that all interviewees correspond to the profile described. Contact persons within organisations known by the researcher acted as informants that helped to identify appropriate interview candidates. Informal contacts and relationships often play a role during the identification and selection of respondents for qualitative interviewees (Lamnek 2005, 385). This procedure is not only regarded as advantageous for convincing potential candidates to participate in an interview but also to identify people that fit well with the profile developed.

The data collection was guided by two criteria related to the eight knowledge actions focused by the propositions (section 6.2). Firstly, it was determined that as much steps of a knowledge action as possible considered relevant by the target group need to be identified and appropriately described based on the data collected. Thus it was determined that each knowledge action had to be surveyed at least ten times. It was allowed to include an action in additional interviews if it could be expected that new information is added that allows the identification of new steps or services. This criterion is based on the idea of theoretical sampling that stops upon the saturation of a theory to be developed (Strauss & Corbin 1998). Secondly, the requirement was posed that all eight knowledge actions need be covered in all organisations approached.

The duration of qualitative interviews can be substantially longer than that of quantitative interviews (Lamnek 2005, 336) and varies largely depending on their type (Bortz & Döring 2002, 313ff). Potential participants are only able and willing to dedicate a limited amount of their time to the study so that it was decided that one interview should be conducted per participant with a maximum duration of one and a half hours. One third of the time was reserved for introduction, explanation and the gathering of related data. The remaining two thirds of the time leave room for the discussion of three actions per interview. From this follows that at least three interviews per organisation need to be conducted in order to cover all eight knowledge actions within an organisation. The number of organisations to be approached was not determined in advanced.

Overall, 31 interviews in nine organisations have been conducted within the timeframe from July to December 2006. Table 13 characterizes the participating organisations with regard to their industry sector, the number of employees and their sales revenue. All of them can be classified as large according to § 267 of the German commercial code based on the number of employees and the sales revenue. Personal data of the interviewees has to be secured from unauthorized access and it has to be taken care of that the respondents cannot be identified (Bortz & Döring 2002, 313). Names of organisations and also of the interviewees therefore have been anonymised by exchanging them with indices. These will be used for reference during the description of the results in order to link the analysis to the empirical data.

	industry sector	**number of employees** (approximation)	**sales revenue** (millions of €)
O.01	automotive manufacturer	106 000	46 600
O.02	IT consultancy	350	64.3
O.03	IT consultancy	61 036	7 000
O.04	certifier of nautical vessels	2 900	319
O.05	semiconductor manufacturer	36 000	7 200
O.06	IT consultancy	2 000	224
O.07	software manufacturer	2 000	414.8
O.08	polymer manufacturer	14 000	1 122.1
O.09	automotive supplier (electronics)	53 000	9 000

Table 13. Employees and turnover of the organisations surveyed[139]

[139] The data is based on the fiscal year 2004/2005 since the accounting activities of the year 2005/2006 were not finished at the beginning of the study. It was accessed on the Web sites of the organizations and if appropriate, contact persons within the organisations were asked to supply it.

The average age of the interviewees was 36.71 years (standard deviation 5.44). Two interviewees are female (6.5 percent) and 29 male (93.5 percent). All of the respondents had more than three years of work experience, on average 10.89 years (standard deviation 5.86). About one half of them were able to look back on between three and ten (48.39 percent) and the other half on more than ten years of experience in their job (51.61 percent). All of them hold a university degree, in most cases a diploma in business studies, informatics or MIS. One half of them has rather business-oriented tasks such as process improvement, project management and team management (54.84 percent) and the other half deals with conceptual tasks related to software development such as requirements definition, conceptual design and support of IT users within the organisation (45.16 percent).

Each knowledge action has been surveyed eleven to thirteen times. Table 14 gives an overview of the interview partners categorized according to the type of knowledge actions and their organisation. The knowledge actions to be discussed were selected before each interview. The selection was based on the two criteria defined above, i.e. a knowledge action had to be investigated at least ten times or more and all of the eight types of knowledge actions need to be investigated in each organisation. These requirements were fulfilled.

organisation	**interviews**	**authoring**	**co-authoring**	**training**	**acquisition**	**update**	**feedback**	**expert search**	**invitation**
O.01	4	I.16, I.26	I.11	I.28	I.16	I.11, I.26	I.16, I.28	I.26, I.28	I.11
O.02	4	I.04	I.14, I.22	I.14, I.22	I.04	I.04	I.09	I.09	I.09, I.14, I.22
O.03	3	I.31	I.01, I.15	I.01	I.15	I.31	I.01	I.15	I.31
O.04	4	I.10	I.12	I.10	I.02, I.21	I.02, I.12	I.12	I.10, I.21	I.02, I.21
O.05	3	I.18	I.20	I.18, I.20	I.25	I.25	I.20	I.18	I.25
O.06	3	I.03, I.06	I.13	I.06	I.03	I.13	I.03	I.13	I.06
O.07	3	I.17, I.29	I.05	I.05	I.17	I.29	I.05	I.17	I.29
O.08	4	I.08, I.24	I.19	I.08	I.08, I.24	I.23, I.24	I.19, I.23	I.23	I.19
O.09	3	I.07	I.30	I.27	I.27	I.30	I.07	I.07, I.30	I.27
sum	31	13	11	11	11	12	11	12	12

Table 14. Overview of interviewees per knowledge action and organisation

Interview guideline

An interview guideline contains a set of general of questions that is based on the research questions (Bortz & Döring 2002, 315; Brymann & Bell 2003, 348f). It structures the topics to be addressed during the interview, makes the data comparable and represents a framework for data collection and analysis. An important characteristic is its flexibility: It leaves enough room to incorporate topics that emerge during the interview situation.

The interview guideline used for this study covers two general aspects: Questions about the interviewee and her or his work tasks including a KM-oriented characterization as well as starting points for the discussion of knowledge actions (appendix A). It is structured into six sections: (1) The first section labelled *personal data* contains only few items that ask for general information such as name, affiliation, gender and age. (2) The second section deals with the *education and professional experience* of the respondent, particularly her or his graduate degree, the denomination of the position, a short description of the main work tasks and the overall time of work experience. The first two sections allow gaining a general picture of the interviewee's responsibilities. (3) The third section includes a *characterization of work activities* from a KM-oriented view. They are based on selected characteristics of knowledge work that above have been subsumed under work tasks: the need for continuous learning, the need for creative solutions and the existence of strong cooperation as well as communication needs (section 2.3). Each of them is addressed by a specific statement (statements a, c, d and g). Based on the distinction between the two KM foci of codification vs. personalization, four additional statements are developed (section 2.4).[140] Whereas personalization is primarily oriented towards solving new problems, is based on individual expertise and on direct collaboration between individuals which can only be moderately supported by IT, codification is characterized by reuse of documented knowledge and supported by IT systems facilitating storage and retrieval of knowledge. Consequently, the statements included address the reuse of documented knowledge, the dealing with comparable topics, the sharing of knowledge in documented form and the role of IS as being a container for knowledge in contrast to supporting direct communication of knowledge (statements b, e, f and h). The degree to which the statements apply is rated based on a 7-point-Likert scale from *not or very weakly* to *very strongly*.

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[140] The two other foci of enterprise effectiveness and intellectual capital are excluded here as this study deals with individual knowledge actions and not with organisational and strategic levels.

(4) The first three sections of the guideline were designed to be answered concisely in order to quickly proceed to the main aspect of the interview included in the fourth section: the discussion of three *knowledge actions*. The concept of knowledge action firstly needed to be explained to the interviewees. Therefore, a figure was presented that was also included within a printout of the interview guideline handed out to the interviewees (Figure 38). Knowledge actions represented by a circle were explained to be triggered by occasions and to result in a more or less clearly defined end-state. They were characterized to be accomplished by a number of steps that potentially are supported by IT services, e.g., doing an enquiry for a documentation of some system based on an Intranet search engine. It was emphasized that steps principally can but need not necessarily have a specified order and that only those steps supported by IT are relevant for the interview. Individually rather than formally defined steps were noted to be of interest, which is the reason why the pictogram of a human was included. The suggestion of steps by the interviewer had to be avoided. Instead, ideas about further steps were sparked by referring to three antagonisms included as a bulleted list: the distinction between consumption and creation of knowledge already highlighted in section 2.7, documented knowledge vs. competences of individuals reflecting two primary and easily comprehensible media of knowledge (section 2.2) and more active vs. more passive steps in order to also include tasks that are performed (partly) by IT systems. These were explained shortly and referred to by the interviewer later on.

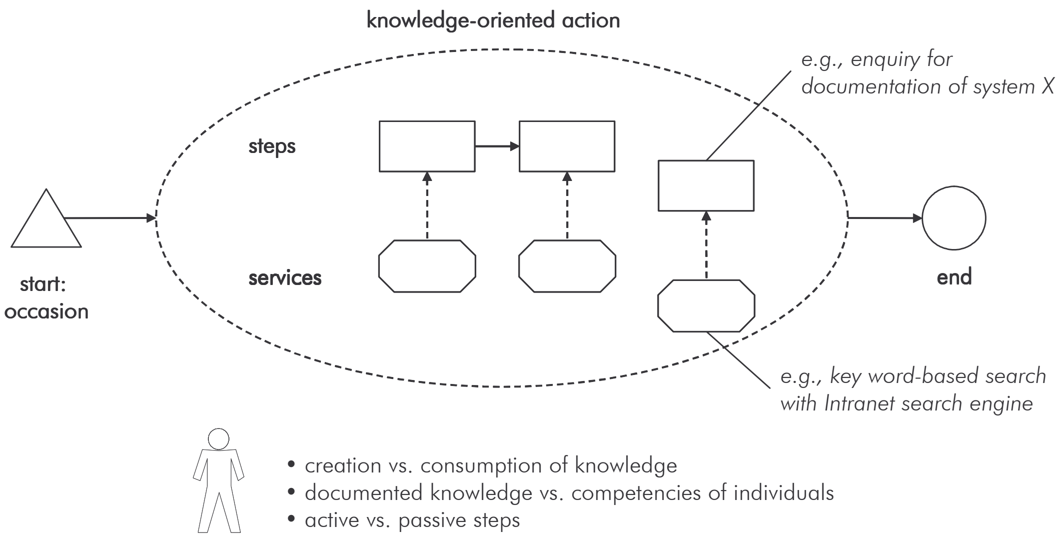

Figure 38. Illustration of knowledge actions within the interview guideline

The concrete knowledge action to be discussed was characterized by a short definition, examples for occasions and the description of possible end states. These were developed based on the description of knowledge actions (section 3.4.4). In the context of this study, mainly task-oriented occasions were noted as examples in order to maintain a close relation to the actual work tasks of the interviewees (section 3.4.2). The very concise description within the guideline was explained more thoroughly and where possible, additional examples adapted to what was known about the interviewee's work context were included. The discussion started with naming a knowledge action, enumerating its characteristics and making a suggestion to think about similar occasions related to the own work context. Closed questions at this stage were avoided as far as possible. In some cases, it was necessary to clarify the intended level of detail and to remind interviewees that only IT-supported steps are relevant. Though going off on tangents was allowed, interviewees were kept back on track of the knowledge action if they wandered to far off the main focus of the interviews. Typical questions posed were "Which step follows after completion of the step just described?", "How is this step supported technically?", "Are there other alternatives for this step?" and "What determines whether this step is accomplished or this service is used?" It was also allowed to activate the reflection on things that seemed to be self-evident to the interviewee, e.g., if steps were described on a too rough level of granularity or if technical support was not explained thoroughly (Lamnek 2005, 389).

(5) The fifth section of the guideline requests to estimate the number of times a knowledge action is accomplished per week. A *quantity structure* can be derived based on this that targets the comparison of the frequency with which knowledge actions are accomplished. Up to this point, the interviewee was only familiar with three knowledge actions and thus a table was presented with a short description of each of the eight knowledge actions. If interviewees wanted to relate their ratings to other time frames such as months or years, they were allowed to do so.

(6) The sixth and last section of the interview guideline just as the third part contains a set of structured statements that aim at a *further characterization of work tasks* from a KM-oriented perspective. The extent to which they apply similarly is rated on a 7-point-Likert scale. This part is less relevant than the discussion of knowledge actions and thus it was put at the end of the interview so that it principally could have been answered later on by the interviewees on their own. The statements pick up selected characteristics and challenges of knowledge work related to work tasks, organisation, IT support and economics as described in section 2.3. For the characterisation of *work tasks*, statements concerning increased training needs, a larger room for decisions and the relevancy of knowledge sharing are included.

Those concerning the aspect of *organisation* target increased cooperation needs and the requirement for cooperation with external cooperation partners. With respect to *IT support*, the need for support by mobile technologies, the relevance of semi-structured data and information as well as the continuous need for network access is addressed by the statements. The area of *economics* is represented by one statement that investigates whether interviewees are evaluated based on quantitative measures at all. Within the guideline, it is subsumed under organisation. Furthermore, the interviewees were asked to estimate the number of formal roles they have, the number of teams they are a member of and the number of work-related informal groups they participate in.

The interview guideline was pre-tested and re-worked in two rounds. Firstly, initial interviews were conducted with two friendly users. The guideline was reworked afterwards based on their comments. Particularly, the characterization of knowledge actions and some of the statements were clarified and the guideline was shortened in order to meet the time planned for the interviews. After overall twelve interviews, the completed guideline was redistributed to the interviewees and they were asked whether all contents were correct and if they felt that aspects were unclear. Six replies were received that led to minor changes of the guideline with respect to the word choice in some questions.

6.3.3 Conduct and documentation

This section firstly summarizes details of the actual conduct of the interviews and then turns to the way how the data was recorded and documented.

Conduct

The language used in the interviews was German. The interviewees received a cover letter that contained some information about the goals of the study and the contents of the interviews as well as contact information of the researcher. At the beginning of the appointments, the researcher introduced himself and the context of the study. It was tried to rouse curiosity about the topic. Afterwards, it was clarified that the interview needs to be recorded but that anonymity is ensured. The interview guideline was filled out electronically on the notebook by the researcher and a printout was handed out to the communication partner. It was always taken care to let the interviewee look on the notebook display in order to create a cooperative atmosphere (Bortz & Döring 2002; Laatz 1993, 162). Most interview sessions as planned lasted between one and one and a half hour. In some cases, respondents were willing to spend more time on the interview and also presented some of the software systems they referred to. It was tried to distribute the time for the discussion of each action evenly. However, the discussion of training, acquisition, co-authoring and authoring tended to take more time and that of expert search, invitation, update and feedback in many cases required less time. This was determined by the number of steps and services discussed in an interview as well as by the degree of detail in which these were explained by the respondents.

Various recommendations for correct communication behaviour in interviews are formulated (Bortz & Döring 2002, 310f; Hron 1994, 133ff; Laatz 1993; Lamnek 2005, 155ff). Kvale (1996, 148f) summarizes them with ten pragmatic yet partially competing advises. He states that a successful interviewer has to be (1) *knowledgeable*, i.e. familiar with the focus of the interview, (2) *structuring*, i.e. gives purpose for the interview and rounds it off, (3) *clear*, i.e. asks simple and short questions, (4) *gentle*, i.e. lets people finish and tolerates pauses, (5) *sensitive*, i.e. listens attentively and is emphatic, (6) *open*, i.e. responds to what is important and is flexible, (7) *steering*, i.e. knows what he or she wants to find out, (8) *critical*, i.e. is prepared to challenge what is said, (9) *remembering*, i.e. relates what is said to the previous discussion, and (10) *interpreting*, i.e. clarifies the interviewee's statements but does not impose meaning on them. These were followed as far as possible.

Though face-to-face communication is common for qualitative interviews (Brymann & Bell 2003, 350), the four sessions with the interviewees I.03, I.15, I.29, and I.31 were conducted over phone in order to complement the data collected for each knowledge action. Phone interviews compared to direct conversation may have some disadvantages, e.g., it is less personal and the interviewer cannot engage in observation. Advantages are that the interviewee is less influenced by characteristics of the interviewer and that phone interviews are much cheaper and quicker (Brymann & Bell 2003, 120). The interview guideline in this case was sent out to the interviewee at least one week in advance together with a short description of the intention of the interview. Special attention was paid to keep time spent on parts other than about knowledge actions short. The phone interviews lasted between 45 minutes and one hour.

Documentation

The interviews were documented in two ways. Firstly, the guideline was filled out electronically. The discussion of knowledge actions was documented by making concise notes within an electronic table that contained three columns: *steps*, *technical support* and *comments*. This table turned out to be less important for documentation but represented a valuable means for structuring the discussion of knowledge actions during the interviews as it could be used as a point of reference by both communication partners. Additional notes were written down a short time after the interview if necessary.

Most important for analysis were the audio records created with a digital voice recorder. These were transcribed for further analysis (Bortz & Döring 2002, 353ff; Brymann & Bell 2003; Gläser & Laudel 2004, 188f). The texts produced this way allow for a repeated and detailed analysis of the conversation and its processing with specialized software (Kuckartz 1999). The principal possibility to compare the transcripts with the results of analysis enhances the methodological reliability (Lamnek 2005, 390). Transcription is a very time consuming process (Brymann & Bell 2003, 354) and thus it was decided to transcribe only those parts of the interviews that deal with the discussion of knowledge actions, i.e. with part four of the interview guideline. As a result, about two thirds of the overall interview time needed to be processed.

Transcription can be based on differently complex systems: Simple transcription systems just transfer spoken words literally to text whereas commented transcription also records non-verbal features such as accentuations, pauses or gestures (Kuckartz 1999, 58ff; Mayring 2002, 89ff). The choice of the transcription system largely depends on the research goals. Commented transcription induces significantly larger efforts and may limit the readability of transcripts. For the purposes of the study, it was sufficient to directly transfer speech to text and to mark only those aspects that have an obvious influence on the interpretation of the statements such as large pauses, incomprehensible words and specifically laughs that may indicate ironic statements. Some aspects important for analysis were already marked and commented during transcription in order to regard as many details as possible. The transcription of one interview required between three and five hours. It produced approximately 375 pages of text.

6.4 Analysis

Content analysis appears as an adequate method because allows to classify and summarize parts of the qualitative data based on their relation to a specific step or service (Mayring 2002, 103ff). The data gathered with structured questions is analysed based on descriptive statistics. The following section outlines content analysis and based on this portrays the approach chosen (section 6.4.1). Then, the general procedure of analysis will be outlined (section 6.4.2) and subsequently the coding process will be described in more detail as this is particularly relevant for content analysis (section 6.4.3).

6.4.1 Content analysis

Content analysis is a flexible method for the investigation of different types of reproducible contents, most frequently textual ones (Brymann & Bell 2003, 193f). Like other methods of social research, it develops the common process of interpreting communication further in order to satisfy the requirements of scientific research (Lamnek 2005, 478). This is achieved by categorizing contents on different levels of granularity such as words, sentences or paragraphs and by analysing the resulting classification. It is traditionally applied for the analysis of mass media in order to answer questions about when and how selected media report about which topics within a specified time-frame (Brymann & Bell 2003, 194; Lamnek 2005, 478). In this sense it is defined as "… a research technique for the objective, systematic and quantitative description of the manifest content of communication" (Berelson 1952, 18). *Objective* refers to the explicit definition of rules for the assignment of data to categories and *systematic* to their consistent and unbiased application (Brymann & Bell 2003, 194). *Manifest* refers to the objectivity of the interpretation. Principally, it can be put into question whether manifest content exists at all since as soon as a reader attaches meaning to symbols, words, and sentences, his predispositions become involved that distort comprehension (Berelson 1952, 19). Berelson (1952, 20) thus formulates the requirement that content analysis needs to deal with denotative communication materials, i.e. communication where a direct and specific meaning can be assigned, and not with connotative materials that are characterized by the fact that a meaning is suggested by words that are apart from the aspect they explicitly name or describe. However, this distinction remains blurry so that this issue cannot be completely resolved. Berelson's definition roots content analysis strongly within a quantitative research strategy.

Qualitative content analysis in contrast is characterized by placing less or no emphasis on measurement, is more concerned with a systematic and traceable classification of symbolic-interactively mediated interaction and has the goal to understand, explain and reason about it (Bilandzic, Koschel & Scheufele 2000; Lamnek 2005, 483ff; Mayring 2003, 16ff). Mayring, one of the proponents of qualitative content analysis, defines it as a systematic approach for the theory-guided and rule-based analysis of affixed communication in order to reason about selected aspects (Mayring 2003, 13). Quantitative content analysis focuses on contents not intentionally created for analysis and promotes non-reactivity due to the absence of relationships between researcher and subject as an advantage (Lamnek 2005, 485). In contrast, content analysis in qualitative social research is applied with the goal to analyse purposefully collected data in order to make theoretical statements about social life (Lamnek 2005, 490). Content analysis approaches discussed within the Anglo-American literature are invariably quantitative ones (Gläser & Laudel 2004, 192).

The distinction between qualitative and quantitative content analysis is criticized as misleading and being too idealised (Früh 2004, 67ff). Many approaches cannot be classified clearly as they bear both, quantitative and qualitative characteristics. Früh (2004, 67ff) argues that methodology should try to combine both perspectives and their respective strengths, e.g., by combining the inductive and deductive creation of categories. Lamnek (2005, 506) in this relation notes that qualitative content analysis can be used to prepare a quantitative one.

The approach chosen for this study can be characterized as qualitative content analysis. Contents are intentionally created by means of interviews. Main goal is the detailing of the propositions made in section 6.2, i.e. the identification of steps that are part of the knowledge actions focused as well as supporting services. Quantitative data will be used to describe the frequency of steps and services that are identified but in contrast to quantitative content analysis is not applied in order to test hypotheses.

Software tool support

Software tools can substantially raise the efficiency of managing and analysing the potentially large amount of data as they take over many of the clerical tasks associated with manual coding and retrieval of data (Brymann & Bell 2003, 444). Tool support can reach from the rather simple support of the creation and change of textual contents with text processing software over data bases that allow organising and presenting excerpts based on categorizations up to specialized programs that implement a specific procedure of analysis (Mayring

2002, 135f; 2003, 100ff). Qualitative content analysis (QDA) software also referred to as computer assisted or computer-aided QDA software (CAQDAS) focuses the latter two ways of support (Brymann & Bell 2003, 444; Kuckartz 1999). This study primarily requires support for managing the category system and the passages assigned to them. A large number of different tools are available and no market leader such as SPSS for quantitative data analysis can be identified (Brymann & Bell 2003, 445f). The selection depends on the research method and also on individual preferences (Kuckartz 1999, 42f; Mayring 2002, 139). Examples for widely-used tools are Atlas.it[141], MAXQDA[142] and NVivo[143]. NVivo was used for this study as it fulfilled all requirements. It is an advanced version of the very popular NUD*IST (Non-numerical Unstructured Data Indexing Searching and Theorizing) software (Brymann & Bell 2003, 445f).[144] The transcribed sections of the interviews were split according to the knowledge actions and imported into NVivo which then was used for handling all data created by means of transcription. Quantitative data such as the frequencies with which categories were identified was exported from NVivo to spreadsheets, e.g., in order to create tables and diagrams required for analysis.

6.4.2 Procedure of analysis

The analysis is based on the general procedure model suggested by Mayring that follows nine stages (Lamnek 2005, 518ff; Mayring 2003, 42ff): (1) Firstly, the contents to be analysed need to be determined. Here, these are the parts where interviewees describe how they proceed during a knowledge action. (2) Secondly, information about how the interview protocol was created needs to be gathered, e.g., about the people that were present during the interview or a general description of the interview situation. In this context, more information than presented in section 6.3 is not required to achieve the research goals. (3) The data used for analysis needs to be characterized. This relates to the transcription system used in order to generate the data (section 6.3.3). (4) As next step, the direction and objects of analysis have to be determined based on the research questions, e.g., sensitivities of the interviewee or the emotional, cognitive and task-related state of conversation partners. Only the actual content topic of the discussion is relevant here. (5) The theory-based differentiation of the research

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[141] URL: http://www.atlasti.com, last accessed: 2007-12-02

[142] URL: http://www.maxqda.com, last accessed: 2007-12-02

[143] URL: http://www.qsrinternational.com, last accessed: 2007-12-02

[144] A detailed description of the application of NVivo can be found in Brymann & Bell (2003, 447ff).

question as the next step concerns the detailing of the research questions with regard to the exact aspects that need to be analysed. This corresponds to the goals and propositions as outlined in section 6.2.

(6) Sixth step is the selection of one out of three methods of analysis: summarization, explication and structuring (Lamnek 2005, 520ff; Mayring 2003, 56ff). *Summarization* is the gaining of abstract statements e.g., through generalization, selection and paraphrasis that condense and characterize the empirical data. *Explication* is the gathering of additional material for selected passages in order to allow explanation, clarification and enhancing the comprehensibility of the data. *Structuring* is the pivotal technique of content analysis. It filters a structure incorporated by a category system from the data (Mayring 2003, 82f). Potential goals are to work out an internal structure represented by, e.g., semantic networks (formal structuring), to filter selected contents and topics that later on may be condensed with summarization (content-oriented structuring), to identify prominent characteristics such as theoretically relevant, extreme or very frequent characteristics (typifying structuring) or to rate aspects of the data based on pre-defined ordinal scales (scale-based structuring). In order to answer the research questions of this study, a combination of typifying and content-oriented structuring will be applied. Typical steps and services firstly need to be found out based on typifying structuring and then are condensed and abstracted which is characteristic for content-oriented structuring.

(7) Subsequently, the textual unit of analysis has to be determined. Here, it was decided to assign one or more sentences of the interviewee or the interviewer to a category. (8) The data then is analysed based on the procedure selected in step six. The process of typifying structuring that comprises breaking down qualitative data into components and assigning names to them is also referred to as coding (Brymann & Bell 2003, 567). A code is a label or a tag assigned to chunks of information compiled during a study, in this case the units of analysis of the data selected during step seven (Miles & Hubermann 1994, 56f). It can be based on a category system or take more complex forms, e.g., metaphors. The assignment of codes to chunks of the data enables their subsequent retrieval and organisation. The terms code and category will be used synonymously here as the codes assigned during analysis are organised as a hierarchical system of categories. Coding includes the iterative evaluation and adaptation of the category system paralleled by restructuring the data based on this system. The exact procedure of coding will be described in detail in section 6.4.3.

(9) The results are interpreted afterwards with regard to the research questions by abstracting from individual cases to a cross-case discussion and an overall presentation of typical cases based on the categories. The categories therefore are summarized and condensed, i.e. unneeded or repeated parts are left out and the contents of a category are reduced to the main statements. This corresponds to the method of summarization (Mayring 2003, 59ff). Results are presented in the following chapter complemented by the discussion of the further data gathered based on the remaining sections of the interview guideline. (10) The last step comprises the evaluation of the quality of the research process, i.e. its validity and reliability. This may comprise measurement of key indicators if applicable or other alternative ways of quality assurance as discussed in more detail in section 6.5.

6.4.3 Coding procedure

The description of the exact procedure of coding in the following will be discussed in more detail as it is constitutional for the quality of the results of this study. Firstly, two general strategies for coding and particularly for the creation of categories will be outlined, i.e. deductive vs. inductive definition of categories. Then it will be turned to the way how single categories in the context of this study have been defined.

Deductive vs. inductive category definition

Quantitative and qualitative content analysis differ fundamentally with regard to how the structure is created with which the empirical data is approached with. Quantitative content analysis emphasizes the *deductive definition* of categories where theoretical considerations determine the composition of the category system, particularly the hypotheses that are defined at the outset of the study (Brymann & Bell 2003, 202ff; Früh 2004, 141ff; Mayring 2003, 74f). In the context of qualitative content analysis, it can be used for scale-based structuring. *Inductively defined* categories are based on generalizations of the empirical data. The approach strives for a naturalistic representation of the data in a way that is unbiased by the researcher's assumptions (Mayring 2003, 75).

A combination of deductive and inductive category creation is not unusual. Gläser & Laudel (2004, 193) criticize that many qualitative content analysis approaches start out with a predefined category system and thus actually use the procedure of quantitative content analysis.[145] They present an approach that takes the inductive definition of categories more explicitly into account. Bilandzic et al. (2000) argue that qualitative content analysis should firstly start out with theory-based definition of general criteria that govern the decomposition of the empirical data and then should develop categories close to empirical data. Dey (1993, 96f) similarly calls for a conceptually and empirically grounded category system, i.e. one that relates to an appropriate analytic context and is rooted in relevant empirical material. Früh (2004, 141ff) from a more deductive perspective suggests to start with main categories based on the hypothesis to be tested and then to detail them or even to include additional main categories based on the empirical data. This points to the fact that there is a continuum between quantitative and qualitative approaches rather than two clearly separable classes of them, depending on where category definition is based upon. The repeated discussion of this topic also makes clear that creating an appropriate category system represents a methodological challenge.

Initial categories

Four general categories are used as a foundation for the category system. They represent the aspects of the qualitative data to be analysed and are based on the propositions stated in section 6.2. The first main category concerns the *steps* to be identified (proposition 1). It is further refined based on the four informing practices that were used to define the knowledge actions, i.e. expressing, translating, monitoring and networking (section 3.4.4). They should be suited for a general and evenly distributed categorization of the steps identified. The second main category structures the *knowledge services* to be identified (proposition 2). It is detailed based on the four types of knowledge services publication, discovery, collaboration and learning as outlined in section 5.5.

Figure 39 depicts these main categories that are complemented by a further category is used in order gather examples for occasions referred to be the interviewees as well as a main category for classifying context factors identified. They do not refer to a proposition to be refined but represent aspects to be regarded during analysis. Context factors are classified based on the six dimensions of the KWS context product, process, person, productivity tool, time and

[145] More recent research projects that apply qualitative content analysis are documented in, e.g., Mayring & Gläser-Zikuda (2005). Inductive definition of categories is repeatedly addressed there which argues against this critique.

location as described in section 3.4.3. All of these main categories are populated with categories identified based on the qualitative data. Apart from the deductive definition of the top-level categories outlined, this study is based on the inductive creation of categories which follows from the nature of the empirical data and the research goals. More detailed categories used for structuring responses cannot be foreseen in advance (Dey 1993, 97f). All categories during the coding process were labelled in German language for the sake of accuracy and after completion of analysis were translated to English.

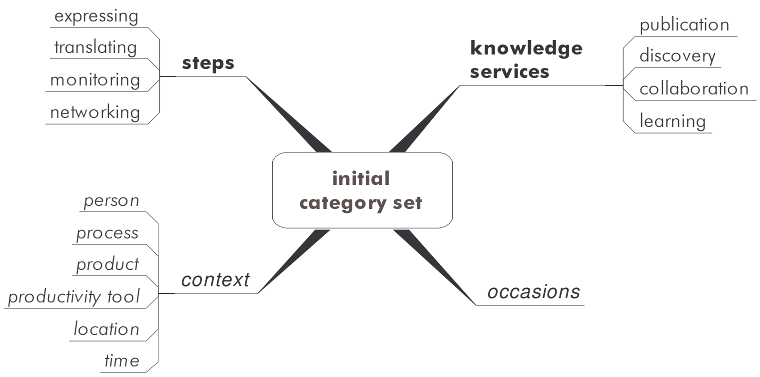

Figure 39. Initial set of main categories for coding

Inductive identification of categories

General guidelines concerning the process of how categories should be inductively identified are formulated by proponents of Grounded Theory (Strauss & Corbin 1990, 57ff). Other authors extend and refine this procedure (Dey 1993, 56ff; Mayring 2003, 75ff; Miles & Hubermann 1994, 58ff). Strauss & Corbin (1990, 72f) advise working through the data line-by-line, sentence-by-sentence or paragraph-by-paragraph in order to firstly define initial and potentially very detailed categories with labels as close as possible to the data, e.g., based on expressions or formulations used by respondents. Even working through the data based on the level of entire documents or interviews can be a feasible approach (Strauss & Corbin 1990, 73). As stated, one or more sentences were assigned to a category (section 6.4.2).

The labels subsequently need to be reviewed and slightly more general categories need to be generated that can be attributed to multiple incidents and observations. Additionally, at set of criteria needs to be defined that allows to definitely decide where a category is assigned and to clearly delimit the categories. The system of categories should be documented in a so-called coding manual that contains definitions of categories, examples of text sections where the category is typically assigned to and coding rules that resolve potential ambiguities

(Mayring 2003, 83). It is also used in the context of quantitative content analysis where it is more static but much more comprehensive especially if multiple people are assigned with the task of coding (Brymann & Bell 2003, 202ff). The meaning of a category evolves step-by-step based on its definition and data assigned (Dey 1993, 102). Depending on the units of analysis, this is a very fine-grained and time-intensive approach. A growing number of categories that the researcher needs to keep track of also implies an increasingly challenging and error-prone process of analysis as all categories need to be remembered (Dey 1993, 106).

After working through a share of the data, e.g., ten to 50 percent depending on its overall volume, the category system needs to be evaluated with regard to its suitability for analysis and its appropriate level of abstraction (Mayring 2003, 76ff; Miles & Hubermann 1994, 61). Furthermore, it needs to be complete in the sense that it contains all relevant aspects, e.g., all steps and services, and selective, i.e. no category is allowed to overlap with another (Früh 2004, 85f). The evaluation process is characterized by re-reading data assigned to a specific category, comparing categories and revising examples and rules documented within the coding manual. In case of changes, the coding process has to be repeated for the data analysed so far in order to ensure that all categories are assigned correctly. The remaining part of the data then is analysed, potentially intercepted by multiple further evaluation phases. Software tool support substantially enhances the efficiency of this process compared to a paper-based approach as categories and data assigned can easily be retrieved, managed and changed. Availability of QDA software thus induced notable changes within the qualitative research process (Brymann & Bell 2003, 445). In conclusion, the inductive identification of categories is characterized by a continuous interplay between empirically grounded definition, assignment and evaluation of categories.

The procedure as described was followed during the analysis as closely as possible. Figure 40 depicts the three phases used to structure this study's coding process. Each is concluded with an evaluation step that led to changes within the category system and thus required a repeated data analysis.

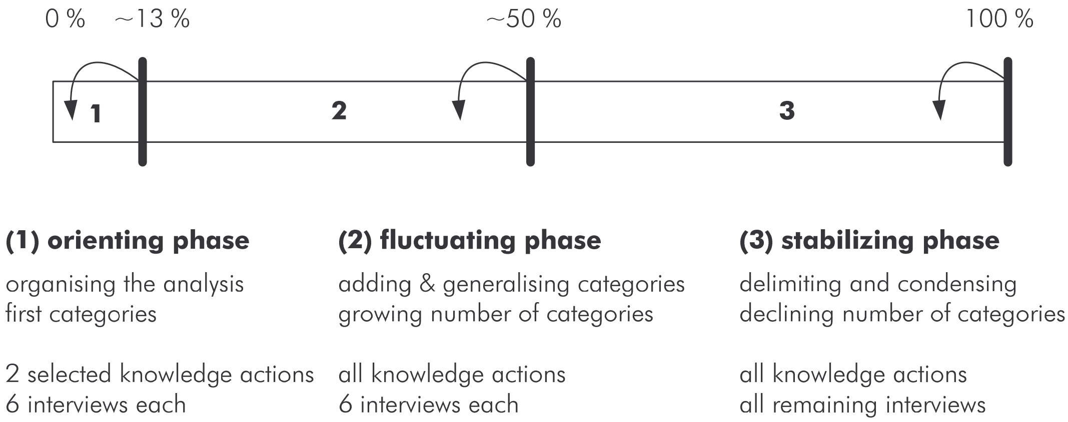

Figure 40. The three phases of the coding process

Orienting phase. Firstly, six interviews about the knowledge actions authoring and another six about expert search were analysed and first categories for steps, services, occasions and context factors were created. As suggested by Dey (1993, 120), the next interview always was selected randomly in order to ensure that no bias was introduced by the sequence of analysis. At this stage it became apparent that variants of knowledge actions exist. The term variant is used here for a specialization of a knowledge action referred to by multiple interview partners and composed of a characteristic set of steps. The variants identified were documented separately within the coding manual by means of short descriptions and a list of the steps typically involved. This was continuously revised and updated. Concerning services it soon turned out that examples and rules were necessary for a detailed definition and delimitation. Steps in contrast always could be distinguished only based on their labels. In addition, the number of application interfaces used to access services was recorded in order to judge whether services could be used consistently throughout a knowledge action. This was documented in a separate spreadsheet. Additional notes were recorded in a text file, e.g., cites of interviewees regarded to be potentially important, open questions, issues to be resolved and the general sequence of steps.

About 13 percent of the overall data was analysed during this initial pass, which was labelled orienting phase since it was not only concerned with the identification and assignment of categories but also with the question of how the analysis should be approached and organised. It was concluded by an evaluation phase where the category system was checked for its consistency and its appropriate level of granularity. Changes led to the need to rescan the data and to correct the assignment of categories. This is indicated by arrows in Figure 40.

Fluctuating phase. Subsequently, six interviews of the remaining six knowledge actions were analysed, so that about 50 percent of the overall data were processed at the end of this phase. Again, variants were identified and revised, steps, services, occasions and context factors were categorized and the number of application interfaces was recorded. Whereas the service categories remained relatively stable, the codings assigned to steps were opposed to significant changes, particularly during the concluding evaluation phase. They had to be defined on a very fine-grained level of granularity, needed to be compared to other sometimes very similar steps and potentially were relabelled or subsumed under other steps. This part was labelled fluctuating phase because it comprised the most significant changes within a growing system of categories.

Stabilizing phase. Finally, the remaining interviews were analysed. This part was called stabilizing phase since it was characterized by a declining number of changes on the category system. This was the result of further generalizations and the subsumption of categories during analysis and particularly during the concluding evaluation phase. Carefulness was invested in clearly delimiting all categories by re-reading and comparing related data. Particularly those categories observed with low occurrences, e.g., one to two occurences, were re-assessed and potentially eliminated by subsuming them under other categories. This is an example of how quantitative measures can guide the process of analysis and interpretation without overemphasizing their relevance (Dey 1993, 223).

After this process where each single part of the transcribed data was read multiple times, the researcher was thoroughly familiar with the data collected and the category system created. The analysis stopped as the structure of the category system was internally consistent and represented the data on a level of granularity that was suitable for the subsequent aggregation based on the method of content-oriented structuring (section 6.4.2). In the following chapter, the empirical data is condensed based on the labels, definitions and rules created as well as the data linked to the categories and further notes such as those about the variants of knowledge actions.

6.5 Quality of the research design

Every research design faces the question whether it is appropriate and will lead to valid results. This relates to the subject of research quality that can be determined based on the criteria objectivity, reliability and validity (Bortz & Döring 2002, 192ff; Mayring 2003, 109f). *Objec-*

tivity specifies the degree to which a test is independent of the subject that applies it. *Reliability* characterizes the extent of accuracy with which attributes are measured. *Validity* refers to how good a test is able to measure what should be measured (Bortz & Döring 2002, 199). Quantitative research is able to measure reliability and validity based on numeric indices. This is not possible for qualitative research as it is not based on quantification (Bilandzic, Koschel & Scheufele 2000). Some criteria may even be unsuited at all if uniqueness, individuality, context dependence and the impossibility of the reproduction of results is emphasized by the qualitative approach (Bortz & Döring 2002, 327). The criteria described thus are modified and complemented in order to suit qualitative approaches (Bortz & Döring 2002, 326ff; Brymann & Bell 2003, 286ff; Kirk & Miller 1992; Mayring 2003, 109ff).

If multiple people code parts of the data, reliability of content analysis can be measured based on the so-called *intercoder-reliability* (Mayring 2003, 110, 113ff). It estimates the degree of conformance with which codes were assigned by different subjects. It is restricted to relatively simple and predominantly quantitative types of content analysis and influenced by the quality of coder selection and of the instruction for the coding process. Moreover, it only measures internal reliability, i.e. the degree to which concepts could be replicated among the observers, rather than external reliability, i.e. the transferability of results to other contexts (Brymann & Bell 2003, 288). This study was conducted by only one researcher and thus it was not necessary to use this measure. Examples for other criteria are the semantic validity of the category scheme developed that can be evaluated by domain experts or by comparing categories with exemplary data, the correlative validity determined by comparing results with those of related empirical studies, the validity of predictions that can be tested by comparing predictions and reality as well as the validity of constructs that can be determined by previous successful application of constructs or theoretical reasoning (Mayring 2003, 111f).

Mayring (2002, 144ff) offers a list of criteria targeted at evaluating qualitative research that can be used in order to assess the quality of this research design. The only criterion excluded here is the triangulation of methods which was not conducted in the context of this study.

Documentation. The procedure chosen has to be documented thoroughly. In quantitative research, references to standardized methods in many cases are sufficient in order to reveal the procedure. Qualitative research in contrast adapts methods based on the concrete subject of research. This has to be documented in detail in order to support comprehensibility. The previous sections are dedicated to this task and particular accurateness was invested in explicating the procedure of analysis and definition of categories (sections 6.4.2 and 6.4.3).

Reasoning and arguments. Interpretations have to be backed by thorough reasoning and arguments. This study is mainly oriented towards description. Interpretation takes place in the sense that data is assigned to generalized categories. Reasoning about this process is supported by rich descriptions of each category, direct references to the empirical data and the inclusion of original voice where appropriate. Interpretations of the researcher were continuously questioned and revised already during the conduct of the interviews (Kvale 1996, 145).

Accepted procedures. Though qualitative research needs to be open for the subject investigated and ready to adapt methods, it nevertheless has to follow accepted procedures and rules of analysis. Mayring (2002, 146) in this context refers to the techniques of qualitative analysis such as summarization, explication and structuring (section 6.4.2). This work adapted the procedures and guidelines as described in the methodological literature as closely as possible. Furthermore, the category scheme developed was evaluated critically and repeatedly based on the qualitative data.

Closeness to the subjects researched. Next, it is demanded that qualitative research has to stay close to the subjects researched. Examples are the preference of data collection in the context of the daily life at the workplace instead of controlled laboratory experiments. Closeness is achieved here not only by conducting interviews on site within the interviewee's organisation but also by selecting a target group close to the researchers own background.

Communicative validation. The validity of interpretations can also be evaluated by means of communicative validation, e.g., by presenting results to interviewees and checking whether they support them. This study is mainly oriented towards description and not with making interpretations so that a separate evaluation phase was not regarded to be necessary.

The validity is not only influenced by the method of analysis but also by that of data collection. Comprehensibility of the interview guideline was tested by two pre-test phases as described in section 6.3.2. Answers are potentially biased by not intended meanings associated with words used by the interviewer, social desirability of answers and general tendencies of respondents to support or deny questions (Holm 1986, 79ff). The researcher cannot claim to be completely independent of influences of earlier interviews or his own theoretical conceptions. Acknowledging this, particular carefulness was invested in letting the interviewees make their own account of steps and related services. Where it was not definitely ensured that interviewees actually accomplish a step or use a service, respective parts were omitted during analysis.

6.6 Summary

Within this chapter, a research design of an empirical study targeted at the exploration of the KWS concept has been developed. It builds on three propositions that focus on selected components of KWS: knowledge actions, the steps they are composed of and the knowledge services used to support them. Occasions and the KWS context dimensions are also taken into account during analysis but it is not the goal to develop corresponding hypotheses. It has been motivated why this study follows a qualitative approach. Main reason is that so far not enough knowledge exists in order to formulate hypotheses about KWS and their technical support. It has been decided that qualitative interviews are most suited for data collection. The approach chosen can be characterized as guideline-based expert interview and has been further specified with regard to e.g., intention, standardization of questions, types of questions and the way of communication. The profile of the target group of the study has been described as well as the strategy of selecting potential participants. The interview guideline used in order to structure the interviews has been presented in detail as well as the conduct and documentation of interview sessions.

Qualitative content analysis has been introduced which is used for the analysis of the linguistic data gathered. Reasons for the selection of this approach have been provided based on the distinction between quantitative and qualitative content analysis. The need to use a software tool, in this case NVivo, has been motivated by the fact that it raises the efficiency of analysis substantially. From the different methods of analysis proposed for qualitative content analysis, a combination of typifying and content-oriented structuring has been selected. The exact procedure of analysis has been explicated in detail, particularly the inductive definition of categories during the coding procedure. Reason for the detailed description of the research design in and the procedures of analysis are that this is proposed as an important way to ensure the quality of research. Measures undertaken in order to ensure a high research quality have been discussed at the end of this chapter. As a result, a considerable amount of data collected based on qualitative interviews was available that has been structured based on inductively generated categories. The results are presented in the following chapter.

7 Empirical results

This chapter presents the results of the empirical study that is based on the research design outlined in chapter 6. The study explores the concept of KWS. The results contribute empirically grounded constructs that can be used to define parts of modelling languages. It is related to technical support in the sense that it describes a set of services used to support knowledge actions as well as the current state-of-the-art of their technical implementation. Hence, the study is related to all of the three levels of systems design concepts, models and systems.

7.1 Overview

Figure 41 gives an overview of the chapter structure. Firstly, the single steps that knowledge actions are composed of are described (section 7.2). This structures and highlights one aspect of qualitative data. The data comprises 31 transcribed interviews that each were split into three parts, one per knowledge action, resulting in overall 93 interview sections. It should be noted that when referring to the frequencies with which categories were identified, each category representing a step, a service, an occasion or a context factor is counted only once although it can be assigned to multiple parts of one of these sections, e.g., if a step or service is discussed repeatedly during an interview. The knowledge services accessed during a knowledge action are described subsequently (section 7.3). They structure the second aspect discussed in the interviews. Both aspects may overlap partly as indicated in the figure: Steps already may be further characterized with regard to technical support and knowledge services are also described in terms of the activities they are used for.

The chapter then turns to the knowledge actions and describes them based on the steps and knowledge services involved (section 7.4). Aspects such as examples for occasions mentioned and the general sequence of steps are also included. Further results concerning context factors as well as the quantitative data collected are presented afterwards (section 7.5). The subsequent reflection of the results turns to higher-level aspects and analyses relations between knowledge actions, characterizes the set of knowledge services identified, compares the organisations surveyed with respect to the technical support of knowledge actions and also summarizes related work (section 7.6).

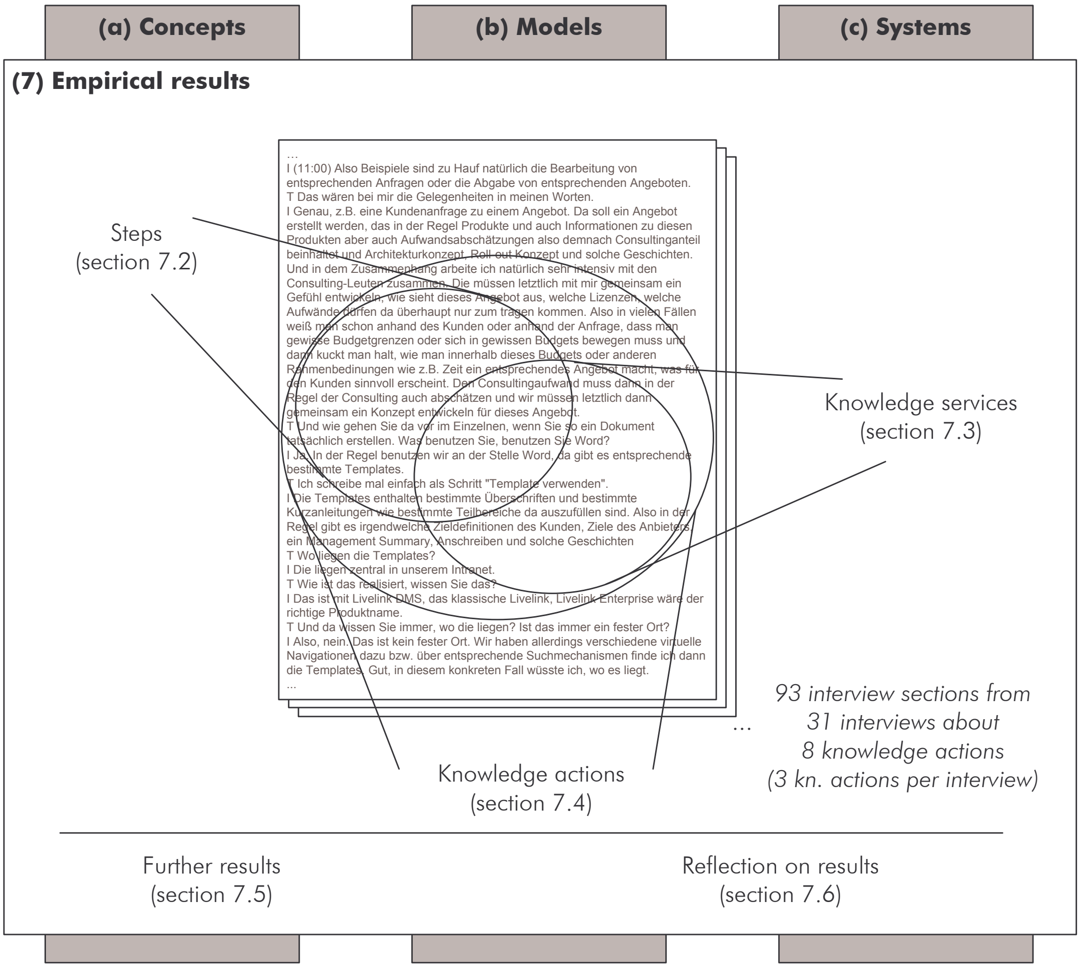

Figure 41. Overview of the chapter *Empirical results*

7.2 Steps

This section characterizes the steps in detail that the knowledge actions explored consist of. Only those steps are included that were explicitly referred to by the interviewees and that are supported by knowledge services. The description of each single step represents a summary of the transcript sections that were assigned to a specific step during the coding process. Where possible and appropriate, the index numbers of the interviewees that referred to a specific fact are cited as reference to the empirical data (section 6.3.2). At the outset of the coding process, it was decided to structure the steps based on the informing practices expressing, translating, monitoring and networking as they represent the conceptual foundation of the knowledge actions investigated. This section is structured accordingly.

Table 15 gives an overview of the overall number of steps that were identified, categorized according to the aforementioned four main categories and the eight types of knowledge actions surveyed. It includes absolute numbers as well as relative values in relation to the o-verall number of steps identified.[146] The absolute values refer to the number of times that all different types of steps were identified. For example, 80 steps were categorized under ex-pressing and assigned to interview sections about the knowledge action authoring. They are associated with 18 of the overall 21 types of steps described within the category expressing (section 7.2.1). Overall, the largest share of steps was classified into the category expressing, followed by networking, translating and monitoring. Concerning the types of knowledge actions, most steps were identified in interviews about co-authoring, followed by authoring, training, expert search, invitation, acquisition, update and feedback.

	authoring		**co-authoring**		**training**		**acquisition**		**update**		**feedback**		**expert search**		**invitation**		**sum**	
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs	rel.
expressing	80	0.15	84	0.16	9	0.02	18	0.03	1	0.00	7	0.01	8	0.02	16	0.03	223	0.43
translating	2	0.00			57	0.11	22	0.04	8	0.02	1	0.00	1	0.00			91	0.18
monitoring	1	0.00	8	0.02	8	0.02	7	0.01	48	0.09	11	0.02	2	0.00	2	0.00	87	0.17
networking	1	0.00	3	0.01	7	0.01	11	0.02			2	0.00	50	0.10	42	0.08	116	0.22
sum	84	0.16	95	0.18	81	0.16	58	0.11	57	0.11	21	0.04	61	0.12	60	0.12	517	1.00

Table 15. Number of steps per category and knowledge action

7.2.1 Expressing

Steps subsumed under the category of expressing are related to the individual or joint crea-tion of contents and also to their storage and distribution. They are described ordered ac-cording to the frequencies with which they were identified, starting with steps that were observed most frequently. The term content will be used here as an umbrella term for all types of electronic information managed with IT systems, e.g., presentation slides, text documents, Web pages and URLs (section 2.2). The term document will be used more broadly than the original definition described in section 5.5.1 in order to refer to files man-aged with office applications.

Create or change contents. This step comprises the creation and change of contents by means of software tools, in most cases office applications such as text processors, spreadsheet

[146] The relative values that correspond to the absolute values one and two were rounded to zero because they were computed as 0.0019 and 0.0039.

applications and presentation software. The creation of contents may be accomplished alone or in direct interaction with others, e.g., for review and enhancement of presentation slides (I.30). Two major modes can be distinguished: structuring, i.e. the sorting of contents (to be) created, and writing, i.e. creating contents such as text documents or slides. During *co-authoring*, tracking functions of text processing software are used intensively in order to mark changes and track activities of co-authors that often also interact directly. Contents created in relation to *training* are reports about training sessions (I.08). Ideas and notes are documented during *acquisition* (I.25). Related to *expert search* and *invitation*, meeting minutes are generated particularly in order to record the discussion about critical topics (I.10).

Forward contents. Forwarding is the transferral of contents to a single person or a group of people, frequently as an attachment to or within the body of an email. It is accomplished, e.g., if senders and receivers do not have access to a joint repository (I.29) or just because it is more convenient to distribute contents by email (I.08). The type of contents forwarded depends on the type of the knowledge action: In the context of *authoring*, contents created such as protocols, project documents or software documentations are made available for those persons who requested or potentially need them. Also, ideas are distributed to interested colleagues (I.09). It may also be targeted at the distribution of corrections or new versions of documents. During *co-authoring*, intermediary results and contributions are forwarded to co-authors, possibly complemented by additional comments. Reports on training sessions and training materials are distributed to colleagues as one of the last steps of the action *training*. Related to *update* and *acquisition*, news, interesting information and contacts are distributed, sometimes with short comments or highlighted passages but often without any changes. Concerning *expert search* and *invitation*, forwarding is focused on the distribution of presentation files and meeting minutes, which is important for documenting meetings obligingly.

Store contents. Storing is the filing of electronic contents in a suitable format labelled with an informative name within a repository such as a fileserver or DMS. Related to authoring, training, invitation and expert search, these are frequently files created or changed by the interviewee. The file format is the format of the corresponding application, in most cases Microsoft Office applications, i.e. Word, Powerpoint and Excel. In the context of acquisition, contents are retrieved from other sources and often are stored without changes. In one case, this step also included the transformation of contents to PDF (I.04).

Request feedback about contents. This step is concerned with the enhancement and extension of contents, e.g., by ensuring their completeness, correcting errors or acquiring opinions from colleagues. Feedback is regarded important in order to align perspectives and to make things plausible. Receivers of the request are colleagues that are going to use the content or that are able to give feedback before the contents are finalized. In the context of co-authoring, other contributors are requested to comment on work in progress. Enquiries are sent out by email or by distributing meeting requests that may also contain topics to be discussed.

Structure repository. Structuring the repository is the search for and the creation of a structure that supports the easy storage and retrieval of contents. In most cases, it involves the creation of a sub-directory on a fileserver or within a DMS. It can be distinguished between relatively stable main-directories labelled according to the main concepts important for an organisational unit, e.g., projects or customers, and sub-directories that represent their more fine-grained structure composed of, e.g., single project phases. This step might be more or less rigidly regulated by rules that determine, e.g., that every project folder needs to contain sub-folders for all project phases as well as for project administration and meetings (I.04). The creation of root-folders may include technical or administrative prerequisites or a formal application.

Select and use standard template. Pre-defined templates that determine the structure and layout of contents are often identified and applied as a starting point for the creation of contents. They standardize documents of specific types such as protocol, requirements definition, service description, implementation concept, project deliverable and project review. Another aspect is the maintenance of a consistent corporate identity, e.g., in presentation slides. The relevance of templates and the extent of support differ between the organisations surveyed. Many respondents note that they roughly know where to find appropriate templates, which can be found, e.g., at specific Intranet locations. However, it is also mentioned that discovery services are applied and that searching templates can be time-consuming. Accounts such as the following were not uncommon in organisations where templates are regarded as important:

> "I.18: Well, we … have a heap of templates; particularly project work is absolutely well documented. … There are specific pages on the Intranet, well, we have a process description and it documents the things to be accomplished - with milestones and so on. And there are links attached to each process step, which templates one can use if one wants to do so."[147]

Share contents with co-authors. This step describes the exchange of contents between two or more authors of the same content. In its simplest form, contents are shared by sending out them by email and waiting for a response, once referred to as "ping pong game" (I.01). Repositories are used for exchanging contents particularly if more than two co-authors are involved. Interviewees then frequently mentioned the creation of multiple versions. This step principally could have been decomposed into the steps forward contents, store contents and request feedback. However, since it is closely related to the co-authoring process, it was decided to conceptualize it separately step with an own meaning.

Request approval of contents. In contrast to the request of feedback, this step targets the formal acceptance of contents by internal or external clients or by supervisors. It is typically related to the actions authoring and co-authoring. Typical types of contents are project results such as requirements specifications and software documentations. The acknowledgement is documented either informally by email or formally by signed print-outs. The degree of formality depends on the type of contents, the organisational culture, established processes as well as preferences of the customers:

> "I.14: We actually have customers that request a cover page that all participants have to sign, they place a very high value on the signature. Others, one sends it by Outlook, gets no acknowledgement and just proceeds and nobody says something about it."[148]

Select storage location. In order to make contents accessible for others, an appropriate storage location needs to be selected. Technically, this step is only supported by providing means to browse through storage structures, directories in fileservers or DMS. The decision where to store contents depends not only on topics and themes, e.g., topics of interest, customers and projects, but also on who needs to access them, e.g., co-authors, other colleagues and target groups:

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[147] In German: „I.18: Also da haben wir auch einen Haufen Templates; gerade Projektarbeit ist bei uns absolut super dokumentiert. … Im Intranet gibt es ganz gezielt Seiten, also wir haben eine Prozessbeschreibung wo drin steht, wie diese Dinge durchzuführen sind - mit Milestones usw. Und dahinter sind Links hinterlegt für jeden Prozessschritt, welche Templates man da verwenden kann wenn man möchte."

[148] In German: "I.14: Wir haben da wirklich Kunden die wollen ein Deckblatt, das dann alle Beteiligten unterschreiben müssen, da legen die sehr großen Wert drauf auf die Unterschrift. Andere, da schickt man das per Outlook, bekommt keine Bestätigung und macht dann einfach so weiter und keiner sagt was dazu."

> "I.26: So one has to think about, when I create a document, who needs access to it, who should work with it, for example make changes or should only be able to read it. That is the linchpin for me to say, where do I actually put this document within the file structure? So that actually all people affected are able to view it or also to use it respectively."[149]

Use similar content as starting point. As an alternative to the identification and use of standardized templates, suitable contents created in the past such as text documents or presentation slides are selected and changed. Motivation is the reuse of easily adaptable contents, e.g., good-structured software or project documentations (I.14). Other reasons are the lack of suited standard templates, that existing templates are judged to be unsuited or that multiple versions exist where it is unclear which is the right one (I.29). Documents acting as templates in many cases are stored personally and are continuously reused and enhanced:

> "I.14: … because the topic is always the same and I only need to adapt them respectively. Though I extend them because always new topics appear … but actually I use the last state of the last project as initial state for the follow-up project."[150]

Assign responsibilities. This step is concerned with the distribution of writing tasks during a co-authoring process by means of the definition and assignment of responsibilities, roles and tasks to each participant. Goals and background information may be communicated within a meeting that marks the joint start of a co-authoring process, initiated by someone responsible for the results. Direct interaction is noted to be important in order to get everyone involved and to create a common ground:

> "I.18: I am not friend of 'cast template and let them eat it' but I like to go through it personally with them in order to discuss the topic and during this, mostly something changes on the version."[151]

Essential part of this step is the creation and discussion of a document structure. It may be created from scratch, based on a first version created by someone responsible or specified by

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[149] In German: „I.26: Der muss sich natürlich immer überlegen, wenn ich ein Dokument kreiere, für wen soll das erreichbar sein, wer soll da drin arbeiten können, Änderungen vornehmen können z.B. oder nur lesen können. Das ist dann der Aufhänger für mich um zu sagen, wo lege ich dieses Dokument denn überhaupt ab in der Filestruktur? Damit auch wirklich die Leute, die es betrifft dort reinschauen können bzw. es auch verwenden können."

[150] In German: "I.14: … weil das Thema an sich ja das gleiche ist und ich die dann jeweils nur anpassen muss. Ich erweitere die zwar dann, weil immer wieder neue Themen hinzukommen …, aber im Wesentlichen verwende ich dann immer den letzten Stand des letzten Projektes praktisch als Anfangsstand des Folgeprojektes.

[151] In German: "I.18: Ich bin nicht so der Freund von ‚Template vorschmeißen und fressen lassen' sondern ich gehe das gerne persönlich mit denen durch um das Thema da dann eben zu diskutieren und da ändert sich an der Version meistens dann noch was."

a standard template that is tailored to the needs of the current task. Technical support is limited to the coordination of appointments and exchange of contents.

Coordinate co-authoring. Joint efforts of a co-authoring process are aligned multiple times during the writing process. Interviewees often note the making of appointments for direct interaction about results, in order to jointly work on sections, share opinions, answer emerging questions and to receive agreement from co-authors. Means of coordination are change histories within documents and spreadsheets that structure tasks and record their state (I.05). The formality of coordination and the degree of documentation vary depending on the type of contents.

Assign or maintain meta-data. Meta-data is used in order to further characterize additional data about contents (section 2.2). Types of meta-data mentioned are authors, content state, versioning number, change history, type of content and keywords. Some organisations use conventions to structure and store meta-data within the filename that frequently is composed of creation date, name and version number (I.11). This ultimately is a vehicle used to implement functions not yet offered by fileservers. Changes in some cases are documented in a change history within documents (I.22) and authors may be contained on a separate front page (I.18). When DMS are applied, mechanisms that indicate the current state of contents such as in progress, review, translation, approved and released are used in order to coordinate the creation process which also may be stored in the content's meta-data.

Consolidate final version. The work tasks of a co-authoring process may be separated based on the structure of contents in a way that every author is able to work independently on his part. The final version then has to be created in a separate step by consolidating these parts. This has to be accomplished manually and once was referred to as "merging documents" (I.15):

> "I.13: Actually, this is always separated by chapter, so that they do not overlap. And then everything is merged at the end of the week. And then there is some poor person (laughs), who has to copy the chapters out of each single document and has to create the final version."[152]

[152] In German: "I.13: Also das ist dann immer kapitelweise unterteilt, dass die sich nicht überschneiden. Und dann wird am Ende der Woche das zusammengefahren. Und dann gibt es einen armen Menschen (lacht), der muss dann die Kapitel rauskopieren aus jedem einzelnen Dokument und muss dann die Final-Version erstellen."

Create personal draft. This step describes the creation of a first working draft that is stored on the local hard disk or in private workspaces. It is regarded to be not mature enough to be distributed to other people. Examples are initial versions of task descriptions, presentation slides and meeting minutes. One interviewee notes that he creates mind maps in preparation for meetings, annotates them during the discussion and later on translates them into a meeting protocol (I.29).

Generalize contents. Generalization prepares the application of knowledge in different contexts or scenarios by removing or marking specifics of a solution created for a specific customer, anonymising contents, valuing contents in terms of their applicability as a reference or best practice, ensuring that no legal rights are violated and checking their overall quality (I.15, I.17). It is concerned with the transferral of contents into a form that ensures their easy distribution and comprehension. In one organisation, this step is supported by a separate KM unit (I.15). Though software tools and ICT are applied, e.g., synchronous communication media and application sharing tools, the task depends largely on the individual skills of the author.

Release contents. This step is about the release of contents in order to enable other people to access and use them. It is often one of the last steps of the knowledge actions authoring and co-authoring. It is either accomplished by labelling the filename to indicate a final version or by changing the content state, e.g., from draft to release which in one case results in the automatic publication of contents on the Intranet (I.30).

Assure quality of contents. This step is concerned with evaluating and enhancing predominantly the formal quality of contents with regard to, e.g., consistent formatting, correct page numbering, an up-to-date table of contents and the appropriate use of language. It is accomplished, e.g., if the content is ought to be stored in a central knowledge base or before it is forwarded to external customers. This may be assisted by a central KM unit (I.01). Quality assurance may also be concerned with evaluating self-tests included in learning modules (I.06).

Maintain access privileges. Privileges determine who is allowed to read and change contents. File servers or DMS offer functions for maintaining access privileges though their use was not referred to during the interviews. The step was realized by calling a centralized service desk or asking project managers for access.

Annotate contents. Annotation is the complementation of contents with comments in order to give feedback, ask questions for comprehension, correct errors or include additional aspects. Interviewees frequently mentioned the use of the Microsoft Word track changes functionality that automatically highlights changes within a document. Alternatively, comments are included within an email that is used to forward them.

Archive contents. When contents are regarded as to be not relevant anymore, they are moved into an archive. Principally, this can be supported by archive functions of a DMS. In the context of this study, the creation of a separate folder was mentioned where working drafts are moved into during the process of finalizing the co-authoring process (I.13).

Frequency of steps

Figure 42 visualizes the number of times with that each of the 21 steps within this category was identified. Each bar represents the number of interview sections that a step was assigned to during coding, i.e. one step can appear with a maximum number of 93. The bars are further partitioned according to the types of knowledge actions. As a result, it can be analysed how often a step was identified in relation to interviews about a specific knowledge action. The types of knowledge actions are ordered according to the overall number of steps related to them as presented in Table 15, i.e. co-authoring, authoring, acquisition, invitation, training, expert search, feedback and update (see caption from left to right). This system will be used for all subsequent diagrams in the sections 7.2 and 7.3.

Expressing is the largest category that contains overall 21 different steps. The steps within this category are most often related to the knowledge actions co-authoring and authoring, which are the two knowledge actions that are based on the informing practice expressing. The steps `create or change contents`, `forward contents` and `store contents` were identified more than twice often than the other steps in this category. The expected value of this group of steps is significantly higher than that of the remaining steps (t statistic 10.71, supported for alpha 0.001)[153]. One reason is that these three steps are linked either to seven or even to all eight knowledge actions. This indicates their relevance for many of the surveyed knowledge actions. Remaining steps are associated with only two to four actions, most often including authoring and co-authoring.

[153] The t-test in this case assumes equal variances (Bamberg & Baur 1996, 192ff).

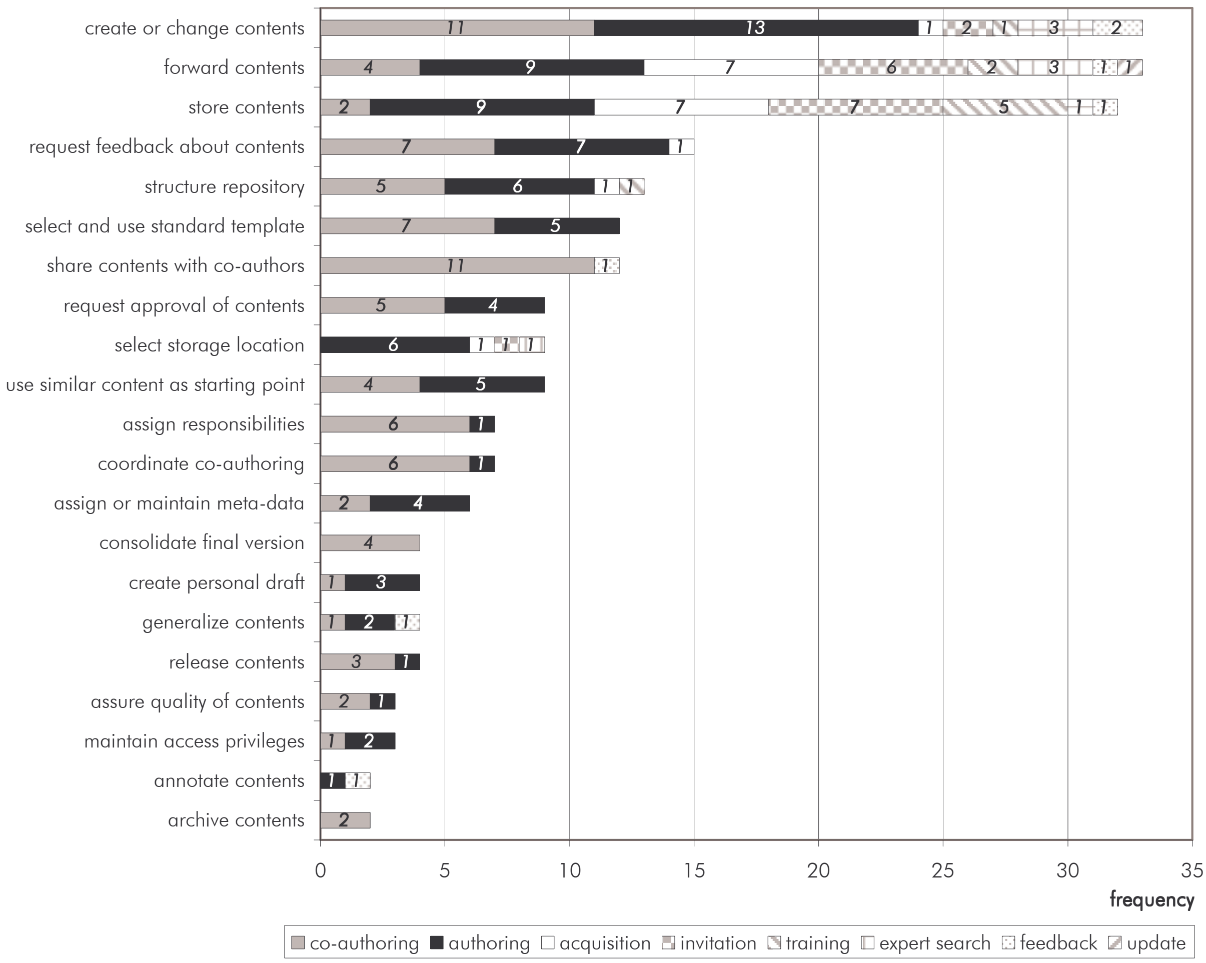

Figure 42. Frequency of steps within the category expressing

7.2.2 Translating

Steps classified under this category are related to the consultation of different resources of knowledge regarded to be applicable for learning as well as steps that are concerned with the forwarding of information to other people. The category also includes rather formal steps such as the booking of a course or the organisation of the journey to a training location. The terms training unit or training will be used here broadly in order to refer to all electronic or non-electronic resources intentionally prepared for and applied for learning purposes. Hence, they are broader than the terms WBT or CBT as described in section 5.5.4. The term course is used for events that comprise one or multiple training sessions conducted in facilities such as seminar rooms or computer laboratories at scheduled points of time.

Check selected external sites. Selected external Web sites are visited for specific types of information and depending on the user's roles and preferences. These are public sites with news and information about selected domains, e.g., Heise online[154] or Golem[155] for IT-related news (I.28). They offer electronic articles and discussion forums where information and issues relevant for a larger audience may be discussed. Other sites consulted mainly act as a reference, e.g., Wikipedia[156]. Furthermore, news agencies such as Forbes, Gartner or Reuters offer large amounts of economic information that can be accessed online. Software vendors such as IBM, Microsoft and SAP put comprehensive information about their software products on the Web. Their Internet presences were noted frequently by the interviewees. They may also include functions to share known problems and solutions within the user community. Examples for contents are online help articles, discussion forums, frequently asked questions, how-tos and helpdesk information.

Identify training. This step describes the identification of appropriate training units in preparation for or after the definition of learning goals. This is within the responsibility of each individual employee who accesses internal training directories offered by HRM or catalogues from external training providers. The latter offer courses either about more general topics such as project management or about specialized topics such as selected software products and related technologies. In the context of this study, large software vendors such as Oracle or SAP were frequently referred to as training providers.

Determine learning goals. This step describes the definition of individual learning goals which was frequently noted in relation to a structured human resources development process and a yearly session with one's supervisor. Organizational learning goals, e.g., of a team or of a department, need to be aligned with individual learning needs and development plans. A team leader describes this task from his view:

> "I.10: Most employees come and say: Once again, I need to do courses. And then I tell them: It's not as simple as that. We firstly need to have an idea what is reasonable for our business, where we do have to educate ourselves. Meaning, what I expect is that everyone has some spark or frame in his mind that first slowly grows a bit."[157]

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[154] URL: http://www.heise.de, last accessed: 2007-12-02

[155] URL: http://www.golem.de, last accessed: 2007-12-02

[156] URL: http://www.wikipedia.org, last accessed: 2007-12-02

[157] In German: "I.10: Die meisten Mitarbeiter kommen und sagen: Ich muss mal wieder Kurse machen. Und ich sage denen dann: Nein, so geht das nicht. Wir müssen erstmal eine Idee haben, was überhaupt sinnvoll für unser Geschäft ist, wo wir uns eigentlich weiterbilden müssen. Das heißt, was ich immer erwarte, dass jeder so eine Art Funke oder Rahmen im Kopf hat, der dann erstmal langsam wächst ein Stück."

Managers of organisational units develop an idea of learning goals based on future business fields, new projects and new challenges. Individual learning goals are determined by skills and preferences, future tasks and the personal career plan. The interviewees also noted mandatory trainings at the start of their career. The step is supported by skill maps, training catalogues and in one organisation by a dedicated human resources development system (I.27).

Notify about contents. Instead of forwarding contents and often complementing their storage, colleagues are informed about new or changed contents with an email that contains a link to and optional comments on the contents. Alternatively, they may be informed orally. In contrast to the request of feedback, this step is rather concerned with a general announcement of contents published for potentially interested target groups. In the context of the knowledge action acquisition, colleagues are informed about discovered and potentially interesting contents. Related to training, they are notified about possibly interesting training materials (I.18).

Organise journey. This step includes all administrative tasks required in order to organise the travel to and from the training site as well as the absence from the workplace for the respective time. Examples are the booking of a car, a flight or a hotel room. This is often supported by electronic systems and in some cases by an internal travel agency.

Use CBT/WBT. CBT and WBT (section 5.5.4) are applied in order to learn about specific topics, e.g., new versions of products and their functions. They are often used as a complement to courses and identified by means of training catalogues or based on Web sites of product vendors. Interviewees frequently referred to WBT, only in one case the possibility to order CBT based on compact discs was mentioned (I.18).

Conduct Internet inquiry. The Internet is an important source for all kinds of information, e.g., related to topics such as software development and system administration (I.28) or for customer information (I.31). Interviewees frequently referred to a search engine such as Google and the browsing of the Web for relevant sites. In contrast to the step `check selected external sites`, it is not clear in advance where to find relevant information.

Determine receivers. This step deals with determining the receivers that information subsequently should be forwarded to. The sender has to make a decision about who requires the information or may be potentially interested. Technically, this task is supported by user directories and email distribution lists.

Investigate internal knowledge base. Internal knowledge bases such as project workspaces or Intranet pages in many cases are the first resource that is scanned for relevant knowledge. Interviewees frequently used the term Intranet in order to denote the subset of all internal systems that store relevant contents, e.g., general Intranet pages or portals, project workspaces and sometimes also internal file servers. Consequently, plenty of different types of information and functions such as search engines, portals and discussion forums are accessed in the context of this step. However, some interviewees note that they lack powerful search and filtering mechanisms, in the following case even in relation to dedicated knowledge bases supported by a separate KM unit:

> "I.31: The problem … is, there is no real filtering mechanism, in other words, people doing projects individually submit their results, also index them on their own and with 50.000 employees one accordingly gets plenty, plenty back. … So, quantity is well represented but quality is a scarce commodity or qualitatively good things are inside, but one needs too much time to find them."[158]

Take examination. Type and extent of examinations that conclude training units depend on the goals of training. Goals can range from the satisfaction of individual interests up to the target of receiving a certificate, e.g., one related to industry-specific standards such as ITIL[159] or one that proves skills related to vendor-specific products. Evaluations may be conducted electronically, e.g., based on multiple choice questions, and then mainly target at practise and immediate feedback about the learning success. Certificates are obtained by passing a traditional written examination.

Use training materials. Training materials are accessed, e.g., in order to rework contents of a course or to prepare for examinations. In most cases, they are paper-based and handed out by external training providers during the course sessions. Internal training materials in contrast are frequently electronically accessible either only for course participants or even freely for all members of an organisation. Thus, materials might be accessed without participating in a course at all, e.g., motivated by a hint of someone who visited the course (I.22).

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[158] In German: "I.31: Das Problem … ist, dass hier kein wirklicher Filtermechanismus, sprich', die Personen, die die Projekte machen, melden ihre Ergebnisse selber ein, indizieren Sie auch selber und dementsprechend bei 50000 Mitarbeitern kriegt man sehr, sehr viel zurück. … Also hier ist leider Quantität sehr gut vertreten aber Qualität dementsprechend Mangelware bzw. sind qualitativ gute Sachen drin, aber man braucht zuviel Zeit, diese zu finden."

[159] ITIL is an acronym for IT Infrastructure library; a today widely applied best practice guideline developed by the British Office of Governance Commerce (OGC) that describes how IT services and their management can be effectively structured (Köhler 2005, 28).

Order textbook. Another source of knowledge are textbooks. Though they are paper-based, identification and access is supported by internal electronic book lists or library systems. Some interviewees referred to the access of online shopping sites for information about books and for their procurement (I.10).

Instruct information agent. The instruction of agents comprises the specification of an information need that is often related to a current problem or challenge for an information agent that is assigned the task to acquire respective information. This is conducted in direct interaction. Communication media such as email frequently are used afterwards in order to distribute more detailed information. The information need may not always be articulated clearly:

> "Researcher: How do you make a request to the research department?
>
> I.15: I call them and say: 'That is what I need.' Specify it a bit, whereas this mostly is imprecise and simply let them run, said sloppy."[160]

Participate in Webinar. A Webinar denotes a seminar conducted based on Web conferencing technologies (DiStefano, Rudestam & Silverman 2004, 89) and includes online virtual group meetings and presentations that enable participants to interact with each other or with the presenter by, e.g., by posing questions or contributing information about issues discussed. They may also include application sharing functions in order to enable hands-on experiences. Two interviewees referred to weekly online meetings of about half an hour targeted at the distribution of technical knowledge to a larger audience of product users or consultants (I.05, I.06).

Report on course. This step concerns informing colleagues about contents of courses or related events visited. In one organisation, every participant has to write a report after his return that then is distributed (I.08). The goal of this is to create awareness about events visited. The report may also act as an internal evaluation of a course. In another organisation, the courses visited are logged in a spreadsheet file that is accessible for colleagues (I.22).

Book course.[161] Booking is the reservation of a place in a course. In most cases, it is conducted after the permission to visit a course has been received. It is either accomplished by

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[160] In German: "Forscher: Wie stellen Sie eine Anfrage an die Research Abteilung?

I.15: Ich rufe die an und sage: 'Das brauche ich'. Spezifizier' das ein bisschen, wobei das ja meistens unkonkret ist und lass die einfach loslaufen, salopp gesprochen."

means of an electronic training directory or in direct communication with the training provider. Two participants noted that courses might be conducted on site if its topics are relevant for multiple colleagues, enabling the trainer to more specifically address the needs of the organisation (I.05, I.14).

Request approval of training. Participation of internal or external courses needs to be approved by those responsible for the training budget. This is either requested informally by an email awaiting a short reply or formally by printing out a document that is submitted for signature.

Frequency of steps

Figure 43 as above visualizes the overall number of times a step was identified which is categorized according to the types of knowledge actions it is associated with. Overall, this category comprises 17 steps. The expected value of the steps `check selected external sites` and `identify training` is significantly higher than that of the other steps within this category (t statistic 5.21, supported for alpha 0.001) though the contrast is not as sharp as in the category expressing. Most of the steps are either related to the knowledge action training or acquisition or to both of them.

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[161] Labelling of this step intentionally refers to courses instead of trainings because computer-based or WBT are not booked formally.

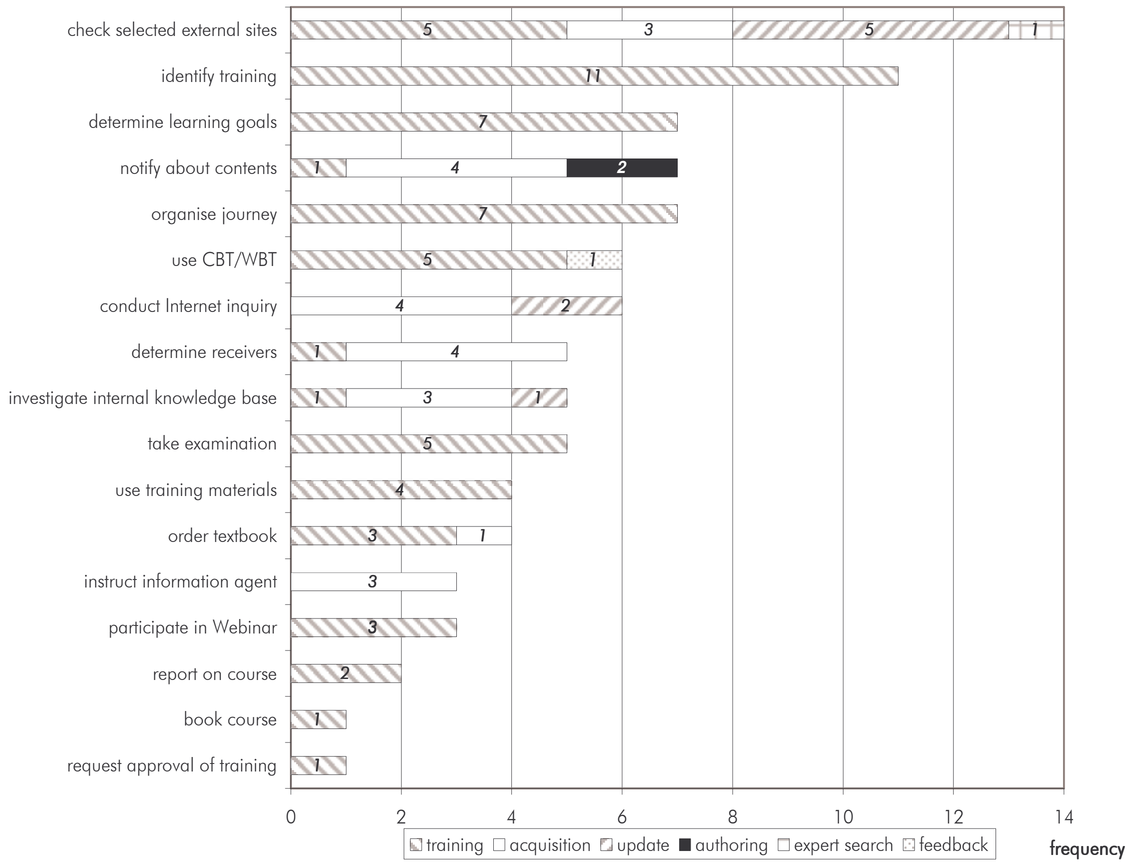

Figure 43. Frequency of steps within the category translating

7.2.3 Monitoring

Monitoring was conceptualized in section 3.4.4 to comprise activities targeted at keeping up-to-date about selected topics, e.g., based on different electronic information resources, and also includes activities concerned with giving feedback and evaluations which helps others to stay informed. The steps subsumed within this category consequently describe the access of various information resources and on the other hand steps that are related to giving and obtaining feedback.

Stay aware about content changes. This step is concerned with monitoring changes on contents by other people and hence can be seen as a counterpart to the steps `share contents with co-authors` and `annotate contents`. It is conducted by checking selected directories on fileservers or in DMS, change histories within documents or marked changes and comments within documents. Other means are automatically generated notifications, emails from co-authors, versioning and locking mechanisms as well as direct conversation.

Check email. Email is referred to by many interviewees as an important, if not the most important medium of communication and thus checking emails is frequently noted as the primary activity of monitoring. Statements such as the following were observed often:

> "I.29: Status report actually describes it relatively well: 'How bad is it?' (laughs) In principle there is a very clear control bridge … and that is simply Outlook, that is email."[162]

Particularly after longer times of absence, e.g., after vacation, a large number of emails has to be worked through. Different strategies are applied such as starting out at the newest, the oldest or the most important emails. Importance is rated based on senders, the topics as described in the subject line or based on the distinction whether emails are generated automatically such as notifications about changed contents or manually by humans.

Access internal news. In contrast to the step `check selected external sites`, this step is conducted more routinely on a daily basis and not triggered by a concrete problem to be solved. It is concerned with monitoring company-related topics based on internal news, press releases and also press reviews distributed by means of internal Intranet information portals or email newsletters.

Evaluate training. Users or participants evaluate trainings in terms of, e.g., the quality of contents or the didactic skills of the trainer. Receivers of this feedback are internal or external training providers or the HRM department. Evaluation is voluntarily and either takes place directly after the last course session or is requested later on by email. In one case, a further evaluation of the training's usability for daily work tasks is conducted in cooperation with the supervisor after 90 days. A rather informal way of evaluation is the recommendation of trainings in conversations with colleagues.

Forward corrections. When errors are identified or extensions are recognized to be necessary then contents are either changed directly and the author is notified or she or he is sent a request for changes or comments on her publication. In contrast to a reply to the step `request feedback about contents`, this step is executed without any explicit demand for feedback. Examples for contents mentioned are software documentations, project results, Intranet pages and documented solutions in a support data base. Authors initially need to be identified,

[162] The interviewee refers to a status report metaphor used by the interviewer. In German: "I.29: Lagebericht beschreibt es eigentlich ganz gut: ‚Wie schlimm ist es denn?' (lacht) Also im Prinzip gibt es da eine ganz klare Kontrollbrücke … und das ist einfach Outlook, das ist Email."

e.g., based on their name contained within documents. One interviewee referred to book reviews he contributes using the review functionality of online book stores (I.09).

Maintain appointments. Appointments are organised by means of electronic calendars. This step includes accessing one's calendar and checking appointments, accepting meeting requests, creating entries and also the access of calendars of colleagues if sufficient permissions are available. In some cases, colleagues are allowed to insert appointments into other calendars though this was noted not to be a well-accepted practice.

Maintain task list. This step comprises the creation of individual tasks on a task list as well as their management. They are recorded and maintained using different tools depending on what is perceived to be most effective or convenient. Calendar entries as well as reminder functionalities are applied to keep track of milestones or due dates. Paper-based notes are pointed out as convenient means to jot down reminders and tasks, e.g., during phone calls. These are transferred later on into electronic formats.

Participate in Jour Fixe. Periodical appointments are noted as an important means to synchronize with others about the current state of tasks, particularly within projects but also in teams or communities such as the software architects in Austria as mentioned by one interviewee (I.31). IT support is restricted mainly to the communication and management of appointments.

Check reports. Reports are either created manually in order to periodically inform everyone involved in a business process or project about past activities or they are created automatically, e.g., with the help of project management or tools for customer relationship management. Another example are log files created by operational systems that are analysed, e.g., in order to guarantee that systems are continuously online.

Evaluate agent results. Employees taking over tasks of knowledge acquisition are referred to as agents since they work on them on behalf of their principal (Eisenhardt 1989). After an agent has completed a task of information acquisition, he or she sends information back to the principal, e.g., the documentation of a problem solution or reports and memos. One interviewee noted that he requests a short presentation about the respective topic (I.21). Potentially, the information need is specified further, e.g., by requesting more details or more concrete information about selected areas, either in direct interaction or by email.

Evaluate support. A support ticket is closed after it is resolved. Either the help desk asks for the permission to do this or open tickets are managed directly by means of Web-based systems. Sporadically, the success of a ticket and the satisfaction with the support are evaluated by means of structured questions. This is conducted based on email or Web-based forms.

Filter information. Filtering information involves the selection, annotation and highlighting of information before it is distributed. One executive referred to this step as a typical management task. He receives lots of information that he needs to distribute to sub-ordinates (I.02). Comments added are short and only more exhaustive when the receiver otherwise might not understand the information:

> "I.25: The less concrete the discussion or contact has been before, the more detailed one describes it. If it refers to a conversation that happened directly before, personally I do not comment it anymore. If it is something for a larger group, where no direct communication preceded, then I describe it within the email."[163]

Rate contents. Two interviewees reported on mandatory ratings of the usability of contents, e.g., a structured question answered on a scale from one to five (I.01, I.03). Both doubted reasonability of such feedback and one of them formulated a strong dismissive opinion, grounded in a low relevance of ratings for his tasks:

> "I.01: Well this whole evaluation, this whole feedback, that is completely insignificant for me. Either I search a content or some structure. And if someone other found it good, bad or however, that has absolutely no relevance for me. I rather find it annoying."[164]

Check audio messages. Verifying one's voice messages, i.e. messages recorded on an answering machine, in contrast to working through emails was noted only once though such functionality is included in many modern telephone systems (I.14).

Request performance feedback. One interviewee noted that in the context of an employee performance appraisal, employees in cooperation with their managers are able to send out requests to colleagues in order to evaluate one's individual job performance (I.05). Goal is to

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[163] In German: "I.25: Je weniger konkret die Diskussion oder der Kontakt vorher war zu dem Thema desto genauer beschreibt man es. Wenn das sich auf ein direkt vorher stattgefundenes Gespräch bezieht, kommentiere ich es persönlich eigentlich gar nicht mehr. Wenn das etwas ist an einen größeren Kreis, wo keine direkte Kommunikation vorher war, dann beschreibe ich es in der Mail."

[164] In German: "I.01: Also diese ganze Beurteilung, das ganze Feedback, das ist für mich völlig unerheblich. Entweder ich suche einen Inhalt oder ich suche einen Aufbau. Und ob das jemand anderes gut, schlecht oder wie auch immer findet, das hat für mich absolut null Relevanz. Ich finde das eher lästig."

decouple the evaluation from the subjective view of one's manager. Ratings can be made based on a Web-based application.

Frequency of steps

Figure 44 presents the frequencies of the 15 steps within the category monitoring. Most of the steps were related to the knowledge action update, co-authoring and feedback. Overall, the steps `request of feedback about contents` and `check email` were noted most frequently. Their expected value is significantly higher than that of all other steps (t statistic 8.26, supported for alpha 0.05). Another comparison that can be made concerns the relationship of the expected value of the group of the first eight steps with that of the remaining seven steps. That of the former is also significantly higher (t statistic 9.08, supported for alpha 0.001).

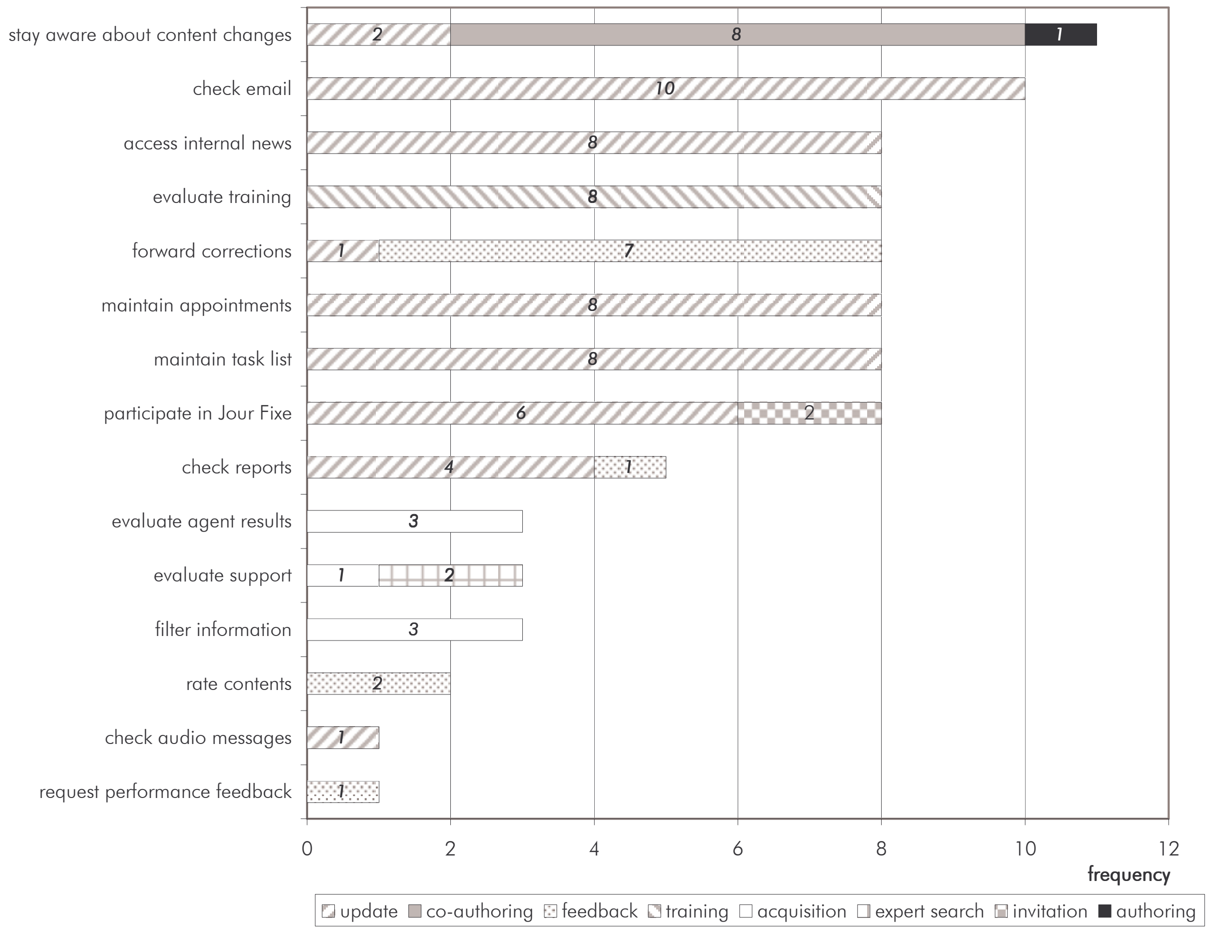

Figure 44. Frequency of steps within the category monitoring

7.2.4 Networking

Steps subsumed under the main category networking deal with the identification of and communication with knowledgeable colleagues. This also includes steps that deal with the preparation and conduct of meetings that may represent an occasion for knowledge sharing.

Identify contact person. Search for experts in many cases starts out based on the organisational structure. Reason is that it provides evidence about the topics that members of organisational units deal with or about the responsibilities they have. Hence, the interviewees frequently noted that they select an organisational unit and contact one of its members, in many cases the department head. This is supported by Intranet pages, organisation charts and directory services. Particularly long-term members of an organisation note that they mainly rely on their individual network and have no need for specialized technical support:

> "Researcher: What do you use to identify people that are responsible for something?
>
> I.02: My head (laughs). Let's say, twelve years with the company, there is a lot of what one knows. Or who one knows and who does what. At least roughly, at least on the level of department heads."[165]

Organisation-external individuals are identified either based on the individual network, e.g., former colleagues, or by means of co-operations, e.g., with product vendors or universities (I.21). This is mainly supported by address books and Internet inquiries. In one case, trade fairs were mentioned as a way to identify potential technology suppliers (I.23).

Discuss topic. Topics are discussed with one person or multiple people in direct interaction, by phone or by email. The choice of the medium is determined by different factors, e.g., urgency, own preferences or the distance to communication partners. Group interaction is supported by online meetings and application sharing, e.g., in order to discuss or present a software product (I.05), which may also support the recording of meeting sessions.

Identify contact details. Before colleagues or externals can be contacted, their contact details need to be identified, i.e. their phone number or email address. This step is well supported by directories accessible over the Intranet. Details about external persons are frequently stored within separate databases such as individual contact lists.

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[165] In German: "R: Was benutzen Sie dazu, um Leute zu identifizieren, die für etwas zuständig sind?

I.02: Meinen Kopf (lacht). Ich sage mal, zwölf Jahre im Unternehmen, da gibt es schon eine ganze Menge, was man kennt. Oder wen man kennt und wer was macht. Zumindest grob. zumindest auf Abteilungsleiterebene."

Make appointment. Direct conversation is coordinated by scheduling appointments that may involve one or multiple individuals. This is often conducted by sending out meeting requests based on Groupware calendars. Direct conversation may complement this procedure.

Navigate through network. This step can be compared to the step *identify contact person*, but is less straightforward and it is conducted in case of a lack of a concrete conception about who could possess the expertise required. Reasons identified are that no knowledge exists whether relevant expertise is present at all within the organisation, e.g., based on past projects (I.28), or that the organisational structure is not suited to identify appropriate people, e.g., because labels or abbreviations do not help or are ambiguous (I.30). The interviewees noted that they contact someone who could possess the right competences. If not, she or he is asked for a contact to someone who could provide further assistance. This often starts out with known people. Accounts such as the following were typical for this step:

> "I.28: There it turned … out, something like this already exists at other locations. At this point, admittedly, I was just lucky, there I met someone from the plant, who could name me a contact person in another plant. With him I discussed it. And then I was again lucky, actually not, because he was not the right one, but he knew, who I was actually looking for."[166]

Advertise meeting. In order to invite participants to a presentation about and discussion of work-related topics, information such as the topic, agenda, time and location are distributed to potentially interested colleagues. The presentations in many cases are about experiences made during projects and may be part of periodical meetings within a team, group or organisational unit. One interviewee also referred to presentations organised for potential customers in order to spark the interest for a topic (I.22). Information distribution is supported by publishing news on the Intranet, sending out emails and using distribution lists that interested colleagues may subscribe. One interviewee mentioned the practice of indirect invitation, i.e. distributing information about the activity to one's individual network and asking people to invite others (I.25).

Establish contact. This step frequently was described as the filing of contact information of selected people, e.g., by gathering business cards or by storing contact details electronically

[166] In German: "I.28: Da stellte sich … raus, so was in der Art gibt es schon an anderen Standorten. D.h. an der Stelle, zugegebenermaßen hatte ich einfach Glück, da habe ich jemanden aus dem Werk getroffen, der mir einen Ansprechpartner in einem anderen Werk nennen konnte. Mit dem habe ich drüber geredet. Und dann hatte ich wieder Glück, also eigentlich nicht, weil der war's nicht, aber er wusste, wen ich denn suche."

after the return from an event. In contrast to the step `identify contact details` it is not mainly concerned with the dealing with of contact information but rather targeted at the creation of links to other people. It was often referred to in relation to the return from a training course. One interviewee also described a relation to expert search:

> "I.18: What may happen is, if you stick some days in such a course, that you then tie a bit of a network. And if you then have a problem about this area that you say: 'Ok, once I got a course together with him. Perhaps he knows what I have to do' and then you call him instantly."[167]

Open support ticket. Support is requested by describing the problem or specifying a need during a phone call with the service desk or by filling out a Web-based form that contains a problem description and additional data that categorizes the request. Later on, the helpdesk may contact the requester for additional information. The problem is ideally solved directly, an answer is received by email or follow-up steps are required.

Acquire meeting resources. For meetings, presentations or training events, resources such as rooms and presentation hardware are often required and need to be reserved. This may be integrated with the Groupware calendar functionality and thus is closely related to the step *make appointment*. It may involve other administrative tasks such as ensuring that enough paper-based handouts are available. Meetings may also be held online using teleconferencing facilities. Resource reservation then needs to ensure that all technical functionalities are provided, e.g., by booking a conference within a portal and notifying participants about the logon data, by creating a team workspace or just by checking whether all participants are able to access a workspace.

Collect meeting registrations. Some activities such as periodical team meetings are mandatory and no separate notification of acceptance is required. For other activities, participants are asked to notify the organisers about their attendance, e.g., in order to allow them the reservation of sufficient resources. For smaller events, the Groupware calendar is used that allows respondents accepting or declining meeting requests. This step may result in rescheduling the time and location of an event, e.g., when key participants such as decision makers otherwise are not able to join the meeting.

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[167] In German: "I.18: Was schon geht, ist dass wenn Du mehrere Tage in so einem Kurs steckst, dass Du dann so ein bisschen ein Netzwerk knüpfst. Und wenn Du dann ein Problem hast zu dem Bereich und dass Du dann sagst: ‚Ok, mit dem habe ich mal zusammen einen Kurs gehabt. Vielleicht weiß der, was ich da machen muss' und dass Du den dann direkt anrufst."

Verify availability. Checking the availability of contact persons evaluates whether colleagues are accessible by phone or email at the moment. This is achieved, e.g., by consulting calendars of potential communication partners or simply estimating whether they are typically available at the current time.

Identify information agent. Information agents need to possess the right competencies that enable them to search for, identify, assimilate and prepare relevant knowledge. Furthermore, they need to be available for the task. Examples for agents referred to by the interviewees are trainees (I.08), sub-ordinated colleagues (I.21) and employees of research departments (I.15). This step is only marginally supported by technology, e.g., it provides basic information about agents such as their contact details.

Maintain competency directory. When new employees join the organisation or when tasks or competencies change due to, e.g., the successful completion of a course, respective directories and in one case a skill matrix need to be updated. This is either accomplished by the employees themselves or by sending an email to the responsible person, e.g., the Intranet administrator.

Collect meeting topics. Interviewees referred to the need to motivate potential presenters to contribute particularly related to periodical meetings targeted at knowledge sharing. Replies then are collected and an agenda is created that later on can be distributed to potential participants. The step is supported by email or accomplished based on direct interaction.

Define required competences. The identification of required competences of potential communication partners is frequently noted as an initial step of the knowledge action expert search. Other criteria such as workload are also taken into account. IT support mainly has the form of electronic lists structuring competencies, e.g., Intranet pages containing expertise areas of organisational competence centres dealing with cross-technological topics (I.13).

Register at workspace. The formerly described steps deal with inviting people or getting invited by someone. This step in contrast is about joining a group by registering to an electronic workspace that acts as a platform for interaction sharing of contents.

Frequency of steps

This category contains 16 different steps whose frequency is depicted in Figure 45. Most of them are related to the knowledge actions expert search and invitation, the two actions that are based on the informing practice networking. The expected value of the steps `identify` contact person, discuss topic, identify contact details and make appointment is significantly higher than that of the other steps (t statistic 6.80, supported for alpha 0.001). Nevertheless, it is lower than that of the steps create or change contents, forward contents and store contents classified under expressing (t statistic -4.54, supported for alpha 0.01).

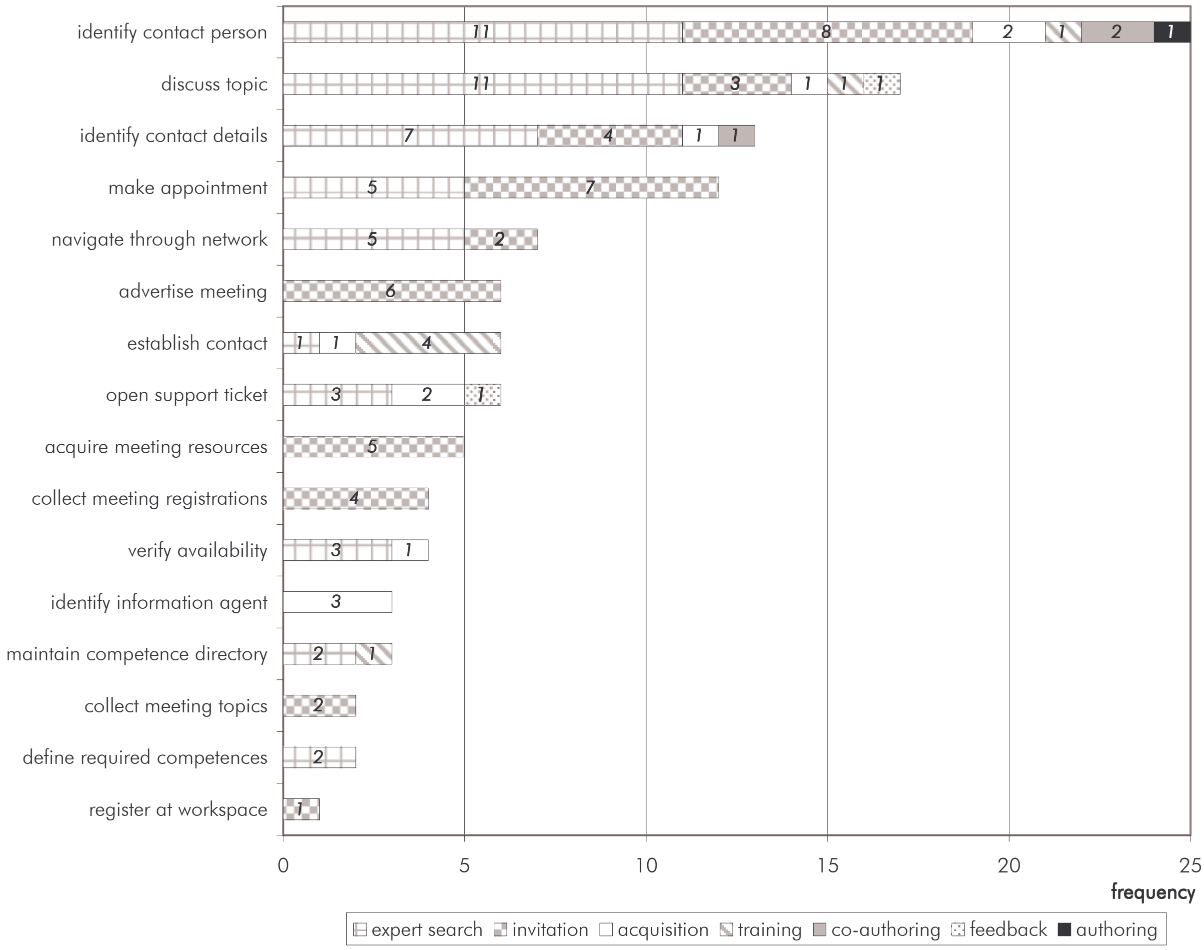

Figure 45. Frequency of steps within the category networking

7.3 Knowledge services

This section describes the knowledge services in terms of their functionality, which as the steps outlined in section 7.2 has been compiled based on the interview transcripts. Actual knowledge services or their interfaces could not be observed during the study since service-orientation is still a young approach. The analysis thus is focused on the identification of possible candidates for services, i.e. functionality repeatedly reported by the interviewees to be used in the context of knowledge actions. Knowledge services are defined here on a rather coarse-grained level in order to restrict their number to a manageable size and to enable the discussion of knowledge actions and services on comparable levels of granularity. For their actual implementation, they would need to be decomposed into a set of more detailed services.

The four main types of knowledge services publication, discovery, collaboration and learning were applied for structuring the services identified. Table 16 gives an overview of the overall number of services that were identified, categorized according to these four main categories as well as the eight types of knowledge actions. As Table 15 in section 7.2, it includes absolute numbers as well as relative values in relation to the overall number of steps identified.[168] The largest number of services was categorized under collaboration, followed by publication, discovery and learning. Most services were identified in relation to co-authoring, closely followed by training, authoring and expert search and then followed by update, invitation, acquisition and feedback.

	authoring		**co-authoring**		**training**		**acquisition**		**update**		**feedback**		**expert search**		**invitation**		**sum**	
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs	rel.
publication	44	0.09	49	0.10	8	0.02	10	0.02	9	0.02	6	0.01	11	0.02	5	0.01	146	0.30
discovery	7	0.01	9	0.02	16	0.03	17	0.03	9	0.02	2	0.00	29	0.06	6	0.01	95	0.19
collaboration	19	0.04	19	0.04	28	0.06	26	0.05	43	0.09	17	0.03	36	0.07	35	0.07	223	0.46
learning	1	0.00			22	0.05					1	0.00					24	0.05
sum	71	0.15	77	0.16	74	0.15	53	0.11	58	0.12	31	0.06	70	0.14	54	0.11	488	1.00

Table 16. Number of services per category and knowledge action

The identification and delimitation of services is strongly based on a user-oriented view, i.e. what the user can actually do with a service, and not on a technical view, i.e. types of systems, components, software objects and other implementation details. Reason is that for researching the technical support of knowledge actions, the work that IT systems perform for their users is relevant rather than how this functionality is implemented. Furthermore, the definition of services as described should start from professional tasks and not from existing technical systems though they need to be taken into account (section 5.5). This approach thus resembles the new perspective introduced by service-oriented approaches that emphasizes

[168] The relative values that correspond to the absolute values one and two were rounded to zero because they were computed as 0.0020 and 0.0041.

how IT systems can serve their users (section 5.2.1) as well as the common procedure of service definition. As a result, the services identified reflect only the technical functionality required by the interviewees and not a comprehensive overview of functionality as described in section 5.5.

The distinction between local and remote execution cannot be used as a criterion for the identification of services. The reason is that components of distributed systems and their services can reside either on the local machine of a user or on a remote system. Though it seems obvious that this is not a suitable criterion and it was noted that the definition of services is not primarily based on the technical architecture, this clarifies the need to also include locally installed applications such as office packages.

Only those services are classified here that were explicitly referred to by the interviewees. If they reported to use a system in way it was not originally intended for, then this was categorized under the type of service that the user actually needed and just realized in a different way. For example, though a spreadsheet application originally is targeted at being used for calculations, it can be applied in order to structure and store tasks. In this case a `task list` service was assigned. This occurred not only in relation to task lists but also in the context of the services `versioning`, `template`, `competence-based search`, `news channel`, `notification` and `awareness`. However, tools and systems referred to by the interviewees frequently allowed concluding directly to the services applied, e.g., Internet or Intranet search engines offer `keyword-based search` services and file servers, DMS or comparable systems are related to `storage` services.

7.3.1 Publication

This category comprises all services targeted at the storage and management of electronic contents (section 5.5.1). The ten services contained again are described ordered according to their frequency in descending order.

Storage. This service enables users to store contents persistently and to retrieve them. In order to store contents, users need to provide one or multiple files to the service and specify a location, in most cases a hierarchically structured directory known from common file systems (Hansen & Neumann 2001, 932f). If the service is provided by a DMS, meta-data can be used for classification. For the retrieval of contents, they need to be identified by their location and name. The obtainment of the specific types of contents Web contents and electronic training units is conceptualized by the discovery service `Web request` and the learning service `training provision`.

Interviewees frequently note that they use multiple different systems for the storage of contents, e.g., their local hard disk, file servers, USB sticks and in case of more advanced support DMS. Software products they mentioned were EMC documentum, IBM Lotus Notes, Open Text Livelink, Microsoft Sharepoint, SAP cFolders as well as code versioning systems (CVS) used to save source code. File servers are mounted as a network drive and then can be accessed like any other disk drive. This type of system was most often referred to by the interviewees. DMS are accessible by means of Web interfaces or integrated as a network drive by means of plug-in technologies or standardized protocols such as WebDAV (Goland et al. 1999). Principally, also external systems may provide storage services, e.g., community portals or Extranets, but were not mentioned by the interviewees.

Content creation&change. All software functions for creating and changing contents that are not managed by other more specific services such as tasks and appointments are subsumed under this service, particularly those used to work with typical office application files such as text documents, spreadsheets and presentation slides. All organisations use the Microsoft Office product suite, i.e. Word, Excel and Powerpoint. Other software applied is Microsoft Project for project planning (I.04), Microsoft Visio for flow charts (I.03), Mindjet Mindmanager for creation of mindmaps (I.29) as well as the tool Scribble in order to manage notes (I.25).

Template. The `template` service returns a standard template of a specific type, e.g., templates for reports, protocols, risk analysis (I.05) or process descriptions (I.18) and in a specific format, e.g., text documents, spreadsheet files or sets of presentation slides. Principally it can also be used to publish templates though this was not observed based on the interview data. Templates are accessed from within office applications or downloaded from central locations such as dedicated Intranet pages. Templates updated infrequently are sometimes stored on the local hard disk and retrieved from there. However, using up-to-date templates is regarded important and thus retrieval from centralized locations is preferred. Similar documents used as a starting point for authoring are retrieved by means of `storage` services.

Storage structure. Repositories are structured by means of hierarchical directories or alternatively by means of meta-data. This service returns information about the storage structure and allows changes in case the user has sufficient privileges. The interviewees frequently referred to the creation or deletion of directories on fileservers or in DMS.[169] The use of metadata for categorization was referred to only in one case (I.17). Directory templates with predefined sub-structures for selected types of folders that may also contain other contents such as project guidelines were referred to once (I.05). Directory structures of the different systems accessed need to be manually mapped and their contents synchronized (I.14).

Versioning. Versioning allows managing multiple versions of the same content item. Ideally, new versions are created automatically if contents are stored. They are identified by version numbers. The service also offers assignment of different stages to contents, e.g., work in progress, review and approved (I.06). Versioning is a basic DMS function (section 5.5.1). In two organisations, CVS are applied in order to manage selected contents and their versions (I.04, I.10). Many organisations have file servers installed that do not offer any versioning mechanisms. Versioning therefore is often pragmatically implemented by including version numbers in filenames and by incrementing or changing them manually (I.11). Documents may also contain a version history that is maintained by the authors (I.18). In some organisations, specific procedures for the assignment of version numbers exist, e.g., main versions such 1.0, 2.0 and so on are reserved only for approved documents (I.10). Versioning also enables users to stay aware about changes by analysing versioning histories.

Annotation. The annotation service enables users to attach additional information to contents such as comments, notes or information about changes. It also allows to access it. Interviewees often refer to the annotation of Microsoft Word documents by engaging the track changes function that automatically marks every change applied to the document so that other users subsequently are able to identify them. Alternatively, colours are used in order to manually indicate changed sections (I.01) or comments are marked explicitly within the document's body (I.10). Other examples are the inclusion of additional comments or the highlighting of parts of contents forwarded within an email (I.03) as well as the publishing of a book review in online shops such as Amazon.com[170] (I.09). In one case, differences between textual contents are identified automatically with the help of CVS functions (I.20).

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[169] This service was only identified and counted if interviewees mentioned that they actually change storage structures. Retrieving information about the storage structure, e.g., while browsing through the directory structure of a file server, was subsumed under the `query` service.

[170] URL: http://www.amazon.com, last accessed: 2007-12-02

Check-out. The `check-out` service basically allows reserving write access to selected contents for one user or a group of users. This is necessary to avoid simultaneous changes on contents that may result in versioning conflicts. It also supports revoking a reservation after the changed contents were stored, which is referred to as check-in and may be coupled with the creation of a new version. File servers currently do not offer explicit check-out mechanisms though write access to open files is blocked by the operating system.

Privileges. Access to contents or workspaces is governed by privileges administered with the `privileges` service. They are often managed on the level of folders or workspaces. The right to change privileges frequently was noted to be restricted to selected people such as project managers or technical administrators. Systems implementing this service are file servers and DMS and also team or community workspaces. Here, this service also was assigned when new participants were added to a workspace (I.25, I.27) or vice versa when someone applied for the access to a workspace (I.31).

Library. The library service offers functions that enable users to query and manage references to electronic or paper-based information sources. It may be offered by OPAC systems dedicated at managing a potentially large number of references to, e.g., books and electronic or paper-based journals. The service was observed in the form of manually maintained electronic list of books (I.04), an internal OPAC system (I.20) and also a list of favourites managed within a Web browser (I.27).

Transformation. This service supports the transformation of contents from one format into another. A common example is the creation of a Postscript or PDF file in order to enable others to access the contents independently of the native application. This was reported once by an interviewee (I.08), another dialogue partner referred to the use of macros in order to export comments from text processing documents to spreadsheet files so that they can be worked through in a structured way during a review session (I.03).

Frequency of services

Figure 46 visualizes the overall number of times publication services were identified in the same way as the diagrams in section 7.2. Again, the maximum theoretical number of occurrences of a service is 93, which corresponds to the overall number of knowledge actions surveyed. The storage service was identified most frequently within this category and in relation to all knowledge actions. The expected value of the two steps `storage` and `content` `creation&change` is significantly higher than that of the other services (t statistics 6.89, supported for alpha 0.001). The diagram points to the relevance of publication services for the knowledge actions co-authoring and authoring followed by the action acquisition.

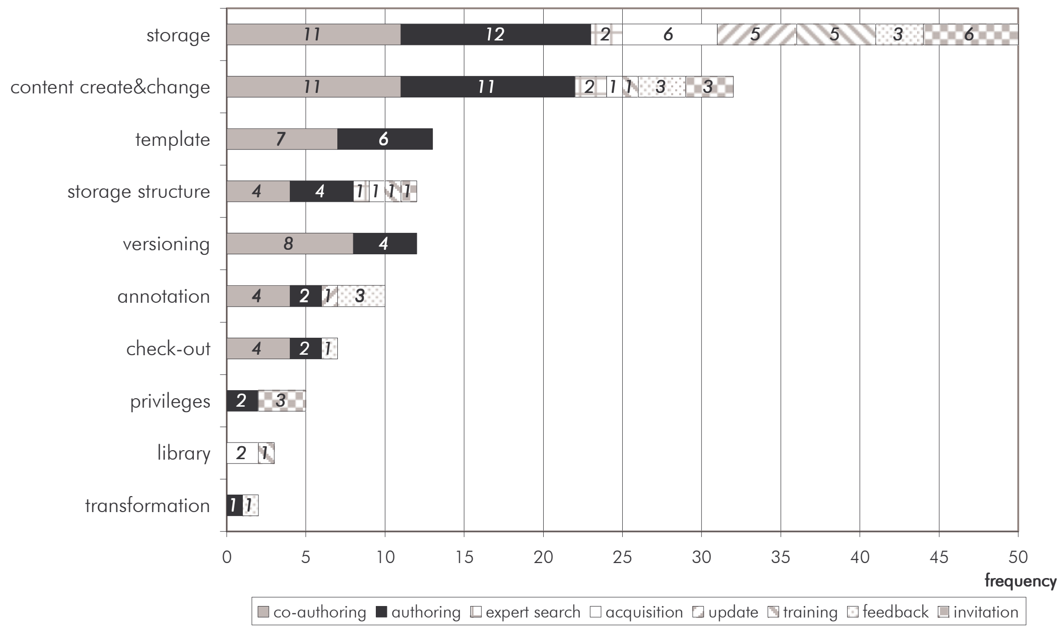

Figure 46. Frequency of publication services

7.3.2 Discovery

The category discovery comprises services that support the identification and retrieval of electronic contents as well as the localization of people (section 5.5.2). It contains seven different types of services that are described in the following:

Web request. This service returns a Web page identified by a unified resource locator (URL) that can be rendered with a Web browser, i.e. a page that ideally conforms to one of the different HTML standards[171] and may also contain programming code such as ECMAScript[172] in order to enable dynamic interaction. Web request services are provided by Web servers accessible on the Internet or Intranet. The service is typically invoked to obtain information for solving a problem, e.g., from portals of software vendors to (I.22), internal knowledge portals (I.25) or generally the Intranet (I.30). In contrast to the `storage` service, information obtained

[171] URL: http://www.w3c.org/html/, last accessed: 2007-12-02

[172] URL: http://www.ecma-international.org/publications/standards/Ecma-262.htm, last accessed: 2007-12-02. ECMAScript is the official and vendor-neutral standard of JavaScript originally defined by the company Netscape.

with this service is not changed but only retrieved. Publishing Web contents by means of CMS was not referred to by anyone of the interviewees. The reason for a separate categorization of this service is that Web contents were identified to represent an important source of information.

Full-text search. The `full-text search` service returns a result page enlisting contents that fulfil search criteria specified by the user. Concerning Web searches, these are most frequently only one to three keywords (Jansen & Pooch 2001, 241). Other criteria that can be used to restrict the search are language, formats and search scope. The types of formats and scope of resources indexed may differ substantially from a very restricted set of Intranet pages to many types of contents from various systems including proprietary file formats depending on the implementation of the service. Examples for software products identified are SAP Netweaver Search and Classification[173] used for indexing contents on fileservers (I.22), the Open Text Livelink search engine that indexes various types of contents stored within the system (I.17), search engines integrated with support portals of software vendors (I.08, I.09), those of news agencies such as Forbes or Reuters (I.15) as well as Internet search engines such as Google[174]. Internal search engines were sometimes criticized by the interviewees for delivering results that are not specific enough (I.07, I.09, I.31).

Contact directory. This service enables the retrieval and storage of contact information about people such as their email-address, phone numbers, affiliation, location, position or an image of them. Within the organisations surveyed, contact directories are accessible in two ways: either by means of Web front-ends and specialized applications or by means of user directories that are integrated into the Groupware clients Microsoft Outlook and IBM Lotus Notes (I.02, I.11, I.14). These clients also offer the possibility to maintain individual contact lists which are also subsumed here. One interviewee referred to mindmaps he uses in order to flexibly structure contacts according to work-related topics (I.07). An advantage of Groupware clients noted is their ability to synchronize data with personal devices such as cell phones or personal digital assistants (I.04, I.07).

Notification agent. This service notifies users about selected events. Notifications are delivered by email or pop-up windows on the user's desktop. They inform about new or changed

[173] URL: http://www.sap.com/platform/netweaver, last accessed: 2007-12-02

[174] URL: http://www.google.com, last accessed: 2007-12-02

contents, appointments, answers to questions in discussion forums and the status of support tickets. All agents referred to by the interviewees are configured manually. Systems providing this functionality are DMS such as Open Text Livelink (I.05) and Intland Codebeamer[175] (I.13), support portals of software vendors such as SAP (I.09, I.22), Groupware clients that notify about appointments (I.04, I.14) and also helpdesk systems applied for managing support tickets (I.09, I.18).

Competence-based search. This service offers and stores information about the competences of people. Ideally, users are able to specify the competences they search for and obtain a list of people that fulfil the search criteria. The service is realized only in two organisations by means of a dedicated competence directory (I.15, I.30) and in a third organisation by a so-called IT map that relates technologies and systems with responsible individuals. One respondent noted that he searches for documents within a DMS and analyses the authorship of documents in order to identify experts (I.29). It may also be implemented by means of contact directories that store information about responsibilities, interests and competencies (I.10) as well as Intranet pages offering such information about organisational units (I.13, I.30).

Knowledge map. The `knowledge map` service returns different knowledge-oriented visualizations in order to enable users to locate experts within an organisation. Only examples for rather basic knowledge maps were observed within the context of this study. Four interviewees referred to organisation charts that reflect responsibilities for selected topics they accessed on the Intranet in order to identify contact persons (I.06, I.07, I.13, I.18). In one case, a skill matrix based on a spreadsheet file is applied that relates employees and knowledge about software products (I.05).

Query. This service returns dynamic views on electronic contents based on structured meta-data. Just as the `full-text search` service it returns dynamic views based on specified search criteria but in contrast is mainly based on structured meta-data. Comparable to the `storage structure` service it enables users to retrieve information about the structure of a repository. However, it is not restricted to the primary storage structure but rather offers dynamic views on contents. In contrast to the `knowledge map` service, it focuses on contents and is not concerned with locating experts. Interviewees noted to use dynamic views in order to identify specific contents, e.g., new contents in selected areas such as business units

[175] URL: http://www.intland.com, last accessed: 2007-12-02

(I.17), certain types of contents such as templates as well as those specifically relevant for selected roles such as account managers or consultants (I.05).

Frequency of services

Figure 47 depicts the frequency of the services described within this category. The expected value of the services `Web request`, `full-text search` and `contact directory` is significantly higher than that of the other services (t statistics 5.66, supported for alpha 0.01). All services within this category are linked to at least three different knowledge actions, the former three services to at least six types of knowledge actions.

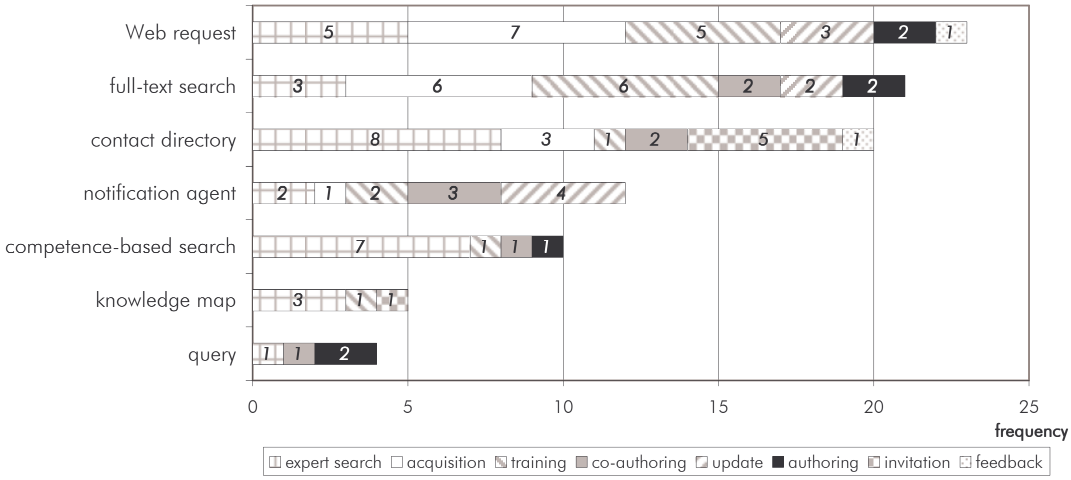

Figure 47. Frequency of discovery services

7.3.3 Collaboration

Collaboration is the largest main category of knowledge services with overall 13 different services. Principally, collaboration services comprise all services that enable and support communication, coordination and cooperation (section 5.5.3). However, also a number of rather basic services were identified and included within this category such as `email`, `phone` and `calendar` as they represent the foundation where more advanced collaboration services can be built upon.

Email. The `email` service enables users to send text messages to one or multiple respondents as well as to retrieve text messages. It offers all common email functions and conforms to standardized protocols such as POP3, IMAP and SMTP as well as related standards such as the RFC 822 that structures the headers of an email as well as MIME that specifies how different content types may be included within an email (Tanenbaum 2003, 588ff). Groupware clients such as Microsoft Outlook or IBM Lotus Notes were frequently referred to as user agents. They also integrate other services such as `calendar` and `task list` within one user interface.

Email is used for a variety of tasks such as bilateral or multilateral communication, distribution of contents, arrangement of appointments and obtainment of newsletters or of notifications. It has the advantage to span multiple systems and platforms. This is particularly relevant for people working in changing system environments, e.g., of different customers, or for work groups that have no access to a shared storage location (I.01, I.11, I.14). Email is also used in order to record communication, e.g., by distribution of meeting minutes (I.29) or by creating and distributing emails that document issues formerly discussed orally (I.24, I.25). However, some interviewees criticize to receive too many emails, e.g., from internal or external email distribution lists or when they are included within the carbon copy-field. It was also noted that more complex communication processes involving multiple replies tend to get unstructured and that single emails may fast get overlooked (I.08, I.09, I.14).

Phone. The phone service creates synchronous audio connections to communication partners that are identified by a phone number. This service is provided by specialized organisation-internal systems or the public phone system. It is often used as an alternative to email, e.g., because communication is perceived as more personal and as to involve less effort than writing an email (I.03).

Calendar. The calendar service offers functions that can be used in order to manage and access individual or shared calendars and the entries they contain. This is governed by privileges. Interviewees frequently note that they invite participants to appointments by means of meeting requests that are automatically generated based on calendar entries. They may also contain additional information such as an agenda or references to documents stored in other systems (I.03, I.30). Creating calendar entries may also be integrated with the reservation of resources such as cars or meeting rooms (I.14, I.30). Group calendars and the ability to access calendars of colleagues were mentioned relatively seldom (I.11, I.29). All calendars used by the interviews are either based on Microsoft Outlook or IBM Lotus Notes.

News channel. The `news channel` service offers functions that enable to access or distribute frequently updated contents that are relevant for a larger audience. In contrast to the `storage` service, it is mainly concerned with the distribution of information to specific target groups. In the organisations researched, this service was always based on Web technologies.

None of the interviewees mentioned that he or she himself accesses a CMS. News was always published by contacting responsible roles by email (I.09, I.19, I.26). They are accessed on the Intranet where separate pages that aggregate internal and external news might be offered (I.11, I.12, I.13, I.28, I.29, I.30, I.31) that partially could be customized and filtered with regard to topics preferred (I.25). In one case, a pop-up window with a Web page is displayed after logon which presents daily messages (I.30). Access of selected external mainly news-oriented sites also is subsumed under this service (I.13, I.29).

Poll. The `poll` service exposes functions for creation, management and answering of surveys based on structured questions and is accessible by means of Web-based interfaces. Examples identified are mandatory evaluations of contents based on one simple structured question after the access to an internal knowledge base (I.01) or to an external portal (I.07, I.09, I.22) and the sporadic evaluation of support calls (I.18). It is often used in order to gather feedback on trainings, e.g., by external or internal training providers that ask participants to fill out electronic forms after the completion of a course (I.27, I.28, I.01). The only example of the creation of a poll observed is the request for a performance evaluation sent out by email to selected colleagues by means of a HRM system (I.05). Goal is the gathering of feedback for yearly performance evaluations.

Task list. This service provides functions for managing lists of structured tasks specified at least by a name and in many cases also by a state and due date. Only two interviewees refer to task lists offered by widely-used Groupware clients: one for individual task management (I.04) and one also for managing tasks within a team (I.30). Alternatively, the calendar is used to keep track about important milestones that mark the end of a more comprehensive task (I.11, I.24). The interviewees also mentioned the creation of individual task lists based on spreadsheet files or text documents (I.07, I.23) that may also be printed out in order to enable convenient annotations (I.02, I.12). Spreadsheets are also applied for the coordination of tasks between team members (I.05).

Discussion forum. This service offers or manages one or multiple discussion forums. Its functionality and the structure of how the contents are organised can be compared to traditional Usenet newsgroups whose usage requires a dedicated software client. Discussion forums are frequently noted to be accessed with Web interfaces. The service may also be integrated with the email system so that contributions to a forum can be received and answered conveniently within one's email client. Interviewees most often referred to forums on organisation-external sites such as the support portals of the software vendors IBM and SAP (I.08, I.09, I.22), community portals such as the community of IT administrators (I.28) and social networking sites such as topic-related forums within the social networking portal Xing[176] (I.16).

Distribution list. Messages sent to distribution lists identified by an individual address are forwarded to a defined group of recipients. All distribution lists mentioned during the interviews were based on the email system. The service also offers functions for the administration of the list. Only one respondent noted the creation of individual distribution lists with the help of the Outlook address book (I.11). The other respondents referred to centrally managed lists they apply in order to distribute emails to all members of a department (I.02, I.09) or project (I.11, I.13), to people working in selected topic areas (I.17) or to those having specific roles (I.27) as well as to all employees of an organisation (I.11).

Support ticket. This service exposes functions for the creation of support tickets that consist of a problem description and meta-data used for classification, retrieval and management. Creating tickets is supported by structured Web forms in support portals of software vendors such as IBM and SAP (I.08, I.09, I.24) and also by specialized internal systems such as HP Mercury Quality Center[177] or the BMC Remedy family of products[178] that may also be accessed based on Web-based interfaces (I.13, I.16). They are frequently used in order to report software defects. A support ticket may also be opened by contacting the helpdesk by phone (I.07).

Application sharing. The `application sharing` service transfers information about the interface and user interactions between computers with the goal to give users access to a remote desktop which enables them to view and control remotely executed software applications or operating systems. Within the organisations surveyed, the service was part of a Web-based video conferencing software or implemented based on tools such as Microsoft Netmeeting or IBM Lotus Sametime. It was noted to be applied, e.g., in order to discuss how an application should be presented to customers (I.05, I.13, I.16) or for the joint review of documents (I.01, I.18).

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176 URL: http://www.xing.com, last accessed: 2007-12-02

177 URL: http://www.mercury.com/us/products/quality-center, last accessed: 2007-12-02

178 URL: http://www.bmc.com, last accessed: 2007-12-02

Availability. This service returns information about the current availability of colleagues over selected communication media. It is related to the class of IT functions that support awareness (section 5.5.3). Availability information was gained by accessing calendars of colleagues that granted access (I.13), by reading out of office notifications (I.18), by requesting information about whether an email was read or received by enabling the respective option within the email user agent (I.26) as well as by accessing a list of people currently present at one's location (I.11).

Video. The video service enables the establishment and management of a video-based communication connection. It may be a part of electronic conferencing systems. Examples identified are the consumption of video records of live presentations (I.06) and the use of separate video conferencing rooms installed to ease communication between different locations (I.22).

Text chat. This service can be used in order to create and use a synchronous text-based communication channel such as on the IRC. It was identified once in relation to an online presentation and discussion (I.22).

Frequency of services

Figure 48 shows the frequency of services subsumed under collaboration. The expected value of the services `email`, `phone`, `calendar` and `newschannel` is higher than that of the other services (t statistic 4.20, supported for alpha 0.001). The remaining services were referred to less often by the respondents. Most services overall were mentioned in relation to the knowledge action update. A possible explanation for this is that this action sparked reflection about all kinds of media used to stay informed about events. Another explanation is that this category includes many services that do not resemble collaboration services but rather represent universal communication and information services. From this perspective, collaboration services are underrepresented within the sample.

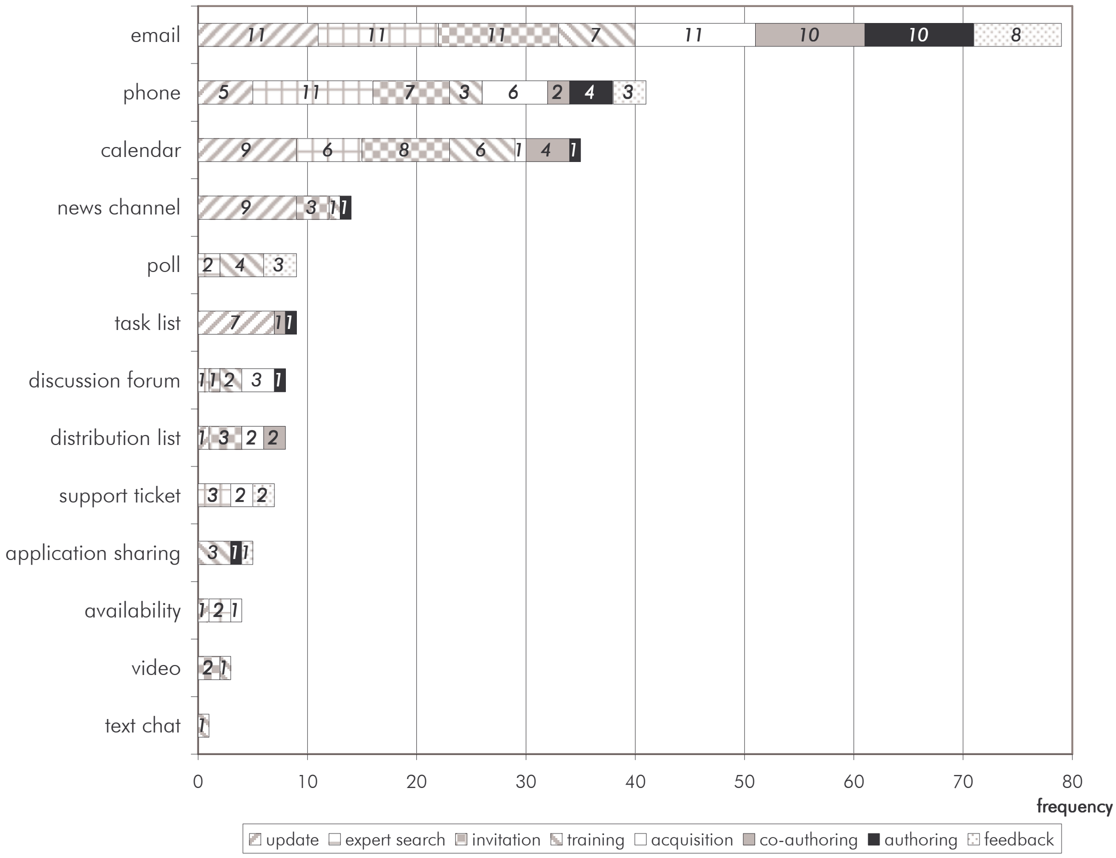

Figure 48. Frequency of collaboration services

7.3.4 Learning

Five learning services are identified that subsume the creation, booking and retrieval of courses as well as related evaluations (section 5.5.4).

Training directory. The `training directory` service is targeted at the management and retrieval of information about courses and electronic training units. It typically was referred to in relation to internal training offerings. External courses are either promoted without technical support based on paper-based training catalogues or on the Web site of an external training provider (I.20, I.21). Realizations of this service range from simple Intranet pages that indicate available courses and required skill levels (I.01) or PDF files that have to be printed out and signed by supervisors (I.10) up to specialized internal systems that offer structured course directories which can be browsed or searched with keywords and may be coupled with workflows targeted at the coordination of tasks related to the application for a training unit (I.18, I.28). The only more advanced external training directory observed is the so-called SAP marketplace[179] where courses are enlisted and various kinds of electronic training units can be accessed (I.22).

Training provision. The `training provision` service returns an electronic training unit that may have been identified before with the `training directory` service. It can be accessed immediately in contrast to traditional courses that require the approval of one's supervisor. They may be composed of multiple linked Web pages that can be retrieved from the Intranet (I.01, I.27), may contain presentation slides with audio comments (I.05) and other multimedia objects such as audio and video of recorded presentations or they are composed of files that can only be viewed with specialized software such as the SAP Tutor (I.22). In one case, it was noted that compact discs with CBT may be requested electronically (I.18).

Course request. This service allows requesting the registration to a course which has to be approved by a supervisor. Within the organisations investigated, this is either accomplished by forwarding a spreadsheet file or just an email containing all relevant data to one's supervisor or the team assistance awaiting an approval by email (I.01, I.06). Alternatively, it is implemented as a workflow within a training system (I.18, I.28) or procurement system (I.27) that notifies one's supervisor who then has to signal his agreement before the course can be booked. The service is also offered by external portals, e.g., of software vendors such as the SAP marketplace (I.06).

Learning authoring. This service supports the creation of electronic training units. It also enables the distribution of learning contents to relevant target groups and was identified in relation to the storage of training materials within a community space (I.27) as well as to the publication of so-called self-tests (I.06).

Evaluation. The `evaluation` service enables the verification of the learning success of participants. In principle, it is a specialization of the poll service for learning settings and implements functionality for the creation of structured electronic examinations. It was implemented based on Web-based electronic forms that contain structured questions related to the contents of electronic training units. The service was used in order to ensure that all relevant units are worked through (I.05) or that all learning goals are achieved (I.27).

[179] URL: https://websmp209.sap-ag.de, last accessed: 2007-12-02

Frequency of services

Services within this category are predominantly used in the context of the knowledge action training (Figure 49). However, this action in turn is supported by services from all categories as will be described in section 7.4.3. The services identified most often are `training directory` and `training provision`. The expected value of these two services is higher than that of the others (t statistic 2.59, supported for alpha 0.05).

Figure 49. Frequency of learning services

7.4 Knowledge actions

This section describes the variants identified, the occasions referred to by the respondents, the steps that a knowledge action comprises as well as the services accessed during its course for every knowledge action. They are listed in the order of their presentation in section 3.4.4. Table 17 gives an overview of the four categories that were used to classify the steps based on the number of times they were identified. It is distinguished between infrequently, less frequently, frequently and very frequently observed steps. The upper boundary varies between eleven, twelve and 13 because the number of interviews per knowledge action differs.

category	relative frequency	absolute frequency
infrequently	> 0%, ≤ 25%	> 0, ≤ 3
less frequently	> 25%, ≤ 50%	> 3, ≤ 6
frequently	> 50%, ≤ 75%	> 6, ≤ 9
very frequently	> 75%, ≤ 100%	> 9, ≤ 11, 12, 13

Table 17. Categories used for the classification of steps

In the following, these categories are used in order to highlight dominant steps. Therefore, they are visualized with different types of circles (Figure 50). Absolute and relative frequencies are included in brackets behind the name of the step. Mapping of concepts to different visual shapes is a common procedure for the visualisation and analysis of qualitative data (Dey 1993, 203ff). It should be noted that low occurrences do not necessarily indicate a low relevance. There are a number of other reasons why a step might not be mentioned by an interviewee, e.g., because it is not perceived to be noteworthy by a respondent, the interviewer did not ask questions that triggered reflection about it, it lacks IT support or simply due to the limited time available for an interview. On the other hand, at least the fact that a step was identified frequently or very frequently is an indicator that it is an important part of the knowledge action in this sample and that a larger amount of data was available for its characterization.

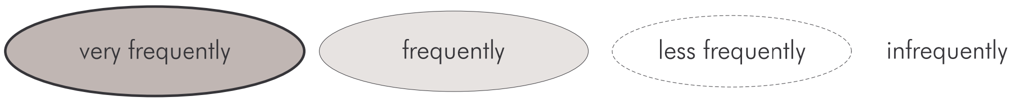

Figure 50. Visualization of steps

The order of steps was identified to be not strict enough for the definition of structured processes. Thus, they are brought into a general structure by grouping them and ordering these groups according to logical progressions as described by most of the interviewees. Besides the discussion of steps that compose a knowledge action, the services typically referred to during the interviews are highlighted, it is explained in which context they are used and how they are related to the steps and other services that are relevant in the context of an action. Just as related to the frequencies of steps, the number of times a service is identified should be interpreted cautiously.

Exact correlations between single steps and services cannot be computed. Main goal of the study is the identification, classification and characterization of steps and services. Statistically, the services and knowledge actions are variables based on a nominal scale which limits the number of applicable statistical measures. Available quantitative data are the frequencies of steps and services and their respective classification according to the eight knowledge actions (Table 35 in appendix B and Table 36 in appendix C). Here, the question is relevant whether the services are statistically correlated with the knowledge actions. The nominal variables relevant in order to answer this question are the set of eight knowledge actions investigated and the set of 35 services identified. The statistical correlation of two variables can be estimated with the contingency coefficient *C* computed as $C = \sqrt{\chi^2 / (n + \chi^2)}$ with a range of $0 \le C \le C_{max}$ (Bamberg & Baur 1996, 35f, 40ff; Hippmann 1997, 105ff). For the data, χ^2

has the value of 602 and thus *C* equals to 0.74. C_{max} is calculated as $C_{max} = \sqrt{(m-1)/m}$ with *m* as the minimum of the number of columns and rows, i.e. eight, because the number of services is 35 and that of knowledge actions is eight. Comparison of *C* and the resulting value of 0.94 for C_{max} indicates that both variables have a statistical correlation. It thus can be stated that the type of knowledge action statistically correlates with the set of services accessed.

7.4.1 Authoring: Ad-hoc and formal authoring

The knowledge action authoring was surveyed 13 times. Overall 21 steps were identified in this relation. As has been stated, examples for *occasions* were provided to the interviewees (section 6.3.2). In this case, it was referred to the circumstance that different types of contents such as ideas, messages, reports or protocols need to be published and distributed. Two different variants of this action were identified: ad-hoc authoring of ideas and formal authoring. The former mainly describes the creation of short notes on ideas or questions and their electronic distribution. Occasions referred to by the interviewees in this relation were the need for documentation and storage of ideas (I.04, I.08), the need to create and distribute meeting minutes (I.03, I.07), the need to publish news on the Intranet (I.26) and the fact that one has an answer to a question found in a discussion forum (I.17). One interviewee noted the occasion of recognizing that an already existing document might be relevant for others. It is surely related to authoring but it triggers content distribution rather than its change or creation:

> "I.17: Actually it is seldom that I say: 'Now I finally write down how this and that functions, so that everybody knows it.' … Rather, something exists and I find it sufficiently worthwhile to publish it."[180]

Formal authoring in contrast is more structured and frequently triggered by an internal or external customer who orders contents to be produced, e.g., software documentations, project deliverables or requirements definitions. This occasion was referred to by ten interviewees. The difference to ad-hoc authoring is particularly represented by steps that are concerned with getting feedback and approval by the client that the content is created for.

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[180] In German: "I.17: Also es ist jetzt selten, dass ich sage: 'So, jetzt schreibe ich endlich mal auf, wie das und das geht, damit das mal jeder weiß.' … Das ist mehr so, dass etwas existiert und das finde ich ist ausreichend werthaltig, dass man das publizieren sollte."

Figure 51 visualizes the steps identified in relation to authoring and indicates their frequency based on the categories described in section 7.4. The arrangement in vertical direction is based on the general order of steps as expressed by the interviewees. The horizontal alignment of the steps is orientated at their frequency. The more often a step was identified, the closer it is placed to the centre of the horizontal axis. If two steps have the same frequency they are ordered alphabetically. As a result, the figure visualizes a "main trail of steps" as described by most participants.

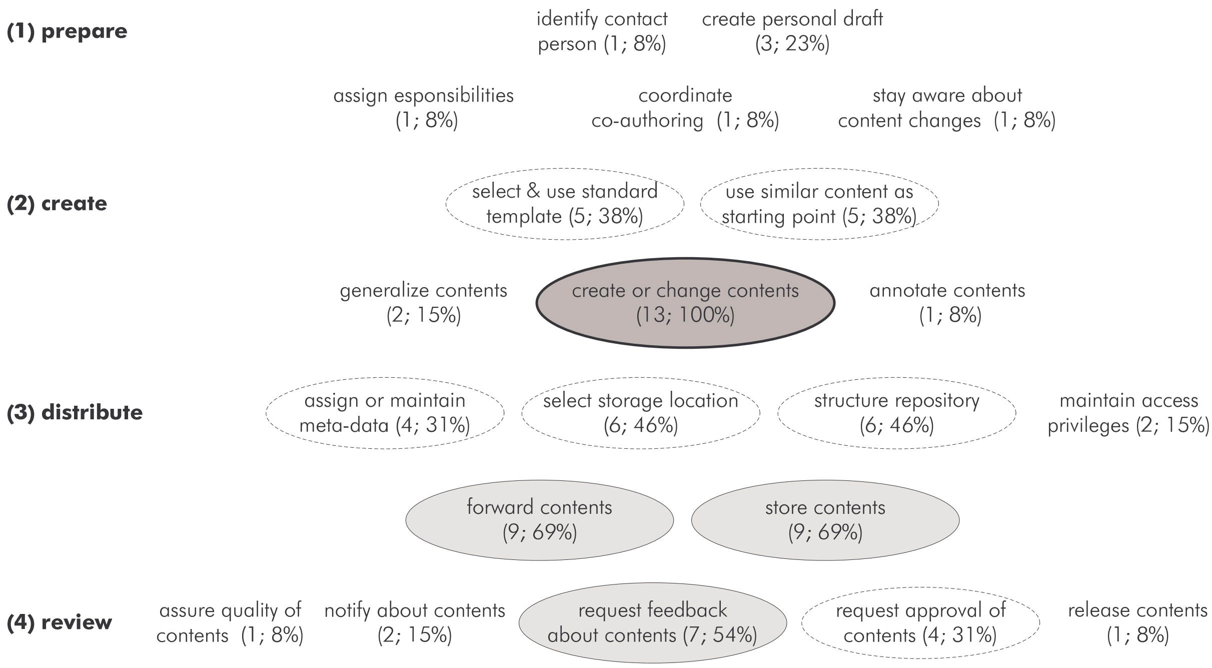

Figure 51. Steps of the knowledge action authoring

Authoring steps can be subsumed under the groups preparation, creation, distribution and review. This resembles the generic steps of the publication process as described in sections 5.5.1. (1) *Preparation* comprises the creation of personal drafts and steps that otherwise are typical for co-authoring, e.g., `assign responsibilities` and `coordinate co-authoring`. Here, these steps appear only infrequently and can be traced back to exceptional cases where boundaries between co-authoring and authoring are not clear. (2) Starting point for the *creation* of contents is either a similar document or a standardized template. Afterwards, contents are changed, annotated or generalized. `Create or change contents` was identified in all 13 interviews. (3) Contents are *distributed* by storing or forwarding them. Distribution may involve steps concerned with structuring contents and the repository, i.e. `structure repository`, `select storage location` and `maintain access privileges`. The step `assign or maintain meta-data` has also been subsumed as in most cases it is concerned with the specification of meta-data used for the classification of contents. (4) *Review* concludes formal authoring and comprises assuring the quality of contents, notifying and requesting feedback from target groups. This either leads to revision and repeated distribution or to approval and release of contents.

Feedback and approval of contents are tasks performed in order to assure quality and to legitimize contents. Maier & Schmidt (2007) refer to the legitimization of knowledge as one aspect of knowledge maturing. The maturing of knowledge or at least of contents was observed at several points related to this knowledge action: Personal drafts are created and later on act as foundation for the creation of contents, initial versions of contents are completed that are revised and approved later on, contents are generalized and documents that act as templates are continuously revised. The ordering of the four groups as presented above reflects the general succession of steps in both variants. Ad-hoc authoring is shorter and characterized by creation and distribution of contents. Formal authoring can be portrayed by the chain of all groups and thus by preparation, creation, distribution and review.

Support by knowledge services

Table 18 lists the overall 21 different services identified in relation to authoring, classified according to the general type of knowledge service and ordered according to the number of times they were identified.[181] It includes respective frequencies as absolute and as relative values compared to the 13 interviews. The following description is structured according to the groups of steps created above. A more detailed assignment of services to single steps than the one made below based on the qualitative data is not possible since quantitative data is only available for the relation between services and knowledge actions and not for the association between services and single steps.

(1) *Preparation* steps are supported by services such as `email` and `task list` for coordination and assignment of responsibilities, `competence-based search` for identification of contact persons, `content creation&change` for creation of personal drafts and `storage` applied in order to stay aware about content changes. (2) The *creation* and also the distribution of contents are key tasks during authoring and hence the services `content creation&change`, `storage` and `email` were identified most often as they support the most fre-

[181] This table and also the following tables are extracts of Table 36 in appendix C.

quently identified steps `create or change contents`, `forward contents` and `store contents`. *Creation* of contents is also supported by `Web request`, `query`, `full-text search`, `template` and `storage` services used to identify and access standardized templates or similar documents. Ad hoc authoring involves the use of `discussion forum` and `news channel` services. Generalization and annotation of contents is supported by `content creation&change` and `annotation` services. It may also involve the use of collaboration services such as `phone` and `application sharing` if a central organisational unit assists the submission of contents to a knowledge base. (3) Besides `email` and `storage` services, *distribution* is also based on services such as `storage structure`, `versioning`, `privileges` and `transformation` used to ensure that everyone is able to access the latest version published. (4) *Review* steps are strongly based on `email`. They involve making appointments managed with `calendar` services and releasing contents with `check-out` services. The only learning service identified was `learning authoring` because one interviewee referred to the authoring of electronic training units (I.06). All publication services except `library` are applied. It thus can be stated that this knowledge action is strongly based on this type of service but also involves discovery and collaboration services.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
storage	12	0.92	full-text search	2	0.15	email	10	0.77	learning authoring	1	0.08
content creation&change	11	0.85	query	2	0.15	phone	4	0.31			
template	6	0.46	Web request	2	0.15	application sharing	1	0.08			
storage structure	4	0.31	competence-based search	1	0.08	calendar	1	0.08			
versioning	4	0.31				discussion forum	1	0.08			
annotation	2	0.15				news channel	1	0.08			
check-out	2	0.15				task list	1	0.08			
privileges	2	0.15									
transformation	1	0.08									

Table 18. Services identified in the context of authoring (13 interviews)

7.4.2 Co-authoring: Authoring with collaborative steps

Co-authoring was surveyed in eleven interviews and 21 steps were identified in this context. The action is closely related to authoring, particularly the variant formal authoring and thus triggered by similar *occasions*. Examples for occasions noted by the interviewer are the creation of a draft by multiple authors for an external or internal customer as well as the contribution of contents to a Wiki system. Nine interviewees referred to the assignment of the task to create a concept or documentation such as software requirements definitions (I.13) or blueprints (I.14) by internal or external customers. Other examples are the joint creation of presentation slides (I.30) or of offers for potential customers (I.05). Figure 52 visualizes the related steps and their frequencies.

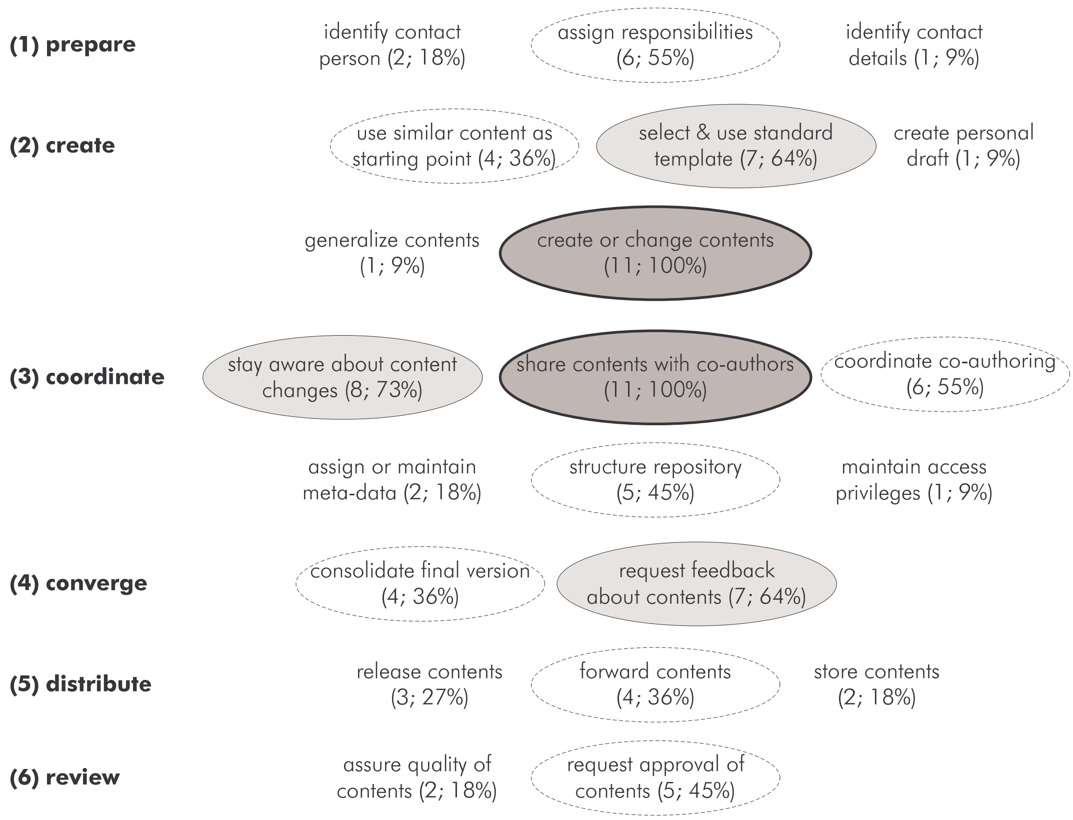

Figure 52. Steps of the knowledge action co-authoring

The steps of this knowledge action can be subsumed under the groups prepare, create, coordinate, converge, distribute and review. (1) *Preparation* deals with identification of co-authors, their contact details and the separation of responsibilities with respect to tasks and results. In most cases, one person is responsible for the overall results and coordinates activities. (2) Similar to authoring, contents are *created* based on standardized templates or similar contents. This also may include the generalization of contents and the creation of personal drafts. Work in many cases is distributed based on an initial version of the content structure such as a table of contents that subdivides a document into a manageable number of sections. (3) Access to contents shared by means of electronic repositories or by email is *coordinated* between co-authors by means of direct communication between authors and the maintenance of task lists as part of the step share contents with co-authors. This group also comprises the creation of appropriate storage structures, the assignment of privileges and meta-data and the monitoring of changes. The creation and sharing of contents may be accomplished multiple times in a reciprocal process, i.e. one creates contents, shares them with co-authors, they make contributions which again triggers own changes and additions to contents.

(4) The step request feedback about contents is targeted at receiving feedback from co-authors and not from the ultimate receivers of the results as in relation to the action authoring. Together with consolidate final version it forms the group *converge* that was labelled this way because both steps are concerned with the creation of consistent results. (5) Contents are distributed comparable to traditional authoring by means of the steps forward contents and store contents that here are concerned with publishing contents to their ultimate receivers rather than being about sharing contents between co-authors. (6) Similar to authoring, the group *review* comprises steps targeted at quality assurance and the request for approval of contents. As can be seen, traditional authoring and co-authoring have many steps in common though there are a number of specific co-authoring steps such as share contents with co-authors, stay aware about content changes, coordinate co-authoring, assign responsibilities and consolidate final version.

Support by knowledge services

Table 19 summarizes the 17 different services identified in relation to co-authoring. All types of services except learning services are applied. This action just as authoring is mainly focused on the creation and exchange of contents and thus they way of technical support is akin. (1) Steps grouped under *preparation* that are about assignment of responsibilities and identification of potential co-authors are supported by competence-based search, contact directory, calendar and task list services. (2) The group *creation* is supported by content creation&change services. If similar documents or standardized templates are used as a starting point then they firstly need to be located by means of discovery services such as query and full-text search and retrieved with storage and template services. Annotation services are mainly used for reviewing and changing contributions of co-authors. (3) *Coordination* which includes the sharing of contents is based on storage, versioning and email services. Distribution list services are applied in order to pass contents to the group of co-authors and notification agent services are used in relation to the step stay `aware about content changes`. Similar to authoring, the step `structure repository` involves the usage of the `storage structure` service. (4) Steps concerned with *converging* contents primarily access `email` and `content creation&change` services. (5) Steps concerned with the *distribution* of contents again are based on `email` and also on `storage` services. (6) Finally, *review* steps are primarily based on `email` as well as on `check-out` services.

Altogether, it can be stated that the relevance of the specific co-authoring steps noted above for this action is not reflected clearly by the set of services identified. One reason is that these particular steps are supported by `email`, `phone` and `create and change` services that were identified also in relation to other steps. Services additionally observed are `notification agent`, `distribution list` and `contact list`, those missing compared to authoring are `privileges`, `Web request`, `application sharing`, `discussion forum`, `news channel` and `learning authoring`. All of these services were only identified once or twice in this context. `Calendar`, `versioning` and `annotation` services were more often referred to during the interviews than in the context of authoring, which may reflect the need for making appointments for direct communication, for the creation of versions in order to indicate changes and for the annotation of contributions by co-authors.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
content creation&change	11	1.00	notification agent	3	0.27	email	10	0.91	none		
storage	11	1.00	contact directory	2	0.18	calendar	4	0.36			
versioning	8	0.73	full-text search	2	0.18	distribution list	2	0.18			
template	7	0.64	competence-based search	1	0.09	phone	2	0.18			
annotation	4	0.36	query	1	0.09	task list	1	0.09			
check-out	4	0.36									
storage structure	4	0.36									

Table 19. Services identified in the context of co-authoring (11 interviews)

7.4.3 Training: Individual learning and formal training

The knowledge action training was discussed in eleven interviews and comprises 24 steps. Examples for *occasions* provided were the need to acquire knowledge in a certain area based on an internal or external course or an online training unit as well as the participation of a course in agreement with one's supervisor or the human resources department. This knowledge action can be decomposed into two variants: individual learning and formal training. The former refers to ad-hoc, unplanned learning based on the electronic resources available, e.g., Internet sites and internal knowledge bases. It is best described by the metaphor "practice makes perfect" because it is driven by the need to resolve problems that individuals encounter during daily work and by their interests with regard to task-related topics. Occasions noted by the respondents are the introduction of new products and solutions that are to be presented to customers in the near future (I.05), the receipt of a request that cannot be answered based on one's own competences (I.08), the recognition of skill gaps related to concrete tasks and processes (I.18), a hint of a colleague about new and relevant topics or to access specific documents (I.13, I.20, I.26) and the need for information suited to resolve a technical problem with a software system (I.22).

The variant formal training is frequently based on an institutionalized human resources development process initiated by yearly meetings with supervisors. The occasion most often mentioned was the identification of an existing or future skill gap based on current and future tasks, e.g., concerning solutions that potentially will be requested by customers soon (I.14) or about systems to be introduced within the organisation (I.08). This occasion was identified six times. This variant may also be triggered by the suggestion of a supervisor to visit a specific course (I.01, I.05, I.06, I.20, I.28) or by the appearance of a new version of a training catalogue (I.01). An occasion that generally relates to training but not directly to one of the two variants is a periodical meeting targeted at knowledge sharing (I.05, I.22). Steps of both variants are summarized in Figure 53.

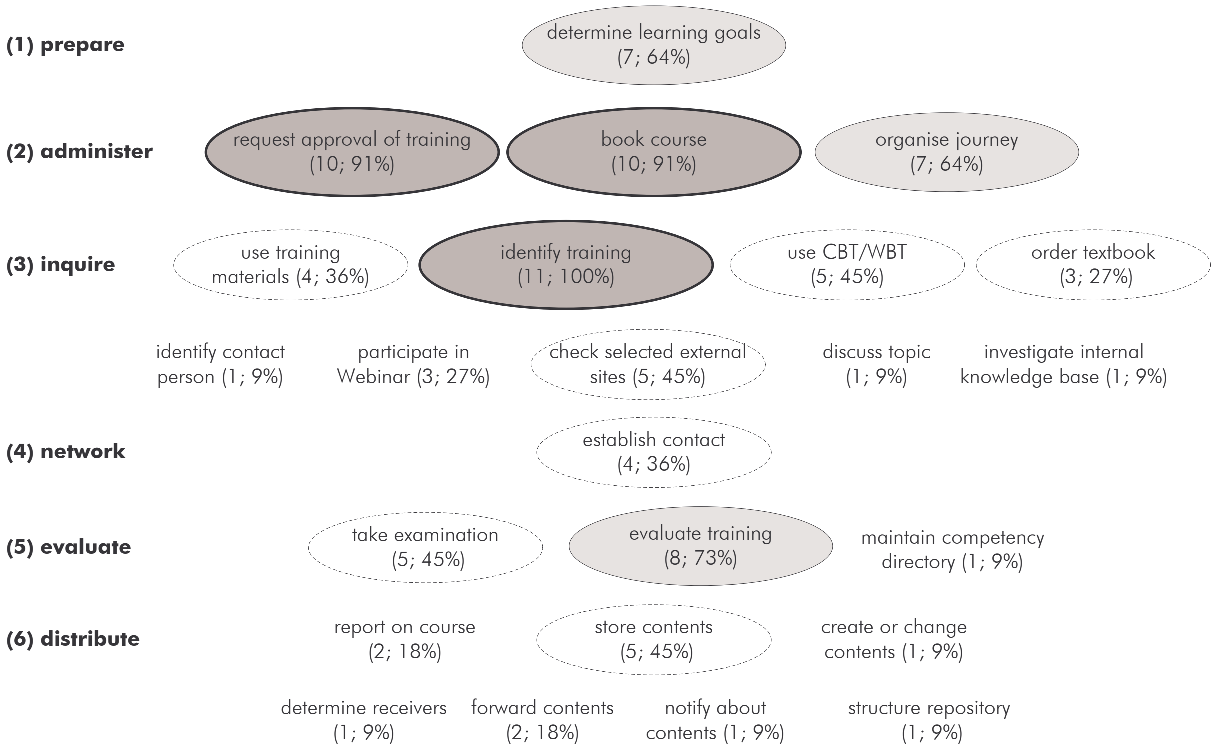

Figure 53. Steps of the knowledge action training

The steps can be structured into the groups prepare, administer, inquire, network, evaluate and distribute: (1) The *preparation* of the formal learning process, particularly the planning of the individual development goals and of courses to be visited in the near future is accomplished yearly in relation to formal training before and within an annual meeting with supervisors. (2) The group *administer* refers to the approval and booking of courses as well as to the organisation of business trips. Steps grouped here are rather formal and related to the variant formal training. (3) Steps grouped under *inquire* deal with the identification, retrieval and use of documented knowledge, i.e. `use CBT/WBT`, `order textbook`, `check selected external sites`, `participate in Webinar` and `investigate internal knowledge base`. They are less formal than the steps of the first two groups and characteristic for the variant individual learning. Employees frequently are responsible on their own for identifying suitable trainings after the learning goals were defined. Thus, the variant formal training also includes steps that otherwise are typical for individual training such as `identify training` and `use training materials`. Steps within this group also deal with the identification and access of knowledgeable people by means of the steps `identify contact person` and `discuss topic`. Contents are provided from internal or external sources and are more or less well-prepared for the use in the context of learning. This suggests that a large variety of resources and content types are relevant for training and particularly for individual learning that is often based on information produced during the daily work. One interviewee noted that he firstly tries to get an overview by starting out with more general information, e.g., marketing-oriented material about software products, and later on consults documents providing more detailed information, e.g., technical documentations or specifications (I.05). This procedure points to the possibility that some of the steps may have a typical order determined by the type of contents and also by individual preferences.

(4) The step `establish contact` was most often referred to in the context of this action and represents the *networking* with people. Courses were pointed out to represent an occasion for the enlargement of one's organisation-internal and external networks. (5) *Evaluation* steps are accomplished after the use of electronic contents for training or after the participation of courses. They are either targeted at measuring learning success, e.g., by examinations or electronic questions, or directed towards estimating the quality of learning contents. Making changes within competency directories is also subsumed here. (6) The last group of steps is concerned with informing colleagues about interesting training materials, e.g., by storing trainings and notifying interested people or by forwarding contents. This also involves the steps `determining receivers` or `structuring the repository`. It is very similar to the *distribution* of contents in the context of authoring and thus this group is labelled accordingly. It may also include a short appraisal of training materials and courses by means of the step `report on course` which involves the creation and change of contents.

The groups of steps prepare, administer, inquire, network, evaluate and distribute reproduce a formal training process. Parts of them were noted by the interviewees to be supported by workflows, e.g., the application for, approval and booking of a course. Informal learning is mainly characterized by steps within the groups inquire and distribution but it may also include the evaluation of electronic training units by means of the step `evaluate training`.

Support by knowledge services

Table 20 lists the overall 24 services identified in the context of this action, which is the highest number of different services compared to all other knowledge actions. As can be observed, publication services are less relevant compared to the two knowledge actions discussed before and clearly more collaboration and learning services are accessed.

(1) The determination of learning goals as part of the group *preparation* is supported by `knowledge map` and `training directory` services for the analysis of training needs and the

identification of available courses as well as `calendar` services used in order to make appointments with supervisors. (2) *Administration* is supported by `course request` and `training directory` services as they are used to request the approval of courses and also for their booking. `Calendar` services are applied for recording the time and place of courses. `Notification agent` services are used here in order to stay informed about possible changes, particularly concerning the time and date of courses. (3) As stated, steps grouped under *inquire* are strongly related to individual learning based on a variety of electronic sources. This is reflected by a large number of different services accessed, i.e. `full-text search`, `library` and `training directory` for identification of relevant contents, `competence-based search` and `contact directory` for locating experts, `application sharing`, `phone`, `text chat` and `video` for synchronous interaction with one or more people or `email` and `discussion forum` for asynchronous communication as well as `storage`, `Web request`, `news channel` and `training provision` for the retrieval of electronic contents and training units.

(4) As described, courses are an occasion for *networking* with other participants whose contacts are maintained by means of `contact directory` services. (5) *Evaluation* is either based on `poll` services if participants are asked about their opinion or `evaluation` services if the learning success is estimated. (6) Electronic contents are *distributed* with `storage` and `email` services, potentially involving the task of structuring a repository appropriately by means of `storage structure` services. Links are forwarded by `email` in order to notify colleagues about new contents or reports about courses are created based on `content creation&change` services. The `learning authoring` service was identified once when an interviewee referred to the storage of electronic training materials within a workspace (I.27).

publication services	abs.	rel.	discovery services	abs.	rel.	collaboration services	abs.	rel.	learning services	abs.	rel.
storage	5	0.45	full-text search	6	0.55	email	7	0.64	training directory	9	0.82
content create &change	1	0.09	Web request	5	0.45	calendar	6	0.55	training provision	6	0.55
library	1	0.09	notification agent	2	0.18	poll	4	0.36	course request	4	0.36
storage structure	1	0.09	competence-based search	1	0.09	application sharing	3	0.27	evaluation	2	0.18
			contact directory	1	0.09	phone	3	0.27	learning authoring	1	0.09
			knowledge map	1	0.09	discussion forum	2	0.18			
						news channel	1	0.09			
						text chat	1	0.09			
						video	1	0.09			

Table 20. Services identified in the context of training (11 interviews)

7.4.4 Acquisition: Individual acquisition and instruction of colleagues

Acquisition was discussed in eleven interviews and comprises 23 steps. Based on the empirical findings, the action can be distinguished into the two variants individual acquisition and instruction of colleagues. As an example for an *occasion*, the identification of a knowledge source relevant for oneself or for other people such as an information portal on the Internet or a knowledgeable person was provided. In contrast to the other knowledge actions discussed so far, the occasions referred to by the interviewees cannot be classified according to the variants identified. They rather differ with regard to the question whether knowledge is discovered and distributed to colleagues or whether it is required, searched for and afterwards shared with potentially interested colleagues. Examples for the first type are discovery of information judged to be important while reading in work-related journals (I.02), the identification of a contact person that could be important for others (I.04), the receipt of an email that is potentially interesting for others (I.16), the discovery of relevant URLs (I.17), the arrival of an interesting document (I.17) and the receipt of an offer about courses (I.21). The second type of occasion is similar to occasions triggering individual learning (section 7.4.3). Examples are the receipt of a request for support (I.08), the need to solve a problem with a software system (I.08, I.23), the curiosity about a specific topic (I.16), the need to look up a definition of a term (I.15) or to get more comprehensive information about a topic (I.02, I.15).

The variant performed depends on the role of the person that accomplishes the action rather than on the type of occasion. In many cases, knowledge is acquired individually. Monitoring and filtering of information and the triggering of subsequent activities was noted to be a typical management task:

> "I.21: Web 2.0 now is a subject. Initially everywhere in the news. Then it is important that our application architect knows this topic and we instruct him to familiarize himself with this. … Or SOA. Then one has to send the people there."[182]

In this case, colleagues may be instructed to acquire knowledge. Examples for the variant instruction of colleagues identified during the study are sending out employees to visit a presentation, course or comparable event (I.21), consigning trainees with the task to solve and document a problem with an application (I.08) and instructing an organisational research department to gather information about a more or less concretely defined subject (I.15). Figure 54 visualizes all steps identified in relation to acquisition.

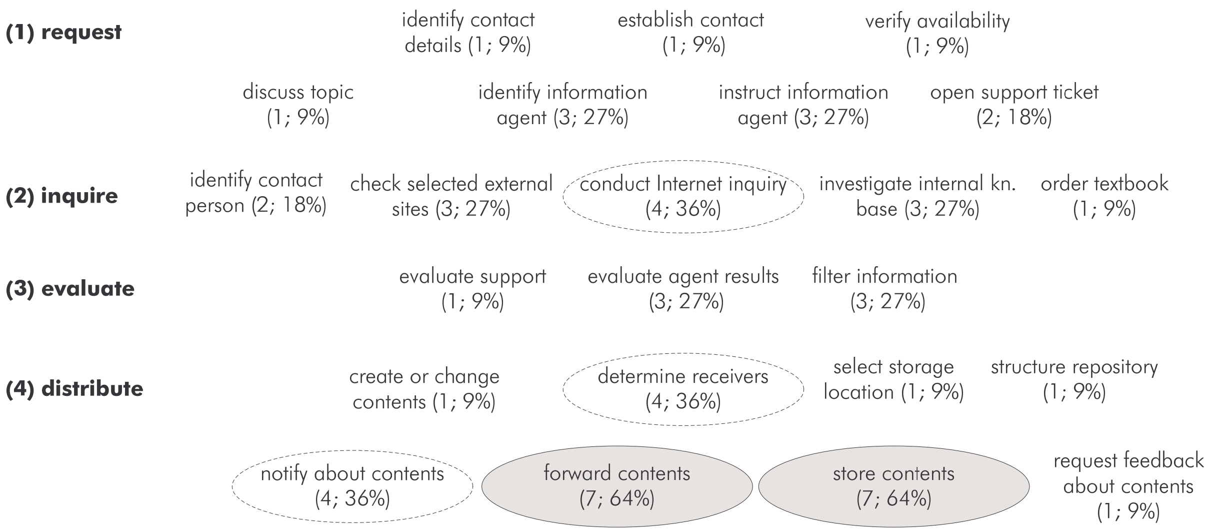

Figure 54. Steps of the knowledge action acquisition

The steps can be distinguished into the groups request, inquire, evaluate and distribute. (1) *Request* is mainly concerned with asking others for help, be it in the form of the discussion with colleagues, the opening of a support ticket or the identification and instruction of information agents. It also includes the identification of contact details, the establishment of contacts and the verification of the availability of other people. These steps were subsumed under this group as they are concerned with requesting help from others. (2) Alternatively, various sources of documented knowledge are consulted as part of the group *inquire* by con-

[182] In German: "I.21: Web 2.0 ist jetzt Thema. Erstmal in aller Munde. Da ist es wichtig, dass unser Anwendungsarchitekt das Thema kennt und dass wir dann sagen, der muss sich dort einarbeiten. … Oder SOA. Dann muss man die Leute da hin schicken."

ducting the steps investigate internal knowledge base, check selected external sites, conduct Internet inquiry and order textbook. Nevertheless, this might also involve the identification of potentially helpful individuals. (3) Steps grouped under the label *evaluate* are targeted at analysing results of support requests or those produced by information agents with respect to their quality and usability. It also includes the filtering of information before it is distributed. (4) *Distribution* is mainly targeted at the dissemination of contents to potentially interested colleagues. This includes the determination of receivers and the forwarding of contents as well as the steps select storage location, structure repository, store contents and notify about contents. It may also comprise creating or changing contents and requesting feedback about contents.

The variant instruction of colleagues is mainly characterized by the steps identify information agent, instruct information agent and evaluate agent results and thus by the groups request and evaluate, whereas individual acquisition is characterized by successions of steps in the groups request or inquire, evaluate and distribute. Only a small number of steps can be characterized as being specific or characteristic for individual acquisition. This is due to the fact that acquisition in terms of searching for documented knowledge as part of the group inquiry and for knowledgeable colleagues related to request is associated strongly to the variant individual learning of the knowledge action training and the variant person search of the action expert search. Another part of this action to a large share consists of steps concerned with the distribution of knowledge, i.e. of typical authoring steps.

Support by knowledge services

Table 21 presents the overall 15 services observed in relation to acquisition. Again, knowledge services of all types were identified except learning services. (1) Steps grouped under *request* either use support ticket services in order to open support tickets, contact directory services in order to identify people that can be contacted by email or phone services with the goal to discuss an issue. Appointments are made and recorded with the calendar service and the availability service is potentially applied in order to check whether a person could be approached with a question. Email was mentioned by all interviewees and is also relevant for distributing contents.

(2) Steps subsumed under *inquire* are concerned with the search for and access of electronically documented knowledge and consequently are based on the services full-text search, Web request, storage and discussion forum. Library services are used in the

case references to books or other sources are searched for. In contrast to be driven by a challenge, acquisition as noted may also be triggered by the discovery of information potentially relevant for others, e.g., by receiving messages from the `notification agent` service. (3) Analysis and *evaluation* of results delivered by an information agent as well as filtering information is mainly based on `email` and `phone` services. (4) As already observed in relation to authoring, co-authoring and training, *distribution* is mainly based on `email` that is used for forwarding of attachments and notification about the state of contents as well as on `storage` and `storage structure` services applied for the filing of contents. Just as in the context of co-authoring, `distribution lists` are also relevant in this context. Forwarded contents remain unchanged or at most short remarks are added and thus the `content creation&change` service was only referred to once.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
storage	6	0.55	Web request	7	0.64	email	11	1.00	none		
library	2	0.18	full-text search	6	0.55	phone	6	0.55			
content creation&change	1	0.09	contact directory	3	0.27	discussion forum	3	0.27			
storage structure	1	0.09	notification agent	1	0.09	distribution list	2	0.18			
						support ticket	2	0.18			
						availability	1	0.09			
						calendar	1	0.09			

Table 21. Services identified in the context of acquisition (11 interviews)

7.4.5 Update: Comprehensive update and catching up on events

The knowledge action update was surveyed twelve times and comprises 13 steps. Typical *occasions* are the need to catch up on events and news after returning from larger times of absence, e.g., after a vacation or business trip or during the start of work in the morning. These two occasions were mentioned by the interviewer as examples. Respondents agreed on them but in contrast to other knowledge actions gave no further examples themselves except for occasions otherwise rather related to individual learning (section 7.4.3) such as the need to look up specific information (I.26, I.30). Apart from agreeing on a more comprehensive update process in the morning, it was often not possible for the communication partners to clearly delimit a broader update activity involving multiple steps from isolated steps concerned with catching up on events conducted during the workday. This also became apparent during the task to estimate the number of times this action is accomplished per week. It was frequently reported that this action is conducted once per day more comprehensively, i.e. involving a larger share of the steps presented below, as well as continuously throughout the workday by accomplishing only selected steps that are part of the update action such as checking emails. A metaphor that can be used for the more comprehensive update action is "status report" as it best describes a situation where information about the current status of activities needs to be integrated from various sources. Steps and frequencies are visualized in the following (Figure 55).

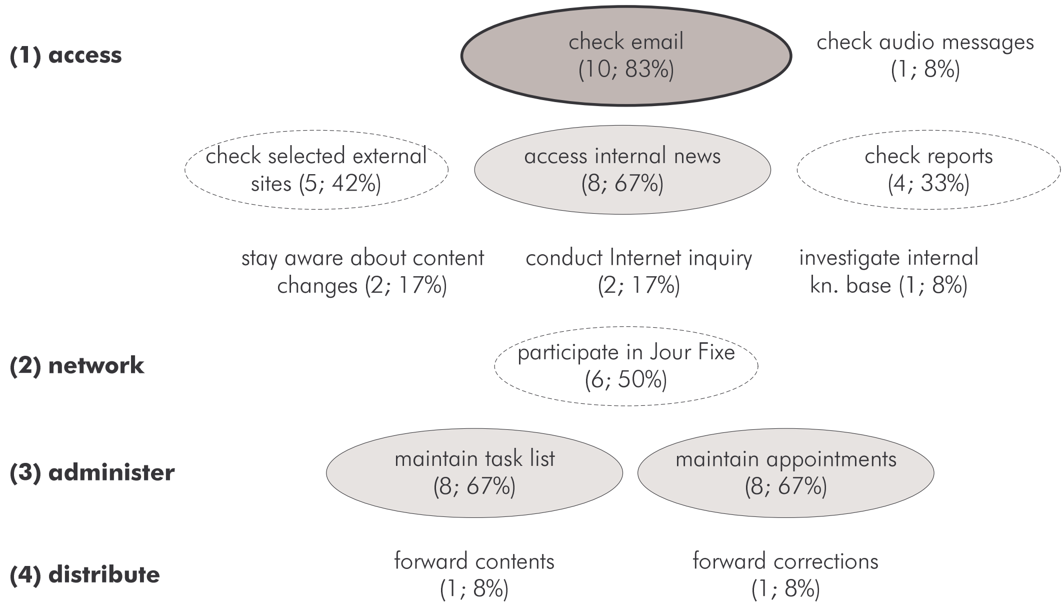

Figure 55. Steps of the knowledge action update

The steps identified can be classified into the groups access, network, administer and distribute: (1) *Access* steps are mainly concerned with checking various sources of information. They are grouped roughly into communication-oriented steps and steps based on internal and external information. The first includes the steps `check email` and `check audio messages`. Internal information is consulted by investigating changes on contents, accessing internal news published on the Intranet, checking reports and investigating the internal knowledge base. Selected external sources are accessed for news about topics of interest or in relation to an Internet inquiry typically triggered by the individual learning occasions mentioned above. (2) Participating Jour Fixes was noted as only step that involves other people and thus was subsumed under the separate group *network*. (3) The group *administer* comprises the management of tasks and appointments which often follows from accessing one's email inbox. (4) This knowledge action might also involve distribution steps though `forward contents` and `forward corrections` each were only referred to only in one case.

A step not included explicitly is the informal communication with colleagues since it is not supported by any services. However, most interviewees emphasized it as a very important activity particularly because it allows socializing with colleagues (Nonaka & Takeuchi 1995, 62ff) and acquisition of soft information (Watson 2002, 34f). In contrast to individual learning, steps grouped under access mainly deal with monitoring information sources. Individual learning is more focused on specific information determined by the current occasion and deals with problem-oriented learning and acquisition of knowledge (section 7.3.4).

Support by knowledge services

Table 22 includes the 12 services identified in the context of update. Publication services are of lower relevance since this action rather is concerned with passively monitoring information sources. Only two out of six discovery services are applied, which can be explained by the fact that this action mainly is triggered by the need to stay informed rather than to search for specific information related to a concrete problem. Use of learning services was not mentioned.

(1) Communication-oriented steps accomplished in the context of the *access* group are mainly based on `email` and in one case on `phone` services. `Storage` services are applied in order to keep on track about content changes. `Email` was always noted as the primary service used for updating, also for retrieving emails sent out by `distribution lists` and `notification agents`. Steps concerned with the access of internal information sources are based on `news channel`, `calendar` and again `storage` services. External information sources are made available by `Web request` and `full-text search` services. (2) The participation of Jour Fixes grouped under *network* is mainly supported by `email` and `calendar` services. (3) The *administration* of task lists and appointments is based on the two services `task list` and `calendar`. `Notification agents` in this context are used in order to stay informed about important tasks or deadlines. (4) Distribution of contents is supported by `email` and if contents are annotated also by `annotation` services. As stated, informal communication is very important and thus also the use of `availability` services was noted once as to be relevant in order to check who is present at the current location.

publication services	abs.	rel.	discovery services	abs.	rel.	collaboration services	abs.	rel.	learning services	abs.	rel.
storage	5	0.42	notification agent	4	0.33	email	11	0.92	none		
annotation	1	0.08	Web request	3	0.25	calendar	9	0.75			
			full-text search	2	0.17	news channel	9	0.75			
						task list	7	0.58			
						phone	5	0.42			
						availability	1	0.08			
						distribution list	1	0.08			

Table 22. Services identified in the context of update (12 interviews)

7.4.6 Feedback: Unsystematic and informal feedback

The knowledge action feedback was surveyed eleven times and comprises 13 steps. The need to give feedback on knowledge applied was referred to as an exemplary *occasion*. It may comprise the correction of errors, the rating of contents and potentially also the evaluation of skills of colleagues. The identification and discussion of this knowledge action as well as of corresponding occasions turned out to be problematic. Some respondents had no concrete idea and stated that there is no typical or systematic way of giving feedback. The time needed for the discussion of this action was shorter and the number of identified steps is lower compared to that of most other knowledge actions. Many interviewees stressed that direct communication is most important for giving positive as well as negative feedback which is not supported by IT services. Giving feedback is perceived as a very personal activity. Hence, answers such as the following were not unusual:

> "I.23: Actually, not by an IT system. Simply by means of a dialogue, by a phone call or one simply meets and talks about it. Then, surely. But this is not stored somewhere in an IT system that has some feedback function as one also can find … on the Internet: 'Did this page help you?' and 'Comment:' and so on. No, not this way."[183]

Feedback is also noted to be given unsystematically right where it is perceived to be appropriate. One interviewee places the responsibility to trigger feedback within the hands of the person evaluated:

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[183] In German: "I.23: Also, nicht über ein EDV-System. Einfach durch ein Gespräch, durch ein Telefonat oder man trifft sich einfach mal und spricht darüber. Da dann sicherlich. Aber das wird nicht irgendwo in einem EDV-System hinterlegt, dass man so eine Feedback Funktion hat, wie man das auch im Internet … findet: 'Hat Ihnen die Seite weitergeholfen?' und 'Kommentar:' usw. Nein, so nicht."

"I.09: You have to claim for feedback. Feedback is not brought to you."[184]

It can be observed that giving feedback is linked to other knowledge actions surveyed, particularly to authoring and co-authoring during review of and conversation about contents as well as to formal training related to the evaluation of trainings or of the participant's learning success. Here, feedback is triggered by the authors, organisers of courses or creators of learning content. Another reason for problems with surveying feedback is that mistakes and errors are corrected instantly if the necessary access privileges are possessed (I.09, I.12, I.16, I.19). Thus, authors themselves do not necessarily obtain direct feedback about changes. Last but not least, general feedback might not be provided because from an individual perspective, it only generates effort. It often is given indirectly, e.g., just by the activity of accessing and reusing contents. Some respondents stated that giving or requesting feedback is an area that could be enhanced. Nevertheless, a number of steps are identified that are visualized in Figure 56.

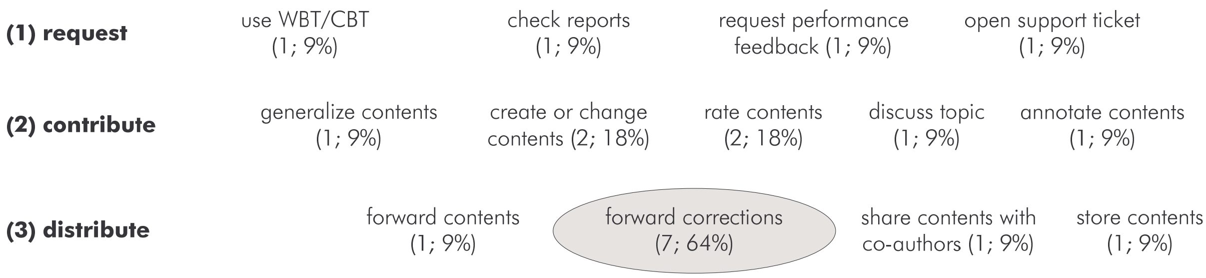

Figure 56. Steps of the knowledge action feedback

Steps can be grouped under the labels request, contribute and distribute. (1) *Request* refers to the access of electronic contents such as WBT/CBT, reports or results of support tickets. These represent the contents that feedback is provided for. On the other hand, steps within this group are about actively requesting feedback or help, i.e. asking colleagues for evaluation of one's skills or opening a support ticket. (2) Steps grouped under *contribute* describe various activities used to correct and change contents, which involves the generalization, rating and annotation of contents as well as the discussion with colleagues. (3) *Distribution* as already discussed in the context of other knowledge actions refers to forwarding, sharing and storing respective contents. `Forward corrections` was most frequently noted and thus could be characterized as a typical feedback step that comprises sending corrected contents

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[184] In German: "I.09: Feedback muss man sich holen. Feedback wird dir nicht gebracht."

to authors without actually being requested for feedback. However, this result might be biased as this step is closely related to the exemplary occasion mentioned by the interviewer.

Support by knowledge services

Table 23 lists the 13 services used in the context of feedback. As can be observed, `email` again is one of the most dominant services. (1) Services used in relation to *request* steps are `storage`, `email`, `support ticket`, `training provision` and `poll`. They correspond directly to the steps identified above, i.e. the retrieval of reports or training units, the opening of support tickets and the request of an evaluation by colleagues. (2) Steps summarized under *contribute* are based on `annotation`, `content creation&change` and `poll` services. They all provide means to contribute one's own view, make corrections or rate items. `Web request` services were used once in relation to the annotation of contents, in this case the creation and publication of book reviews (I.09). Once, a `transformation` service was used in order to systematically work through a set of comments exported from a Microsoft Word document. `Phone` services were referred to as a media used for the direct communication of feedback. Conversations may also be supported by `application sharing` services, e.g., one respondent referred to their use in order to give feedback about a software application (I.16). `Contact directory` services might be accessed in advance to look up contact details. (3) *Distribution* again is mainly based on `check-out`, `storage` and `email` services in order to forward contents and corrections or to store and release them.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
annotation	3	0.27	contact directory	1	0.09	email	8	0.73	course provision	1	0.09
content creation&change	3	0.27	Web request	1	0.09	phone	3	0.27			
storage	3	0.27				poll	3	0.27			
check-out	1	0.09				support ticket	2	0.18			
transformation	1	0.09				application sharing	1	0.09			

Table 23. Services identified in the context of feedback (11 interviews)

7.4.7 Expert search: Submit support call and person search

The knowledge action expert search was discussed twelve times in interviews and comprises 16 steps. The *occasion* provided as an example was the need to search for a person in a roughly defined topic area due to a concrete problem related to one's work tasks or because one needs to familiarise with a new topic. Two variants of this action have been identified, that of submitting a support call answered by a helpdesk and that of searching for a person. The latter comprises the searching for, the contacting of and the communication with people potentially possessing the competencies required. Asking experts was pointed out to lead to faster results than searching for and reading documented knowledge, if it is available at all (I.17, I.28). Occasions noted in relation to the search for persons are the existence or anticipation of more or less complex problems, e.g., a wrong entry in business documents (I.21) or technical problems in the context of software systems maintenance (I.28), the need of a service or product that cannot be created internally and thus has to be sourced externally (I.21, I.23), the need to identify a person responsible for an area that is affected by one's current task (I.10, I.23, I.26, I.28, I.30) as well as the need to identify appropriate candidates during the staffing of teams (I.10, I.21).

Submitting support calls is related to expert search because it represents an alternative way of requesting expertise in order to resolve a problem. It is based on an established service process installed within the organisation. Unlike the variant person search, it is not relevant who actually provides assistance. One interviewee described this as follows:

> "I.07: Actually, one is not interested in the expert but in the solution. How the solution is generated is secondary, as I would put it. The expert is actually only a means to an end."[185]

Hence, the variant support call could also be referred to as request for assistance or for help. Support calls can only be made for relatively clearly defined domains, e.g., related to widely applied technologies within an organisation such as infrastructural technology and office applications. Examples for occasions identified in this context are problems with a spreadsheet application (I.07) or with the network infrastructure (I.18). Figure 57 summarizes steps and their frequency for both variants.

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[185] In German: "I.07: Normalerweise ist man ja nicht an dem Experten, sondern an der Lösung interessiert. Wie die Lösung zustande kommt, ist eigentlich ja sekundär, sage ich mal. Der Experte ist eigentlich nur Mittel zum Zweck letztendlich."

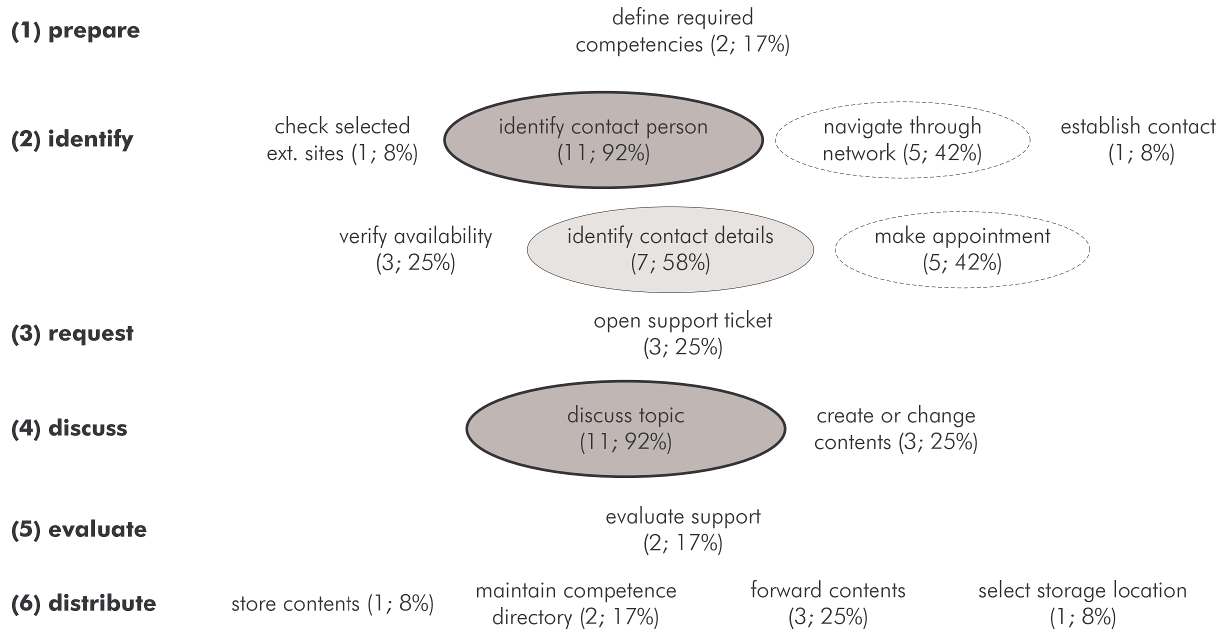

Figure 57. Steps of the knowledge action expert search

Steps constituting this knowledge action can be grouped into the classes prepare, identify, request, discuss, evaluate and distribute: (1) *Preparation* deals with setting up the expert search by defining the competencies required. (2) *Identification* comprises all steps necessary in order to identify and locate appropriate expertise such as the identification of people and their contact details either directly or by navigating through networks of people, the verification of their availability, the agreement on appointments as well as the creation of support tickets. In one particular case, an external site provided by a software partner was checked in order to identify appropriate contents and entries in discussion forums (I.09). Interviewees pointed out to rely on their personal network, i.e. their first step is often to ask people known such as supervisors, colleagues or friends. Responses such as the following were frequently observed:

> "I.18: Principally, there are two possibilities. Either it is known by P.01 or by P.02, who are my supervisor and my colleague, or I find it on the Intranet who is responsible for that."[186]

(3) The *request* for help is represented by the step `open support ticket`. (4) Steps grouped under *discuss* are concerned with the communication about and translation of solutions or answers received to the problem or task at hand. This involves the discussion with experts, the creation or change of contents such as meeting minutes. Meeting minutes are either tar-

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[186] In German: "I.18: Da gibt es im Prinzip zwei Möglichkeiten. Entweder weiß es der P.01 oder der P.02, das ist mein Chef und mein Kollege, oder ich finde es im Intranet wer dafür zuständig ist."

geted at documenting aspects of a discussion obligingly or just at creating a short protocol that every participant can file and access for reference. (5) Evaluation deals with the evaluation of answers on support tickets. (6) *Distribution* is mainly concerned with the storage and forwarding of results of meetings and discussions. This also involves the selection of appropriate storage locations. It may also include updating information about competencies stored in respective directories.

The search for people is characterized by the general succession of steps in the groups prepare, identify, discuss and distribute. Submitting support calls was characterized by the interviewees to mainly consist of the steps `open support ticket` and `evaluate support` and thus involves the groups request and evaluate.

Support by knowledge services

Table 24 lists the 15 services applied in the context of expert search. E`mail` and `phone` services again were noted most frequently. Expert search is the only knowledge action where all six types of discovery services were referred to. Again, no learning services were mentioned.

(1) The definition of required competences which concerns the *preparation* of the expert search is not supported directly by technical services but involves browsing through Intranet pages and contact directories and thus is assisted indirectly by `contact directory` and `Web request` services. (2) The *identification* of experts is based on `competence-based search` and `knowledge map` services if they are available. Otherwise, `Web request` services are applied in order to retrieve Intranet pages or `contact directory` services in order to locate members of potentially relevant organisational units. They are also accessed in order to look up contact details before an expert is contacted. Her availability might be checked before with the help of `availability` services. In one case, a local `full-text search` service was noted to be applied in order to search through contacts and emails. (3) Alternatively, support tickets are created in relation to the group *request* by means of `support ticket` services. The identification of experts potentially is accompanied by the access of `discussion forums` or searches based on `full-text search` and `query` services.

(4) For the *discussion* of an issue, potential experts are either contacted immediately by `phone` or by `email` which may also result in appointments managed with `calendar` services. Meeting minutes are generated with `content creation&change` services. These are either forwarded by `email` or filed by means of `storage structure` and `storage` services. If support

tickets or entries in discussion forums were created, then the requester may be notified by `notification agent` services. (5) The quality of the support potentially is *evaluated* by means of `poll` services. (6) *Distribution* mainly deals with the forwarding of contents to participants by means of `email` services or by storing them with the help of `storage` and also `storage structure` services. It may also involve the maintenance of competency directories which is often done only indirectly by sending out a request by email due to the lack of privileges required for this task.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
content creation&change	2	0.17	Web request	5	0.42	email	11	0.92	none		
storage	2	0.17	contact directory	8	0.67	phone	11	0.92			
storage structure	1	0.08	competence-based search	7	0.58	calendar	6	0.50			
			full-text search	3	0.25	support ticket	3	0.25			
			knowledge map	3	0.25	availability	2	0.17			
			notification agent	2	0.17						
			query	1	0.08						

Table 24. Services identified in the context of expert search (12 interviews)

7.4.8 Invitation: Invitation into a group and individual invitation

Invitation was surveyed twelve times and is structured by means of 15 steps. The *occasion* provided as an example was the circumstance that a person should be invited to an informal network or an event in this context, e.g., a workshop or presentation that presents experiences about a specific topic. Two variants were identified: invitation into a group that organises an event such as a presentation for a small to large number of participants and individual invitation for communication about selected topics in a small group. A typical occasion that was referred to trigger the invitation for an event is that a meeting targeted at knowledge sharing takes place which involves presentations and discussions (I.05, I.06, I.09, I.19, I.22). Such meetings were pointed out to be important for employees that are often away on business. Individual invitations are triggered either by the need to discuss a concrete problem (I.06), the goal to invite younger colleagues into a network of people (I.11, I.14) or the fact that an event is potentially relevant for an acquaintance (I.25). Individual invitation is very similar to expert search in terms of the steps accomplished. Figure 58 depicts the steps identified.

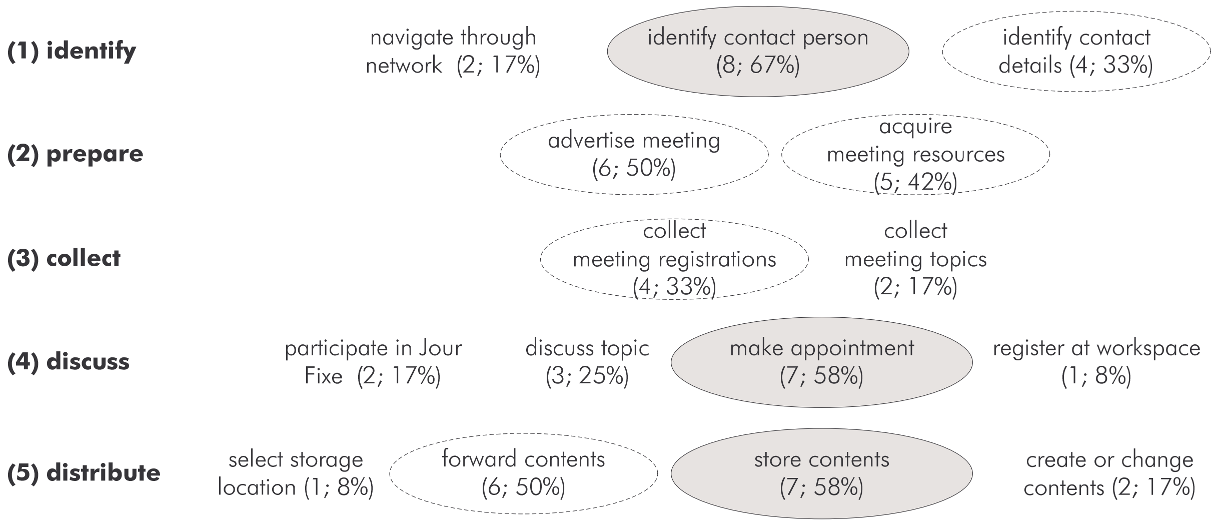

Figure 58. Steps of the knowledge action invitation

The steps are grouped with the help of the categories identify, prepare, collect, discuss and distribute: (1) Comparable to expert search, *identify* comprises the search for suited people and for appropriate ways to contact them. This also includes the navigation through networks of people. Goal is to find people relevant for a meeting or potentially interested in a topic. (2) Steps grouped under *prepare* deal with the acquisition of resources and the advertisement of meetings. (3) As a result, meeting registrations and suggestions for topics to be discussed need to be *collected*. (4) The steps `make appointment` and `register at workspace` are conducted in order to prepare the *discussion*, which is addressed by the steps `participate in Jour Fixe` and `discuss topic`. (5) *Distribution* as above deals with the forwarding of contents in order to disseminate information related to presentations, to store contents in group workspaces and to distribute meeting minutes. This includes the selection of appropriate storage locations. In conclusion, invitation into a group is characterized by steps from all of the groups identify, prepare, collect, discuss and distribute whereas individual invitation mainly is conducted with steps in the groups identify, discuss and distribute.

Support by knowledge services

Overall 13 services were identified in the context of this action and are enlisted in Table 25. (1) *Identification* steps are supported by `phone`, `contact directory` and `knowledge map` services that all more or less indirectly enable the identification of communication partners. (2) *Preparation* steps are most often based on `email` that is used in order to distribute information about an event and for the collection of registrations. This might also involve the use of `distribution lists`. Announcements of events are published with `news channel` services and in one case with a `discussion forum` service. `Calendar` services are applied for resource reservations and for the dissemination of meeting requests to participants. (3) The *collection* of registrations and topics is supported by `email` and `phone` services. (4) `Calendar` services are also relevant for *discussion* steps in order to support the management of Jour Fixes and of other appointments. Synchronous interaction of dislocated individuals is supported by `video` services if teleconferencing functions are available. Communication is initiated by the registration to workspaces which is supported by `privileges` services. (5) As always, the *distribution* of contents such as meeting minutes created during or after meetings with `content creation&change` services or of other materials is based on `email` and on `storage` as well as on `storage structure` services.

publication services	abs.	rel.	**discovery services**	abs.	rel.	**collaboration services**	abs.	rel.	**learning services**	abs.	rel.
storage	6	0.50	contact directory	5	0.42	email	11	0.92	none		
content create& change	3	0.25	knowledge map	1	0.08	calendar	8	0.67			
privileges	3	0.25				phone	7	0.58			
storage structure	1	0.08				distribution list	3	0.25			
						news channel	3	0.25			
						video	2	0.17			
						discussion forum	1	0.08			

Table 25. Services identified in the context of invitation (12 interviews)

7.5 Further results

The previous sections concentrated on results that concern the propositions, i.e. typical steps that knowledge actions are composed of and the services applied in their context. This section presents further results related to the context of KWS (section 7.5.1), the quantity structure of knowledge actions (section 7.5.2) as well as the characterisation of the interviewee's work tasks from a KM perspective (section 7.5.3).

7.5.1 Context factors

The KWS context has been characterized with the help of the six dimensions product, process, person, productivity tool, time and location that describe typical context information as well as based on the six categories of meta-information source, electronic access, change rate, protection, generalisation and reliability (section 3.4.3). The investigation of context factors intentionally is not included as a separate part of this study. Nevertheless, the respondents frequently referred to factors that influence the steps of knowledge actions and particularly their technical support. The number of times that a specific factor was noted is comparably low and thus not suited for the refinement of propositions about the KWS context, which should also regard theories that investigate selected relationships between factors and individual behaviour, e.g., media choice theories that try to explain and predict the selection of communication media (Dennis & Valacich 1999) or task-technology-fit theories (Goodhue & Thompson 1995). However, the large number of examples for factors that were identified represents a useful foundation for the refinement of the KWS context framework. The meta-information about the context no further data is available and thus it is excluded from the following discussion.

During the analysis it turned out that not only the six relatively broad dimensions of context information should be used as categories but also their relationships. This results in the six additional categories product-person, product-process, process-person, person-productivity tool, productivity tool-process and productivity tool-product. Time and location can be used as self standing context categories and otherwise as attributes in order to further specify the four dimensions product, process, person and productivity tool as well as their aforementioned associations. Figure 59 visualizes this refined framework and applies it in order to structure the factors identified. It includes the single dimensions and the relationships between them. The fact that time and location are related to every element is indicated by dashed lines. If a factor is related to one of the two dimensions then this is indicated after its name. The factors are ordered according to the frequency of their occurrence. This information is included in brackets behind each factor. Overall 93 interview sections about knowledge actions have been analysed and thus a factor can be observed with a maximum of 93 times. Most of the factors were mentioned in relation to more than one knowledge action. In the following, the factors are described in clockwise order starting with the dimension product.

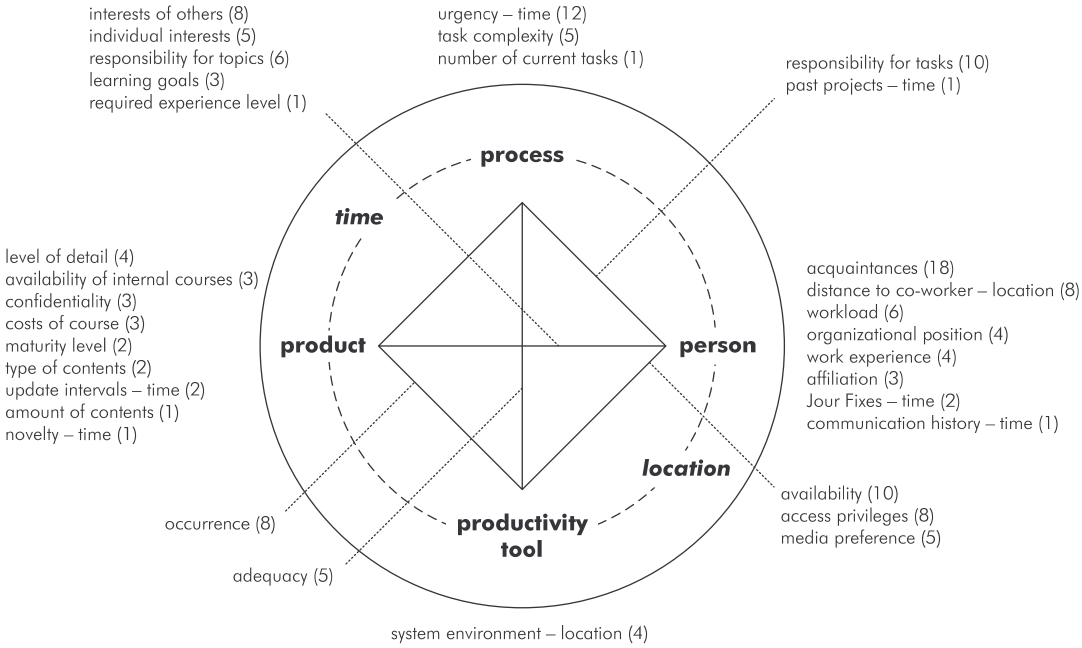

Figure 59. KWS context factors identified

Product. The *level of detail* refers to the specificity of contents required in order to satisfy individual information needs. In the context of training, the interviewees distinguished between a need for more general information, e.g., marketing-oriented presentations or brochures, and the need for more specific and detailed information contained, e.g., in whitepapers or technical specifications (I.05, I.10). In case of more general or unspecified questions, experts are contacted instead of accessing documents (I.17). The *availability of internal courses* determines the identification and approval of courses. Internal courses can be booked and approved by means of internal training catalogues, whereas external courses require other ways of identification and approval (I.27, I.28). The need for *confidentiality* was stated to influence co-authoring with respect to the selection of media and locations for the storage of contents (I.01). It also affects acquisition concerning the decision whether and to whom contacts or results of projects should be forwarded (I.03). Meeting minutes in the context of expert search are created particularly if topics are in some way politically delicate (I.10).

The *costs of courses* determine the need of their approval and thus also their choice (I.06, I.20, I.28). The *maturity level* of contents during the knowledge action authoring was indicated to determine their storage location, e.g., they are firstly stored locally and later on in publicly accessible areas (I.29). Agendas were noted to be distributed over different media, depending on their maturity level (I.27). In the context of authoring, the *type of contents* is applied in order to identify suitable templates or to classify contents during storage (I.17). This refers to task-related classifications of contents such as offer, agreement, how-to and whitepaper rather than technical differentiations based on electronic formats. The interviewees mentioned various types of contents they access depending on their current problem particularly related to the knowledge actions acquisition and individual training (I.22).

Update intervals are noted to determine the storage location in the context of authoring. One interview partner stated that it is more likely that he distributes those contents he updates frequently by email rather than storing them within a DMS (I.07). Templates that are more likely to change within short time intervals are more probably retrieved from the Intranet than from local storage spaces (I.18). The *amount of contents* was characterized to influence their distribution in the context of acquisition. It was stated that it is more likely that aspects are highlighted or annotations are added if larger amounts of contents are distributed (I.03). *Novelty* was indicated to influence the decision whether to forward contents or not, particularly related to news (I.03).

Product-person. *Interests of others* are used in order to decide whether contents are relevant for colleagues and should be forwarded or not. This was observed in the context of update or acquisition (I.11, I.16, I.25) as well as related to training (I.18). They are also relevant for determining who should receive invitations for events (I.11) and for selecting suitable storage locations during authoring (I.17). The number of potentially interested colleagues is also relevant for the decision whether a course could be arranged in-house (I.08, I.14). *Individual interests* play an important role during training, e.g., the selection of training units or courses (I.06, I.18) and the browsing through journals or magazines for relevant articles (I.08). They also determine the selection of books procured during the acquisition of knowledge (I.04) and influence the action update when newsletters are selected or Intranet sites are customized with regard to the information they should present (I.26). The *responsibility for topics* goes hand in hand with that for tasks which has been categorized under the dimension process. Stewardship for topics rather than tasks was noted in the context of expert search related to help desks or competence centres that assist resolving problems (I.07, I.13). It is also used during acquisition in order to identify recipients of emails possibly interested in a topic (I.02, I.03), to decide who needs to be included in a review process concluding co-authoring (I.11) or in order to identify workspaces of communities (I.31). *Learning goals* are influenced by interests or responsibilities and in many cases involve an official commitment to pursue them. They influence the selection of training units and may be based on expected future needs of customers, personal skill gaps and individual career plans (I.14, I.20, I.27). On the other hand, courses may prescribe *required experience levels* strongly related to the factor work experience classified under the dimension person (I.01).

Process. Interviewees stated repeatedly that if tasks are *urgent* they prefer to use the phone instead of email (I.03, I.18, I.25, I.29, I.30). In the case of time pressure, books or other resources are used for training instead of visiting courses (I.20), emails about urgent tasks are read first during update (I.30), questions are resolved immediately instead of shifting them to Jour Fixes (I.04) and in the context of co-authoring contents are separated in a way that enables working simultaneously on parts of them (I.22). The *task complexity* influences the decision whether questions should be resolved instantly using email or phone or otherwise should be discussed separately in meetings. This was referred to in relation to co-authoring (I.19) and expert search (I.21). In the context of acquisition, complexity of a problem influences sources exploited to resolve a problem, e.g., by opening support tickets in case of standardized problems or using other alternatives (I.08). In relation to update, one interviewee noted that it depends on the *number of current tasks* whether he needs to use task lists or not (I.24).

Process-person. The *responsibility for tasks* or more generally for processes were mentioned to influence who is invited for the discussion of a topic, e.g., people with similar tasks or those that are responsible for processes related to the issues to be discussed (I.06, I.09, I.13, I.14). The location where contents are stored during authoring similarly is determined by the tasks and responsibilities of the target groups (I.06). They were also noted to influence the type of contents created, e.g., software documentations for software developers vs. for colleagues in a computing centre (I.23). Who is included as recipient of messages sent in order to give feedback also depends on his or her responsibilities (I.03). The availability of documents that act as templates during authoring was mentioned once to depend on one's *past projects*, which relates to the time dimension (I.29).

Person. Interviewees most often compared to all other factors referred to their *acquaintances*, i.e. the people they work together with inside and outside the organisation such as colleagues within their organisational unit. One reason is that the knowledge, skills and topics they deal with are familiar to the respondents (I.03, I.07, I.15). A common ground based on shared interests, similar age, comparable organisational unit or background and also sympathy may equally play a role but this was not explicitly described and specifically asked for by the interviewer. This factor influences the knowledge action expert search where respondents stated that at the first place they rely on people they know well and only if this is not an option they contact others, e.g., colleagues of other departments (I.15, I.18, I.23, I.28). It was also stated that it is more likely to give feedback on documents from authors known relatively well (I.07), to read articles that were published by colleagues in magazines such as ct[187] or iX[188] (I.13) and that the choice between media such as email and phone may depend on whether the contact partner is known or not (I.13).

Distance to co-workers is a typical example of the relation between the context dimensions person and location that was often referred to. Meetings are more likely to be supported by teleconferencing facilities if participants are distributed over multiple distant locations as noted in the context of invitation (I.06, I.22). Related to expert search it was noted that those people responsible for a topic that are located nearby are asked for help first (I.07, I.26). Co-ordination of co-authoring may happen directly when co-authors are located close by (I.12, I.30). It was also noted that it is more likely to give feedback directly and only in the second place by phone or email and thus giving feedback is more probable if colleagues can be easily contacted directly (I.03). The individual *workload* was stated to influence when or whether at all courses are booked (I.01, I.06, I.20) as well whether one is able to participate in or is invited to meetings in order to share opinions (I.06, I.22, I.28). The *organisational position* during invitation was noted to influence the way how appointments are made. The higher-ranked a communication partner is, the harder it is to get appointments with him (I.11). It was also stated to be more likely to use phone instead of email in order to make appointments if the communication partner has a high organisational position (I.21). In relation to update it was stated that emails from higher-ranked people are more likely to be read first (I.30).

Individual *work experience* was noted to influence the selection of courses, e.g., some courses are mandatory at the beginning of one's career (I.18) and others are explicitly targeted at selected experience levels (I.01). It was also indicated to influence the type of contents accessed for individual training (I.06). Invitation to informal groups was stated to be particularly relevant for new colleagues in order to enable them building a network within the organisation (I.14). The *affiliation* of communication partners was noted to influence the extent of technical support of co-authoring, e.g., because email has to be used as a shared work-

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[187] URL: http://www.heise.de/ct, last accessed: 2007-12-02

[188] URL: http://www.heise.de/ix, last accessed: 2007-12-02

space is not available (I.11) or versioning mechanisms need to be implemented manually because more sophisticated support is not available for all authors (I.22). The organizational affiliation is also used to decide who should join a meeting since it acts as a proxy for the topics dealt with (I.25). Existing calendar entries and particularly *Jour Fixes* were noted to influence the decision whether to shift the discussion of specific topics to Jour Fixes or to make separate appointments (I.23). They are a means for sharing opinions in Communities of Interest and may make separate invitations unnecessary (I.31). It was noted that the extent of annotation of acquired contents depends on previous communication which is labelled here with *communication history* (I.25). Contents forwarded about topics related to foregoing communication are only annotated concisely or not at all. Jour Fixes and communication history relate to of the dimension time.

Person-productivity tool. The factor *availability* refers to whether a person currently can be contacted with some medium such as phone or can be met directly. In relation to expert search and update, interviewees often stated that if they are not able to contact someone immediately then they write her an email (I.10, I.11, I.17, I.21, I.23, I.28). The same was observed in the context of invitation, either related to communication (I.21, I.25, I.29) or to the arrangement of appointments (I.02). *Access privileges* are relevant related to many knowledge actions. Resources accessed during acquisition might be secured by a login and password (I.03). The selection of storage locations in the context of authoring was noted to be determined by access privileges of the colleagues involved (I.26) and it was stated that contents are distributed by email the assignment of appropriate access privileges is perceived as too cumbersome (I.07). Training materials are only accessible for the participants of courses and thus may be forwarded to interested colleagues (I.18, I.27). In relation to invitation it was stated that meeting minutes are distributed by email due to the lack of shared storage locations (I.21, I.22). *Media preference*[189] was identified where it was stated that a direct contact was preferred over email in the context of acquisition, invitation and expert search (I.02, I.21), that file servers are preferred over more advanced yet less familiar DMS (I.13) and also that answers on requests issued during expert search are received later on either by email or

[189] Factors determining media choice and resulting task performance are conceptualized, e.g., by media richness theory (Daft & Lengel 1986) and media synchronicity theory (Dennis & Valacich 1999). According to these theories, the choice of a medium depends on the characteristics and the goals of the task as well as on specifics of the medium.

by phone based on the preferences of respondents (I.30). The following statement is an example of a dismissive stance towards the use of email:

> "I.02: Emails for me is always the last choice. That is just the way I am. There are people that rather like to send emails. As said, my opinion is, if today everyone receives emails, about 50-80 per day, than he may not be heard over the general noise with his single email."[190]

Productivity tool. The factor *system environment* refers to ICT and services available at specific locations and thus is an example of a combination of the dimensions productivity tool and location. Particularly those interviewees often being away on business pointed out that they may have no network access at all or only a limited set of services available, e.g., for individual training during their spare time in hotels (I.14) or for the distribution of contents in the context of co-authoring when working at the customer's site (I.14). They pointed out that they may have to depend on the software environment of a customer. This may lead to the circumstance that different Groupware platforms are used depending on the respective location, which amongst others influences the access to email and calendars during the knowledge action update (I.06, I.31).

Productivity tool-process. The only factor identified with regard to the relation between productivity tool and process is the *adequacy* of a tool for a specific task. In relation to expert search, it was noted to determine the selection of media used to contact experts. Phone or direct interaction were perceived to provide better means to describe a problem (I.07, I.19) than email that in turn is preferably used if documents need to be distributed additionally (I.17). The adequacy can be influenced by the degree of acceptance and maintenance of systems. One interviewee stated that it is actually easier to identify experts based on the Intranet than with a system specifically designed for competence-based search due to the better acceptance of the Intranet system (I.30).

Productivity tool-product. The factor *occurrence* refers to the place where contents are stored, i.e. the location within the storage structure or a system or whether in an internal or external system. Roles, organisational units, projects and processes may be used to determine the storage location or relevant systems. In the context of individual training and update for example, the topics determine the Web sites visited, e.g., support portals of software vendors

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[190] In German: "I.02: Email ist für mich immer die letzte Wahl. Da bin ich halt persönlich so gestrickt. Es gibt Leute, die schicken lieber eine Email raus. Aber wie gesagt, ich bin der Meinung, wenn jeder heute Emails kriegt, oder 50-80 pro Tag, dann geht man gerne unter im Rauschen mit seiner einen EMail."

are accessed in case of technical problems or the Web site of a customer is accessed for more information about his organisation (I.14, I.22, I.28, I.31). The relation between topics and storage location was also noted in the context of invitation and co-authoring (I.21, I.30). During acquisition it was noted that contents might only be forwarded if they are not already accessible on internal systems (I.25).

Discussion

No factor was identified that details the relationship between the dimensions process and product. Other parts of the category scheme are only sparsely populated, e.g., the dimension productivity tool, its relation to product and that between person and product. One explanation is that the number of factors only reflects the aspects judged to be relevant during interviews. Conversation partners were always asked to describe influences from their personal view and did not address general issues such as the use of different types of contents for different processes and tasks. Furthermore, questions were targeted at influences on steps and particularly on the selection of services, i.e. they were directed towards what influences the use of productivity tools and not what their influence is. This might be an explanation why only few factors related to productivity tools could be collected. The interviewees also often had to cope with those tools available and could not choose between multiple alternatives which would have introduced more factors related to productivity tools. In conclusion, the factors identified illustrate that knowledge actions and their technical support are influenced by the context of KWS and thus are relevant for the provision of knowledge services. This supports the choice of a situation-oriented approach for the provision of knowledge services.

7.5.2 Quantity structure

This section presents the quantity structure of the knowledge actions surveyed as part of the interviews (section 6.3.2). For each of the eight knowledge actions, the respondents were asked to estimate the average number of times per week they accomplish a specific knowledge action. If the discussion partners desired to use months or years as point of reference, then the ratings were translated to weeks later on during the analysis. Figure 60 visualizes the average values and also indicates their standard deviations.

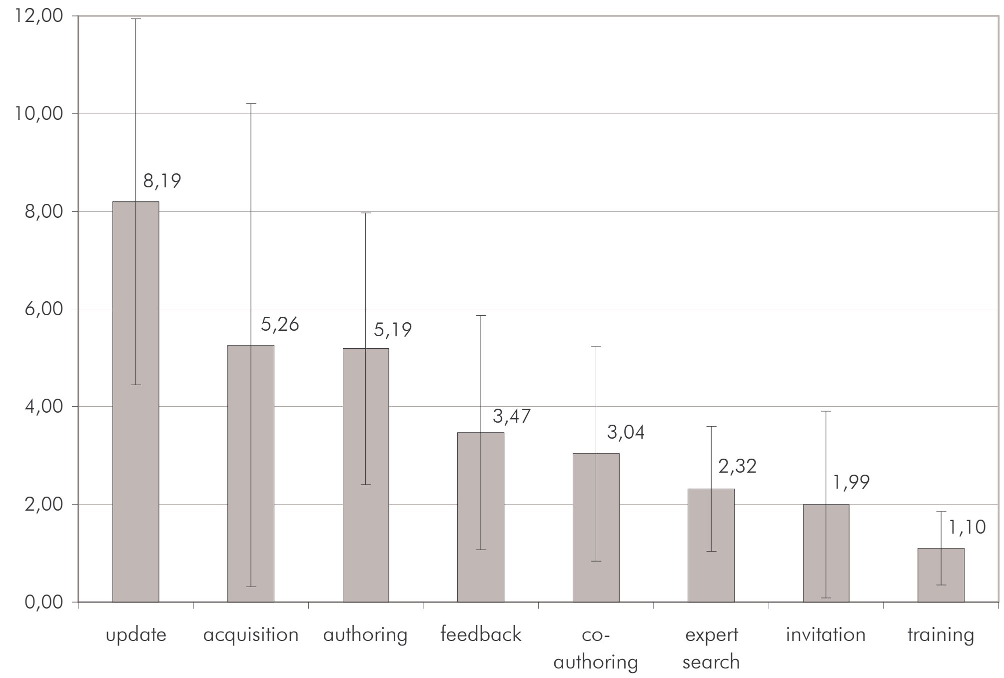

Figure 60. Average number of times the knowledge actions are conducted per week

On average, all knowledge actions are accomplished once per week or more. Update received the highest ratings. Many respondents even stated that they permanently keep up-to-date by checking their emails in parallel to their work tasks. Other knowledge actions that stand out in terms of the average values are acquisition, authoring, feedback and co-authoring. The results suggest that these actions may represent a good starting point for the support of knowledge work, e.g., by means of process services or flexible services (section 5.4.2), as their repeated conduct is an important argument for the justification of efforts invested into their technical support. Some ratings are characterized by high standard deviations. One possible reason for this is that knowledge actions were interpreted differently during the ratings which is also reflected by the distinct variants identified.

7.5.3 Characterization of work tasks

The interview guideline also included two sets of structured statements: one for the characterization of the interviewee's work activities from a KM-oriented view based on the distinction between codification and personalization and another set that focuses on selected characteristics of knowledge work related to work tasks, organisation, IT support and economics (section 6.3.2). All statements had to be rated based on a 7-point-Likert scale from one (no / strongly disagree) to seven (strongly agree). Figure 61 visualizes the mean values and standard deviations for the first set of statements ordered according to the average values. The statements are included within the diagram in a condensed form. They are reproduced at full length in appendix A.

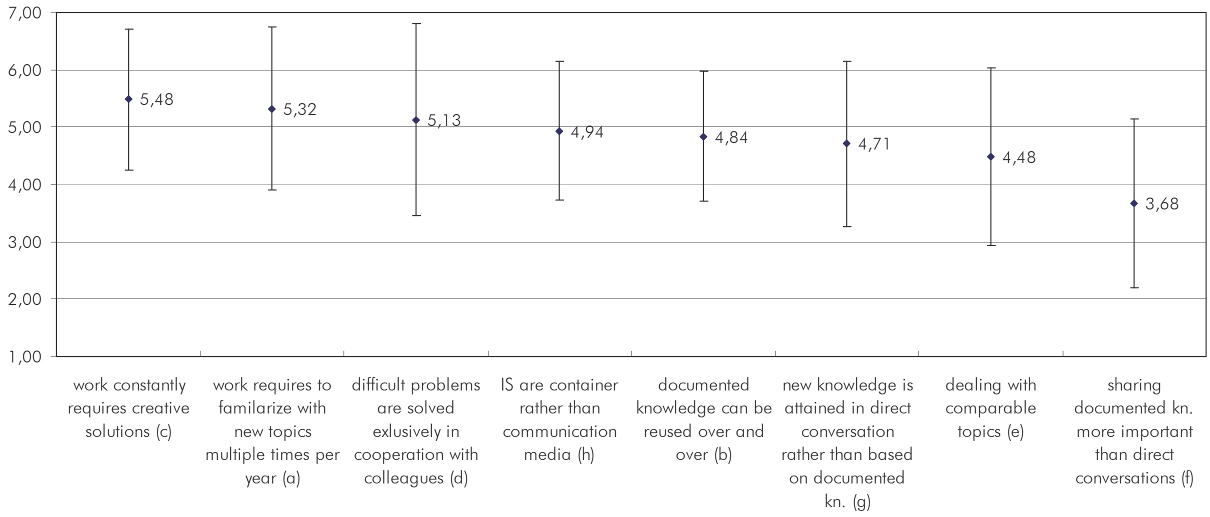

Figure 61. Characterization of work tasks based on codification vs. personalization

Statements c and a have the highest mean values (mean values 5.48 and 5.32, standard deviations 1.23 and 1.42). They address the constant need for creative solutions and the necessity to familiarize with new topics. In the following, it will be stated that the respondents agree with a statement if they rated it either with five, six or seven. Disagreement is identified in case the values one, two or three are assigned. Consequently, 87.1 percent of the respondents agree with statement c and 77.4 percent with statement a.

On the one hand, 61.3 percent of the interviewees agree that documented knowledge can be reused multiple times (statement b, mean value 4.84, standard deviation 1.13) and 58.1 percent support that they often deal with comparable topics which is a precondition for the effective reuse of documented knowledge (statement e, mean values 4.48, standard deviation 1.55). On the other hand, 74.2 percent of them highlight the relevance of direct communication for the resolution of difficult problems (statement d, mean value 5.13, standard deviation 1.67) and 58.1 percent agree that they use direct communication rather than documented knowledge for attaining new knowledge (statement g, mean 4.71, standard deviation 1.44). Sharing knowledge in direct communication is regarded to be more important than by means of documents, which is indicated by the fact that the majority of the respondents (54.8 percent) disagrees with statement f (mean value 3.68, standard deviation 1.47). Nevertheless, the fact that 32.3 percent of the interviewees supports this statement shows that documented as well as person-bound knowledge is relevant for their work. From an individual perspective, this is one of the main differences between the two generic KM foci on codification and personalisation. This is confirmed by the fact that in most cases both, communication-oriented knowledge services, e.g., email or competence-based search, and content-oriented services, e.g., storage and keyword-based search, are applied in the context of knowledge actions. Most interviewees (61.3 percent) agree that for them, IS are primarily a container for documented knowledge rather than being a communication media (statement h, mean value 4.94, standard deviation 1.21). One possible reason is that a codification strategy can be more easily supported with IS than a personalization strategy (Hansen, Nohria & Tierney 1999, 109). This is also reflected by an overall larger number of content-oriented services than of communication-oriented services.

Though all interviewees fully fall into the target group of the study, they are consigned with diverse work tasks, which might be a reason for the high standard deviations. Another explanation are individual preferences and work styles. A question that could be researched by future research is whether the interviewees cluster into two or more groups based on these statements and the knowledge actions accomplished, e.g., one with more communication-oriented tasks and one that more strongly relies on documented knowledge.

Figure 62 visualizes means and standard deviations for the second part of statements, again ranked according to the mean values.

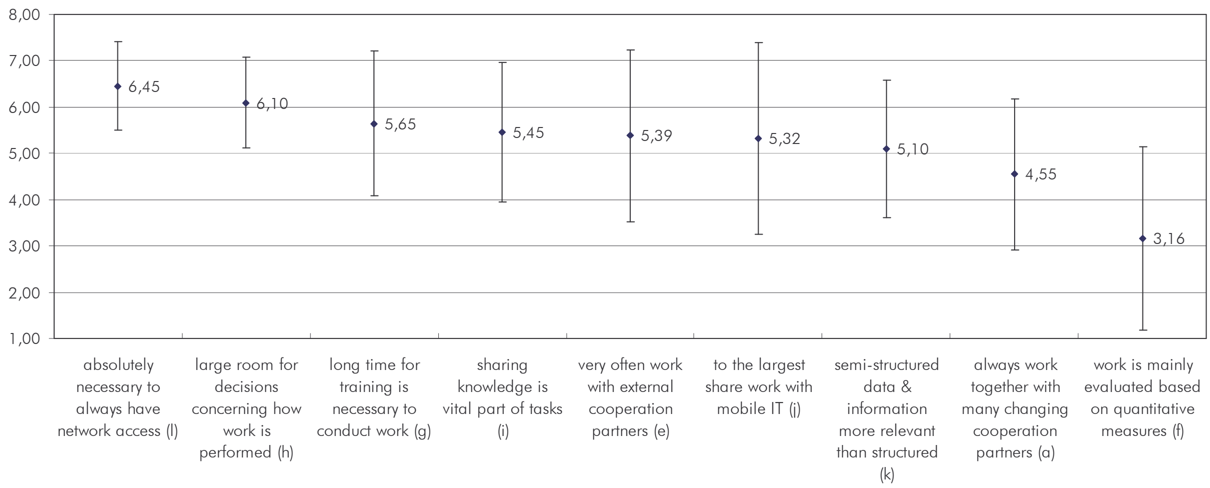

Figure 62. Characterization based on selected characteristics of knowledge work

The constant need for network access was agreed to by 96.8 percent (statement l, mean value 6.45, standard deviation 0.96). The statements ranked at the fourth, fifth and sixth position are concerned with the knowledge-oriented characterization of the interviewee's work tasks. Statement h which refers to a large room for decisions is agreed by 93.5 percent of the respondents, statement g related to a long time required for training by 83.9 percent and statement i stating that sharing knowledge is a vital part of the work tasks is agreed by 77.4 percent (mean values 6.10, 5.65 and 5.45, standard deviations 0.98, 1.56 and 1.50). The ratings approve a high freedom of the respondents for deciding how work is actually performed and indicate that learning and also the distribution of knowledge are important parts of their daily work tasks.

The next two statements in the ranking refer to the necessity to collaborate with external cooperation partners and the use of mobile IT (statements e and j). They are both agreed by 74.2 percent (mean values 5.39 and 5.32, standard deviations 1.86 and 2.07). The statement that semi-structured data and information is more relevant than structured data and information is also related to IT-support and similarly agreed by 74.2 percent of the respondents (statement k, mean value 4.55, standard deviation 1.49). Systems managing structured data overall were mentioned relatively seldom during the interviews. Though the statement about often changing cooperation partners is ranked second lowest based on its mean value, it is still agreed by 58.1 percent (statement a, mean value 4.55, standard deviation 1.63). Only 32.3 percent of the interviewees agree that they are evaluated based on quantitative measures (statement f, mean value 3.16, standard deviation 1.98).

The interviewees also were asked to determine the number of roles, of project teams and of the informal groups they possess or are a member of. Figure 63 gives an overview of the results. The bars are partitioned according to the number of roles, project teams and informal groups. The largest part of the interviewees (67.7 percent) has up to four roles. Most of the respondents belong to less or equal than four project teams (64.5 percent). Hence, 32.3 percent of them have more then four roles and 35.5 percent are part of more than four project teams. Informal groups receive comparably high ratings. The majority of the interviewees belongs to up to four informal groups (58.1 percent) and the remaining share to five or more. On average, the respondents have 4.02 roles (standard deviation 1.45), are part of 4.03 project teams (standard deviation 2.37) and of 4.5 informal networks (standard deviation 3.35).

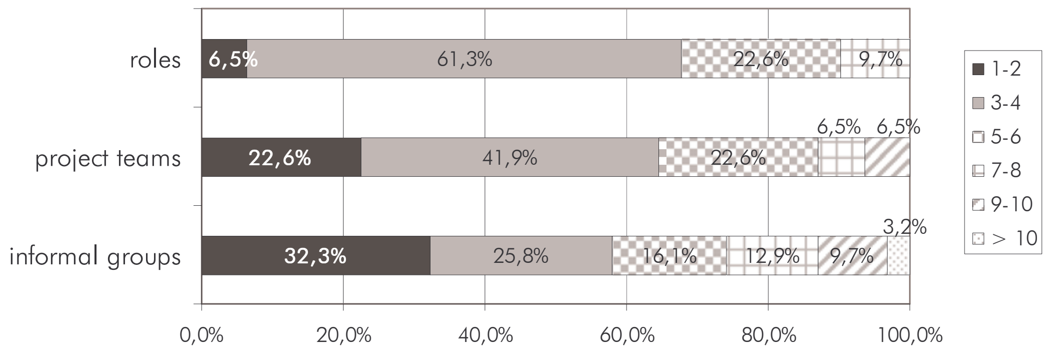

Figure 63. Number of roles, project teams and informal groups

7.6 Reflection on results

The following discussion reflects on selected aspects of the results on a more general level. It already turned out that some knowledge actions share similarities. The relations between knowledge actions in the following will be analysed in more detail (section 7.6.1). The state-of-the practice of technical support in the sample is discussed on a more general level based on the set of knowledge services identified (section 7.6.2). Furthermore, the organisations are compared with regard to the extent of technical support of knowledge actions (section 7.6.3). Finally, an overview of related research approaches is provided (section 7.6.4).

7.6.1 Comparison of knowledge actions

Similarities and differences between knowledge actions in the following are summarized and highlighted by comparing knowledge actions on the level of the groups of steps used above to structure the steps of knowledge actions. Figure 64 categorizes the knowledge actions surveyed according to the informing practices they are based upon and visualizes the groups of steps with the same symbols previously used in order to indicate the frequency of steps (Figure 50 on page 270). The following system was applied for this task: If one or more steps within a group are categorized as very frequently then the group is visualized with the respective symbol. If a group contains steps categorized as frequently and none as very frequently, then the symbol for frequently is used and so forth. As a result, focal points of knowledge actions are emphasized within the figure. Similar groups are placed on same horizontal positions in order to highlight similarities and differences between knowledge actions. The sequence of the groups otherwise remains unaltered. It should be kept in mind that though groups have the same name, they do not contain exactly the same steps.

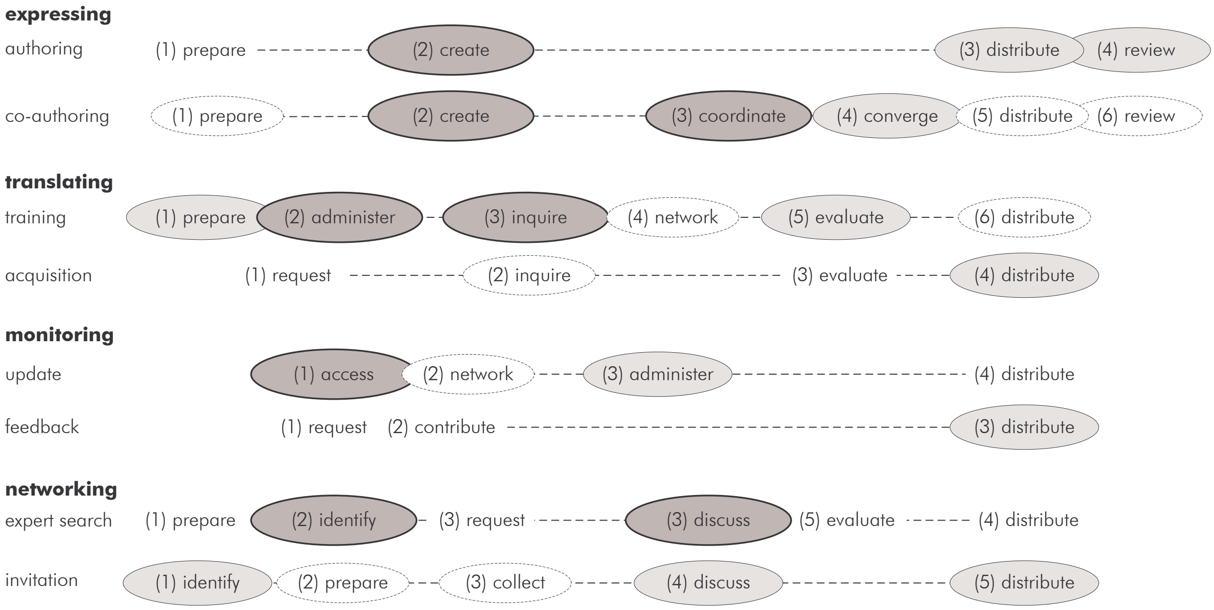

Figure 64. Knowledge actions compared on an aggregated level

It can be observed that all knowledge actions involve steps accomplished in order to share or distribute electronic contents. Except authoring and co-authoring, the group distribute always concludes the knowledge actions surveyed. It also can be perceived that some of the knowledge actions based on the same informing practice are relatively similar with respect to their general structure.

Authoring & co-authoring. Authoring and co-authoring are both based on the informing practice expressing. Their strong relationship already became apparent in section 7.4.2. Authoring principally can be regarded as a part of co-authoring. A main difference is that the acknowledgement and review of contents by its ultimate receivers is noted more frequently related to authoring. Co-authoring in contrast involves more steps that deal with the coordination of activities and the creation of joint results, which is reflected by steps within the groups coordinate and converge.

Training & acquisition. Whereas training is mainly concerned with the enhancement of individual skills, acquisition is targeted at the identification and acquisition of knowledge for other people. Both knowledge actions rely on the identification and application of documented knowledge as well as person-bound knowledge. Steps that distinguish training from acquisition partly are the result of a formalized approach to the learning process such as the specification of learning goals subsumed under the group prepare, administrative steps required for visiting courses as well as the evaluation of the learning success. Accounts about acquisition on the other hand also included the request for help by means of opening support tickets or by instructing information agents.

Expert search & invitation. Expert search and invitation are both based on the informing practice networking and were described by many interviewees in similar ways as involving the identification of, approaching of and discussion with other people including the distribution of contents such as meeting minutes. Invitation compared to expert search also includes more regular meetings targeted at knowledge sharing. Though the general procedure is the same, both actions differ with regard to target groups and the matters discussed.

Feedback & update. Similarities between feedback and update except the usual distribution steps were not identified. One reason for this is the fact that surveying the knowledge action feedback resulted in many different steps referred to with low frequencies (section 7.4.6).

Shared steps of knowledge actions

A more quantitative and open approach for the investigation of the relationships between knowledge actions is the analysis of the number of steps shared by two knowledge actions. Table 26 lists the number of steps identified once or more often in the context of the two actions for every pair of knowledge actions. For example, the pair training and update has three equal steps: `forward contents`, `investigate internal knowledge base` and `check selected external sites`. The table also includes a relative value that estimates the similarity of two actions. It is calculated as $r_{ij} = n_{ij} / min(o_i, o_j)$ where n_{ij} is the number of shared steps divided by the minimum of the two overall numbers o_i or o_j of steps per knowledge action i and j. For example, training with overall 24 steps and update with overall 13 steps share 3 steps and thus $r_{training,\ update} = 3 / 13$ results in 0.23. r_{ij} hence equals 0.5 if half of the steps of the smaller knowledge action are similar to those of the larger knowledge action and it is one if an action is part of another. The overall number of steps of each knowledge action is included in the main diagonal of the table.

	authoring		co-authoring		training		acquisition		update		feedback		expert search		invitation	
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.
authoring	21															
co-authoring	***18***	***0.82***	22													
training	6	0.29	5	0.23	24											
acquisition	8	0.38	7	0.32	***12***	***0.52***	23									
update	2	0.15	2	0.15	3	0.23	4	0.31	13							
feedback	5	0.38	5	0.38	5	0.38	5	0.38	3	0.23	13					
expert search	5	0.31	5	0.31	***8***	***0.50***	***12***	***0.75***	2	0.15	5	0.38	16			
invitation	5	0.33	6	0.40	5	0.33	7	0.47	2	0.15	4	0.31	***9***	***0.60***	15	

Table 26. Number of equal steps for every pair of knowledge actions

A pair of knowledge actions is regarded to overlap substantially if r_{ij} is equal or larger than 0.5. This is the case for five pairs that are indicated within the table by italic and bold type face. Three of them are the same pairs as discussed above: authoring and co-authoring, training and acquisition as well as expert search and invitation. The fourth and fifth pairs are expert search and acquisition as well as expert search and training. The differences and similarities can be analysed on a more detailed level based on Table 35 in appendix B.

Authoring & co-authoring. As already noted, authoring and co-authoring are very similar and mainly differ with regard to the steps that are concerned with the creation of a joint result, i.e. concerning steps such as `share contents with co-authors`, `coordinate co-authoring`, `consolidate final version` and `assign responsibilities` categorized under expressing, `stay aware about content changes` from the category update and `identify contact details` in the category networking. The steps `annotate contents` and `notify about contents` were only observed in relation to authoring and the step `archive contents` was noted in the context of co-authoring but not related to authoring.

Training & acquisition. Training and acquisition share many steps classified under the main category expressing such as `create or change contents`, `forward contents`, `store contents` and `structure repository`, steps classified under translating such as `check selected external sites`, `notify about contents`, `determine receivers`, `investigate internal knowledge base` and `order textbook`, as well as steps classified under networking such as `identify contact person`, `discuss topic` and `establish contact`.

A reason is the comparable need for the access to documented knowledge as well as for the identification of experts in the context of both knowledge actions.

Expert search & invitation. Expert search and invitation have many steps in common due to the same need to identify appropriate communication partners. Thus, they primarily share steps within the main category networking such as `identify contact person`, `discuss topic`, `identify contact details`, `make appointment` and `navigate through network` but also some from the category expressing such as `create or change contents`, `forward contents`, `store contents` and `select storage location` that as noted are mainly concerned with recording communication.

Expert search & acquisition. Expert search and acquisition share steps categorized under expressing such as `create or change contents`, `forward contents`, `store contents` and `select storage location` as well as under networking such as `identify contact person`, `discuss topic`, `identify contact details`, `establish contact`, `open support ticket` and `verify availability`. A reason for the similarity of the two actions is though acquisition is mainly oriented towards documented knowledge, it also includes the identification and contacting people. Vice versa, though expert search is mainly concerned with communication, it also comprises steps of the category expressing targeted at distribution of meeting minutes and of related information.

Expert search & training. Expert search and training share many steps conducted in order to distribute contents, i.e. `store contents`, `forward contents` and `create or change contents` as well as networking steps such as `maintain competence directory`, `establish contact`, `discuss topic` as well as `identify context person`. The similarities thus can be explained by the same need to circulate contents and particularly to identify appropriate communication partners.

As can be seen in Figure 65, 18 of the overall 28 pairs of knowledge actions (64 percent) share one to five steps. In most cases, these are `forward contents`, `store contents` and `create or change contents` categorized under expressing. This is consistent with the observance that these steps are very dominant and related to most of the knowledge actions. One explanation is that interviews were explicitly focused on the support by technical systems and that steps dealing with documented knowledge are supported comprehensively. This in turn may have two reasons: Firstly, they plainly may be very important steps for knowledge work. Secondly, IT support for them can be implemented easily and straightforwardly, which is backed by the facts that a popular starting point for many KM initiatives is to improve the handling of electronically documented knowledge (Maier 2004, 506, 509f) and that IT plays a larger role in the context of a KM strategy primarily oriented towards codification of knowledge (Hansen, Nohria & Tierney 1999, 108f). Nevertheless, person-oriented steps such as `identify contact person`, `discuss topic` and `identify contact details` are also typically shared by two knowledge actions. Hence, the two main orientations of personalisation and codification in general and the two media of knowledge product and person are reflected here. The results of the comparison and particularly the similarities identified represent an important foundation for the redefinition of knowledge actions in section 8.2.

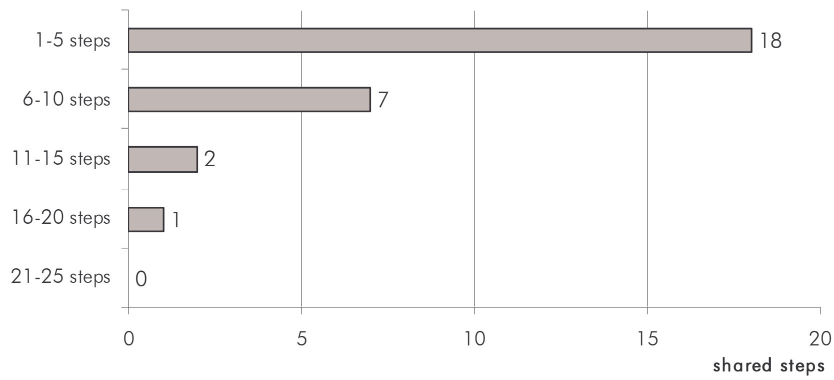

Figure 65. Number of shared steps of knowledge actions

7.6.2 Support by knowledge services

The analysis of technical support so far concentrated on single knowledge services (section 7.3) or their application in the context of knowledge actions (section 7.4). This section reflects on the overall set of knowledge services and its relation to the steps identified. Subsequently, the extent of integrated access to services is evaluated.

The set of knowledge services discussed does not represent a deductively derived framework that organises all functions outlined in section 5.5. This follows from the nature of the design of this research. Rather, it represents a generalized snapshot of the technical functionality accessed in relation to the knowledge actions surveyed based on the sample. Some services are identified substantially more often than others, particularly `storage`, `content creation&change`, `email` and `phone`. This has two reasons: Firstly, they are linked to steps identified very frequently. These target both, creation and distribution of electronic contents as well as communication between people. Secondly, these services are applied in order to accomplish many different steps. For example, `storage` is used for steps such as `archive` contents, use similar contents as starting point, select storage location, store contents, stay aware about content changes, use training materials and check reports. The service thus can be characterized as versatile. Email is another example of a versatile service on the one hand used intensively but on the other hand judged critically by many interviewees. The use of this service for tasks related to communication, distribution of contents and notification often leads to a large number of emails that users have to cope with. Hence, a high versatility of a service implies the danger that it might only be weakly adapted to the characteristics of a specific step and is overburdened with different tasks.

In fact, many of the services classified under collaboration are rather basic services that rather belong to the infrastructure level than being an advanced knowledge service, e.g., e-mail, calendar, discussion forum, distribution list, application sharing, video and text chat (section 5.4.2). One could even argue that these services represent universal services and that this category does not fit any more. Starting points for enhancements of technical support can be found in the specialization of services as well as their adoption based on context factors and steps identified. Examples are services that are based on information about the user's context and automatically deliver documents suited as a template, suggest storage locations or meta-data in order to file contents, inform users about new contents based on their interests, offer suited training materials based on skills or are specialized on the handling of selected types of contents such as lessons learnt.

When generally analysing the association between steps and services, the three types of relationships one-to-one, many-to-one and many-to-many can be identified:

One-to-one relationships. This type of relationship exists where a step is always supported by a service that in turn at all times is used in relation to this step. These are the pairs select and use standard template and template, annotate contents and annotation, request approval of training and course request, access WBT/CBT and training provision as well as verify availability and availability. Many of these services could principally also have been subsumed under storage, create and change contents and calendar services. Nevertheless, they always implement some specialized functionality needed during a knowledge action. One could argue that they represent anomalies of the category system in terms of an over-specialization of categories based on selected steps. However, all of them are identified with sufficient frequencies and comprise aspects of technical support repeatedly judged by the interviewees as worthwhile to be highlighted.

Many-to-one relationships. A many-to-one relationship can be observed where a step is supported by exactly one service that is also used in relation to other steps. Examples are the steps `archive contents`, `generalize contents`, `create personal draft`, and `create or change contents` all supported by the `content creation&change` service, `maintain access privileges` and `register at workspace` both supported by the `privileges` service and `evaluate training`, `request performance feedback` and `rate contents` supported by the `poll` service.

Many-to-many relationships. A many-to-many relationship can be identified where a step is supported by multiple services that in turn are used for several steps. For example, the step `store contents` involves the usage of `storage`, `versioning`, `transformation` and `learning authoring services`. For some steps, clear links to services do not exist, particularly `assure quality of contents`, `generalize contents`, `determine learning goals`, `evaluate agent results` and `filter information`. Reason is that these steps are more strongly based on individual skills but nevertheless involve the application of technical support.

In conclusion, it can be stated that the set of steps and the set of knowledge services are not congruent except some one-to-one relationships. The steps identified can be used as starting points for generating ideas for enhancements of support, particularly for context-oriented adaptation the services identified to be versatile. Knowledge actions are often based on services from all of the categories publication, discovery and collaboration. This clarifies the need for the integrated access to the systems that implement them. The integration on the level of the user interface will be discussed in the following as one aspect in this relation.

Degree of integration

Principally, the best way to assess the degree of integration of services would be a systematic and detailed analysis of each interviewee's IT environment. This is out of scope since this study concentrates on data collected by means of interviews. Nevertheless, the respondents all had an IT background and thus were able to give a more detailed description of the technologies they apply. The number of application interfaces used to access services thus could be extracted from the transcripts in order to judge service integration on an interface layer from a user perspective. The number of application interfaces also gives a rough impression of the number of different systems used as both of them strongly correlate.

Ideally, all services accessed during the course of a knowledge action are available over one consistent interface. In practice, it is necessary for the users to access multiple interfaces of different systems. The relation between application front-ends and services informs about how many services on average can be accessed over one application front-end and thus whether users need to frequently switch between multiple front-ends or not. It will be used here in order to judge the degree of integration. The quotient of services and front-ends should be larger than one because this means that multiple services are accessible with one front-end. If each of the services needs to be accessed by a dedicated front-end then the quotient is equal to one. It is also possible that the quotient is lower than one if services are implemented by multiple alternative systems and/or are accessed with different alternative front-ends.

To give an example, `contact directory` services applied to in order to look up information such as email addresses are often accessible over Web-based interfaces or are integrated within Groupware clients. In the last case, names of people entered into the address fields of an email are automatically extended to their full names and email addresses. Hence, the two services `contact directory` and `email` can be accessed over one interface. If someone has to separately access the contact directory to look up address information and then needs to manually transfer them to the Groupware client, two services offered by two separate application interfaces are applied. The former indicates a better integration or at least a more consistent access.

A number of rules needed to be defined in order to consistently record the number of application interfaces used. Interfaces were only counted if respective services were categorized during analysis. It was required that the conversation partner explicitly mentioned the use of a different interface or system. Support portals of software vendors or other specific systems accessible via Web browsers and offering various services were counted separately as one interface if users referred to them explicitly. Different Web sites and support portals were delimited based on URLs mentioned by the respondents. In case searching and browsing the Internet was mentioned, this was counted as one interface since `Web request` and `keyword-based search` services are both accessed with the Web browser. Office packages such as Microsoft Office were also counted because they implement `content creation&change` and annotation services. They were counted only once because in every case exactly one application such as the text processing software was referred to. If multiple different storage locations were mentioned they were counted separately. Though they can be mounted as network drives, they all incorporate different storage structures and users need to manually transfer data between them, e.g., by copying or moving files. Multiple alternative systems offering the same services are counted separately if they are used simultaneously. The following diagram structures the quotients of services and interfaces into three classes for each knowledge action (Figure 66). Detailed data is included in Table 37 (appendix D).

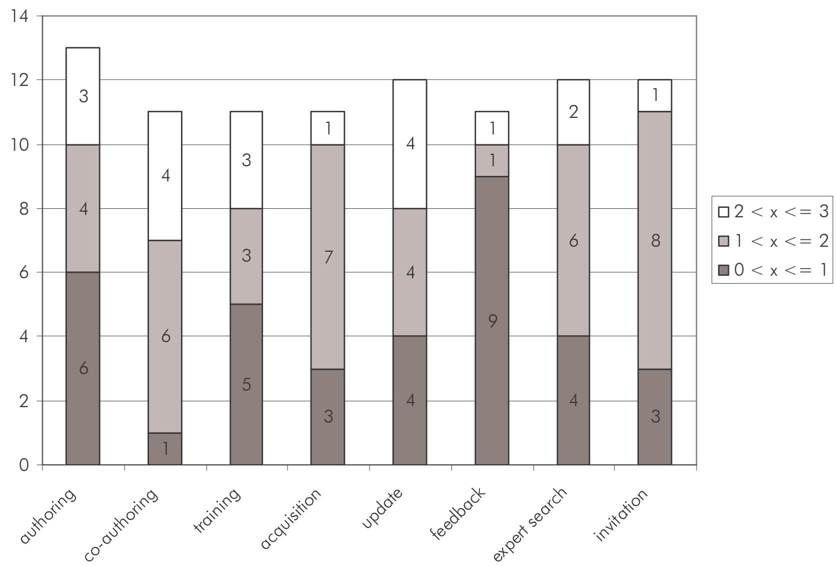

Figure 66. Relation between services and application front-ends

A quotient between one and two can be observed for 39 of the overall number of 93 knowledge actions surveyed (42 percent). However, this is followed closely by the number of 35 knowledge actions that involve access to one different or even to multiple alternative front-ends per service (38 percent). The case that on average between two and three services are integrated per interface was observed 19 times (20 percent), particularly in relation to authoring, co-authoring, training and update.

The results should be interpreted cautiously because two different phenomena are represented here: The integration of services on the one hand and on the other hand the access of one and the same service by means of multiple alternative and thus redundant interfaces. However, the latter case represents an exception in the sample data and was observed only very infrequently. For the interpretation of results it has to be taken into account that the two services storage and email identified in relation to a large share of knowledge actions are offered by types of systems that also implement other services, e.g., file servers besides `storage` services offer `storage structure` and `privileges` services and Groupware besides `email` is also used to access `task list` and `calendar` services. Thus, it originally was expected that the quotients would be noticeably larger than one for most knowledge actions. This is not the case here. Overall, this argues for a relatively low degree of integration.

Table 27 compares the minimum and maximum number of services and front-ends observed in the interviews. Since the integration is relatively low, it can be stated that users very often have to change front-ends, up to thirteen times in the case of co-authoring. In conclusion, a need for integration of services can be identified. This supports the suggestion to use service composition as made in section 5.4.2.

	authoring	**co-authoring**	**training**	**acquisition**	**update**	**feedback**	**expert search**	**invitation**
min/max services	2 / 10	4 / 13	2 / 11	1 / 7	2 / 7	1 / 6	4 / 10	1 / 8
min/max front-ends	2 / 10	3 / 6	2 / 11	1 / 6	2 / 8	1 / 5	2 / 5	1 / 5

Table 27. Minimum and maximum numbers of services and front-ends

7.6.3 Comparison on organisational level

A relevant question is whether the technical support differs between the organisations surveyed. For the comparison, the extent of support is rated for each knowledge action and aggregated to an overall rating. As always, the analysis is solely based on the perspective of the three to four interview partners per organisation. In some cases, the interviewees also presented systems to the interviewer in order to give an impression of the way of their usage. Maturity of IT support is rated pragmatically to be on an enhanced level if an organisation has specialized systems in place that offer services used in the context of knowledge actions. Specialized refers to a technical support that is better than the least technical support that was identified in all organisations, i.e. Groupware clients such as Microsoft Outlook and IBM Lotus Notes for services such as `email` and `calendar`, fileservers for `storage` services and office applications such as the Microsoft Office suite for the creation and change of contents.

Specifically, support was rated to be on an enhanced level when the following systems and services were identified: (1 & 2) DMS or CMS offering `versioning` and `checkout` services as well as `application sharing` services for *authoring* and *co-authoring*, (3) `training direc-`

`tories` and `access WBT/CBT` services for the provision of electronic training materials in order to support the action *training*, (4) `notification` services, internal `keyword-based search` services and also specialized workspaces for *acquisition*, (5) portals, electronic press reviews and notification services for *update*, (6) evaluation and annotation services for *feedback*, (7) skill management systems or communication directories extended by KM-oriented information that implement `competence-based search` services for *expert search*, as well as (8) community workspaces and teleconferencing facilities for *invitation*. Enhanced support is indicated by a '+' within Table 28 that orders the organisations according the maturity of technical support. The extent of technical support is rated to be high when more than four actions are supported on an enhanced level. This is the case in for five organisations. The remaining four organisations only have implemented standard support.

knowledge actions	**O.04**	**O.08**	**O.01**	**O.02**	**O.03**	**O.05**	**O.07**	**O.09**	**O.06**
authoring		+			+		+		+
co-authoring						+	+	+	+
training			+	+	+	+	+	+	+
acquisition					+	+	+	+	
update				+		+	+	+	+
feedback					+				+
expert search	+		+		+	+	+	+	+
invitation			+	+	+	+		+	+
sum	1	1	3	3	6	6	6	6	7
extent of support	low	low	low	low	high	high	high	high	high

Table 28. Rating of the technical support on organisational level

Organisations O.04 and O.08 receive the lowest ratings: O.04 only offers a contact directory slightly extended by topics that employees are responsible for. In O.08, a simple DMS solution is in use. O.08 at the time of the study was migrating to a new technology platform and plans enhanced support for collaboration and content management. O.01 and O.02 both offer enhanced support for three knowledge actions: O.01 offers an employee directory slightly extended by information about responsibilities for expert search, a training directory for internal courses and newsgroups as well as news on Intranet pages and email distribution lists that may support the action invitation. Employees in O.02 are able to access comprehensive electronic learning content by means of a portal provided by a large software vendor that is also a software partner of the organisation, an employee portal that provides access to news, email, calendars and operative systems as well as a video conferencing system.

O.03, O.05 and O.07 offer enhanced support for six knowledge actions. O.03 offers a dedicated knowledge base for publishing project results which is maintained by a separate KM unit, a directory for electronic trainings and internal courses, access to various business news agencies for acquisition of knowledge, evaluation mechanisms for the communication of feedback, a specialized skills database for expert search and Web-based community workspaces that enable knowledge sharing in communities and thus support the action invitation. O.05 has workspaces and application sharing functions installed for co-authoring, offers a training directory and Intranet discussion forums for acquisition, provides customizable news channels on the Intranet for update, supports making support calls in the context of expert search and provides team workspaces for invitation. O.07 uses an advanced DMS as a technical platform that offers services for authoring and co-authoring such as versioning, logging, automatic classification and directory templates. Various types of electronic training units can be accessed for learning, acquired contents may be gathered in dedicated workspaces, customizable email notifications inform about changes within the platform and thus support the action update and search services can be used in order to identify experts based on the authorship of documents.

O.06 was identified to offer enhanced support for seven of the eight knowledge actions surveyed. Authoring and co-authoring are supported by a DMS. Training is supported by a training directory and also by access to a multitude of electronic learning contents offered by a large software vendor who offers products that O.06 introduces at customers. Update is supported by Intranet news and by email notifications about changes within the DMS, feedback by macros for transforming text processing files into other formats such as spreadsheets as a foundation for a structured review process, expert search by an Intranet page where subject matter experts of a KM unit are listed that are responsible for topics relevant for multiple projects of the organisation such as programming languages and database technologies and invitation by electronic conferencing systems. In conclusion, the field of the surveyed organisations splits almost equally into organisations having installed rather basic technologies and those where most actions are supported in an enhanced way.

However, the knowledge actions investigated are not directly influenced by this distinction. This can be illustrated based on a comparison of the number of different steps observed in each organisation. Table 29 focuses on the differences and similarities concerning the number of steps that were observed in each type of organisation. The column “basic support” for every knowledge action lists the number of steps that were only observed in interviews with respondents affiliated with the organisations O.01, O.02, O.04 and O.08. The column "enhanced support" lists the number of steps that were only identified in the organisations O.03, O.05, O.06 and O.09. The column "equal steps" contains the number of steps that were observed in both types of organisations. As can be seen, the largest share of steps of every knowledge action was observed likewise in both types of organisations. The only exception is the knowledge action feedback (section 7.4.6). Otherwise, the picture is unbalanced: In three cases more additional steps were identified in organisations having basic support installed, in two cases more steps were observed only in organisations offering enhanced support and in three cases an equal number of steps characteristic for each type of organisation was counted.

	basic support	equal steps	enhanced support	sum
authoring	2	13	6	21
co-authoring	4	14	4	22
training	3	15	6	24
acquisition	9	12	2	23
update	3	7	3	13
feedback	6	1	6	13
expert search	4	11	1	16
invitation	4	8	3	15

Table 29. Knowledge actions in organisations with basic and enhanced support

7.6.4 Related empirical studies

This section gives an overview of related empirical studies as a wrap-up of the discussion of the results. Those contributions were included that explicitly deal with the identification and characterization of selected activities of knowledge work. They can be distinguished into two groups: Approaches subsumed under the topic KM research start out from explicitly considering a KM perspective. Others contribute to the specification of the practices of knowledge-oriented work without referring to a systematic KM.

KM research

The first group of approaches investigates phenomena relevant for this work from the perspective of an explicit and goal-oriented KM and frequently refers to the concept of knowledge processes (section 2.6). Davenport et al. (1996) were amongst the first who called for a systematic process-oriented approach to KM. Their study investigates projects that target at an enhancement of specific *knowledge work processes*. Concerning data collection, they distinguish between projects that rely on interviews in order to investigate knowledge processes and those that apply softer methods of analysis such as ethnographic studies. The former include the documentation of redesigned processes and education sessions that have the goal to persuade knowledge workers to adapt the new design (Davenport, Jarvenpaa & Beers 1996, 60). They maintain a critical position towards such a "heavy-handed approach" as it runs against the autonomous culture knowledge work. Ethnographic studies in contrast are based on an intervention technique that involves the analyst's participation in the actual processes and the collection of very detailed data over a long time period such as several months. The authors in this context note the advantage that the subjects of the study are not insulted "… by the assumption that all their work can be learned in a brief interview" (Davenport, Jarvenpaa & Beers 1996, 61). However, they also point out the disadvantage that the findings of ethnographic studies cannot be straightforwardly generalized to other settings.

Holsapple & Joshi (2002) investigate so-called *KM episodes* that represent knowledge manipulation activities triggered by a knowledge need and based on the application and manipulation of available resources. Their goal is the creation of a general framework that should help researchers and practitioners to structure their procedure and define their focus. The Delphi method was applied in order to achieve this. KM practitioners and academicians within two rounds were asked to comment on a framework of manipulation activities such as `acquisition`, `selection`, `use` and `internalisation of knowledge`, which subsequently was revised and redistributed. The result structures the interdependencies between these activities and thus the flow of actions conducted during a specific KM episode. As a critique the same arguments as discussed in relation to the generic knowledge processes can be put forward (section 2.6): Such a general framework is only of limited help if one is concerned with the design of organisational or technological interventions. It is also questionable whether the interdependencies between the knowledge manipulation activities as suggested are generally valid. Furthermore, it should be noted that the authors prefer the opinion of experts over the empirical investigation of the actual activities of, e.g., a selected group of knowledge workers.

Hoffmann et al. (2003) propose the analysis of computer log files as an approach for the identification of so-called *hidden knowledge processes*. It is complemented by the analysis of documents stored within workspaces and focused interviews. Based on this, they identify a knowledge process that structures the writing activities of students participating in a university seminar. It describes a co-authoring process (section 3.4.4) where students are inspired by the structure of seminar works of their fellow students, which directly affects the contents they publish within an electronic workspace. This approach prefers a fine-grained analysis primarily of activities that are supported technically. However, more knowledge processes are not identified as the authors primarily are concerned with the illustration of the methodology they propose.

The *PROMET I-NET method* (Kaiser et al. 1999) and the *BKM framework* (Bach 1999) based on an business engineering perspective (Österle 2000) highlight the role of processes that are concerned with the creation, distribution and maintenance of information and knowledge objects (section 4.5.6). Several authors apply these frameworks in order to structure their case studies (Blessing 2001; Christ 2001). They also motivated later contributions, e.g., the one of Riempp who emphasizes the role of processes in relation to EKI (Riempp 2004). Examples for processes described are `creation`, `publication`, `integration`, `maintenance`, `distribution`, `archiving` and `deletion of contents` (Blessing 2001, 39ff; Christ 2001, 91ff), `knowledge distribution with content management` and `publication of skill profiles` (Bach 1999, 76f, 72) as well as `revision and release of contents`, `creation and release of competence profiles`, `initiation of formal communities` and `terminology maintenance` (Riempp 2004, 148ff). These processes are depicted as diagrams that indicate the most important steps and roles responsible. They are identified empirically based on one or multiple case studies. However, the exact methodology of data collection and analysis is not described in detail, e.g., the way how interviews or workshops were conducted and how results were abstracted from single cases. Thus, the findings can be criticised for a low degree of rigidity.

Remus (2002b, 257ff) illustrates the *application of modelling techniques* by PKM initiatives based on the four scenarios enhancement of process transparency, knowledge process redesign, introduction of KM and design of EKI. As suggested in the context of PKM, he uses process modelling methods not only for the description of business processes but also for the specification of knowledge processes. Related to the case of the introduction of PKM in a large transaction bank for example, the knowledge processes `knowledge enhancement and revision`, `knowledge documentation`, `knowledge distribution` and `knowledge use` are identified (Remus 2002b, 275ff; Remus & Schub 2003, 241ff). They are detailed based on extended ARIS-KM diagrams that indicate relevant application systems, their services, inputs and outputs as well as relevant knowledge. These case studies are well-suited to illustrate the application of modelling methods within different scenarios. However, the presentation focuses on methodological issues and does not lead to generalizable findings concerning typical knowledge actions or typical services.

Other research on knowledge actions

The second group of approaches does not explicitly deal with KM but considers the description and structure of knowledge actions. The four *informing practices* proposed by Schultze (2000; 2003) represent an important foundation for this work. The three informing practices `expressing`, `monitoring` and `translating` were identified based on a eight-month ethnographic study in a U.S. Fortune 500 company that focused on three selected groups of workers that were promoting and implementing a knowledge management system: system administrators, librarians and competitive intelligence analysts. The practices are the result of a rigor research approach and thus have a strong empirical foundation. Nevertheless, they need to be detailed with regard to the concrete activities that individuals undertake in order to decide on the selection of appropriate of knowledge services.

The *practice of networking* was proposed by Knights et al. (1993) as a form of knowledge work and was investigated based on a case study about the establishment and building of a strategic network designed to support electronic trading between insurance companies. The authors refer to a process of building networks characterized by four translation phases that are an important part of actor-network theory (Callon 1986): `problematization`, i.e. engaging one or more agencies in defining and exploring a problem, `interessement`, i.e. persuading others to accept the definition developed, `enrolment`, i.e. developing arrangements for tying agencies into the means of producing solutions, and `mobilisation`, i.e. applying different methods in order to sustain commitment to the organisation. However, these phases also are too general for the definition of concrete steps undertaken by individuals and thus the actions expert search and invitation have been proposed and empirically explored.

Ellis (1993, 482; 1997, 395ff) identified and characterized a set of *information seeking patterns* of different work groups such as engineers in an industrial setting and research scientists based on semi-structured interviews and a Grounded Theory methodology. The patterns identified are `starting` (or surveying), i.e. employing means characteristic for an initial search for information which heavily relies on informal contacts and computerized searches, `chaining`, i.e. following chains of different forms of referential connection such as footnotes and citations in order to identify new sources of information, `monitoring`, i.e. maintaining awareness of developments and technologies in a field through regularly following particular sources, `browsing`, i.e. semi-directed or semi-structured and often casual searching such as the scanning of tables of contents, `distinguishing`, i.e. ranking the relative importance of information resources based on own perceptions, `filtering` (or differentiating), i.e. using certain criteria or mechanisms such as fixed periods of time or keywords in order to make information as relevant and precise as possible, `extracting`, i.e. working through sources to locate material of interest, `verifying`, i.e. checking the accuracy of information, and `ending`, i.e. tying loose ends through a final search. They were identified based on a rigor empirical approach and also have been used in order to characterize the knowledge actions acquisition and monitoring (section 3.4.4).

Kulthau (1991) investigated the *user's perspective of information seeking* within a series of five empirical studies: a qualitative part consisting of a case study and two longitudinal studies based on interviews and a quantitative part comprising two large-scale field studies. She focused on tasks accomplished for information seeking and also on affective aspects such as feelings of uncertainty or confidence. Kulthau generated a model of the search process characterized by the stages `initiation`, i.e. a person becomes aware of a lack of knowledge or understanding, `selection`, i.e. the task to identify the general topic to be investigated or the approach to be pursued, `exploration`, i.e. the investigation of information in order to extend personal understanding, `formulation`, i.e. forming a focus from the information encountered, `collection`, i.e. the gathering of information on the general topic, and `presentation`, i.e. the completion of the search and preparation of the findings for their further use, e.g., for a presentation. As in the case of Ellis, the findings are the result of a rigor and well-founded research design. The results of Ellis and Kulthau have been used as far as possible in order to specify the knowledge actions acquisition and monitoring (section 3.4.4). The focus was on those activities that potentially could be supported with ICT and fitted with the definition of the underlying informing practices.

Table 30 gives on overview of the research approaches outlined. It becomes clear that knowledge actions can be studied based on various research methods. The contributions having an explicit KM perspective unfortunately offer no substantial foundations for this work as they either do not have a strong empirical foundation and/or predominantly focus on methodological aspects. This motivates the definition and empirical exploration of a KM-oriented concept such as the one discussed in this work.

authors	research goals	primary methodology
KM research		
Davenport et al. (1996)	analysis of projects targeted at the improvement of knowledge work processes	case study
Holsapple & Joshi (2002)	creation of a framework that structures knowledge manipulation activities	Delphi study
Hoffmann et al. (2003)	demonstration of the identification of knowledge processes	observation
Bach (1999), Blessing (2001), Christ (2001), Riempp (2004)	identification and description of content / information / knowledge processes	case study
Remus (2002b)	illustration of modelling in PKM in different scenarios	case study
Research on knowledge actions		
Schultze (2000)	identification and characterization of informing practices	ethnographic study
Knights et al. (1993)	examination of the process of establishing and building an inter-organisational network	case study
Ellis (1993; 1997)	identification and characterization of information-seeking patterns	semi-structured interviews, Grounded Theory
Kulthau (1991)	investigation of the user's perspective in information seeking	case study, interview, large-scale quantitative field study

Table 30. Overview of related work

7.7 Summary

Main goal of this empirical study was the exploration of the concept of KWS. This chapter presented the results of the analysis of 31 interviews with IT consultants in nine large organisations with the main focus on eight selected knowledge actions. Occasions and context as the other parts of KWS were also taken into account. The knowledge actions have been structured into 69 steps and classified into to the main categories expressing, translating, monitoring and networking. 35 knowledge services have been determined to be used in their context that have been categorized into the four types of knowledge services publication, discovery, collaboration and learning. The main categories turned out to be useful for the presentation of the results. However, they have been determined in advance without knowledge about the steps and services that would be identified. Hence, the question should be posed what an alternative and more suitable classification of steps and services could be that could inform the redefinition of the KWS concept. The groups of steps formed in section 7.4 and applied for the comparison of knowledge actions in section 7.6.1 seem as a fruitful foundation to answer this question which will be taken up in the context of the following chapter (section 8.2). Furthermore, the results will be used in order to revise the set of knowledge actions proposed.

Each step and knowledge service has been inductively derived by means of a qualitative content analysis of interview transcripts. They represent candidates for the formulation of hypotheses. All of the eight knowledge actions have been investigated in practice and have been detailed with regard to their variants, examples for occasions, involved steps and the knowledge services used for their support. The proposition that all knowledge actions are relevant in practice cannot be maintained for the knowledge action feedback which rather seems to be a part of other knowledge actions.

The remaining seven knowledge actions can be used in order to detail the two main propositions described in section 6.2 by means of two sets of hypotheses: one concerning the steps accomplished in the context of knowledge actions based on proposition 1 and one about their support by knowledge services based on proposition 2. Table 31 summarizes the twelve hypotheses of the first set. It contains one hypothesis for each variant of the knowledge actions. It was decided to only include those steps within a hypothesis that at least fall into the category "less frequently" (Table 17 on page 269). Hence, a step is regarded as "typical" for a knowledge action if it was observed at least four times in relation to a specific knowledge action. This represents a conservative approach in the sense that it ensures that enough data is available for the characterisation of each step included and that the hypotheses do not tend to be easily rejected. However, it principally would also be possible to include all steps as the frequency of the steps does not indicate their general relevance. The steps are ordered according to their appearance within the figures that were used in section 7.4 to visualize the knowledge actions.

Table 32 shows seven further hypotheses that based on the empirical findings relate knowledge services to the knowledge actions surveyed. The empirical data does not allow breaking them down to the level of variants of knowledge actions. Services identified only infrequently, i.e. equal or less than three times, were excluded with the same reason as above. The services are grouped according to the categories publication, discovery, collaboration and learning and within these categories based on the frequency with that they were identified in relation to an action.

knowledge action	no.	hypothesis (steps)
authoring	1	The knowledge action *ad-hoc authoring* typically consists of the steps select&use standard template, use similar content as starting point, create or change contents, assign or maintain meta-data, select storage location, structure repository, forward contents and store contents.
	2	The knowledge action *formal authoring* typically consists of the steps select&use standard template, use similar content as starting point, create or change contents, assign or maintain meta-data, select storage location, structure repository, forward contents, store contents, request feedback about contents and request approval of contents.
co-authoring	3	The knowledge action *co-authoring* typically consists of the steps assign responsibilities, use similar content as starting point, select&use standard template, create or change contents, stay aware about content changes, share contents with co-authors, coordinate co-authoring, structure repository, consolidate final version, request feedback about contents, forward contents and request approval of contents.
training	4	The knowledge action *individual learning* typically consists of the steps use CBT/WBT, identify training, use training materials, order textbook, check selected external sites, evaluate training and store contents.
	5	The knowledge action *formal training* typically consists of the steps determine learning goals, request approval of training, book course, organise journey, use CBT/WBT, identify training, use training materials, order textbook, check selected external sites, establish contact, take examination, evaluate training and store contents.
acquisition	6	The knowledge action *instruction of colleagues* typically consists of the steps identify information agent, instruct information agent and evaluate agent results.
	7	The knowledge action *individual acquisition* typically consists of the steps conduct Internet inquiry, determine receivers, notify about contents, forward contents and store contents.
update	8	The knowledge action *comprehensive update* typically consists of the steps check email, access internal news, check selected external sites, check reports, participate in Jour Fixe, maintain task list and maintain appointments.
expert search	9	The knowledge action *submit support call* is represented by the step open support ticket.
	10	The knowledge action *person search* typically consists of the steps identify contact person, navigate through network, identify contact details, make appointment, verify availability and discuss topic.
invitation	11	The knowledge action *individual invitation* typically consists of the steps identify contact person, identify contact details, make appointment, discuss topic, forward contents and store contents.
	12	The knowledge action *invitation into a group* typically consists of the steps identify contact person, identify contact details, advertise meeting, acquire meeting resources, collect meeting registrations, make appointment, forward contents and store contents.

Table 31. Hypotheses about the steps of the knowledge actions researched

knowledge action	no.	hypothesis (services)
authoring	13	The knowledge action *authoring* typically is supported by the publication services `storage, content creation&change, template, storage structure` and `versioning` and the collaboration services `email` and `phone`.
co-authoring	14	The knowledge action *co-authoring* typically is supported by the publication services `content creation&change, storage, versioning, template, annotation, check-out` and `storage structure`, the discovery service `notification agent` and the collaboration services `email` and `calendar`.
training	15	The knowledge action *training* typically is supported by the publication service `storage`, the discovery services `Web request` and `full-text search`, the collaboration services `email, calendar, poll, application sharing` and `phone` and the learning services `training directory, training provision` and `course request`.
acquisition	16	The knowledge action *acquisition* typically is supported by the publication service `storage`, the discovery services `Web request, full-text search` and `contact directory` and the collaboration services `email, phone` and `discussion forum`.
update	17	The knowledge action *update* typically is supported by the publication service `storage`, the discovery services `Web request` and `notification agent` and the collaboration services `email, calendar, news channel, task list` and `phone`.
expert search	18	The knowledge action *expert search* typically is supported by the discovery services `Web request, contact directory, competence-based search, full-text search` and `knowledge map` and the collaboration services `email, phone, calendar` and `support ticket`.
invitation	19	The knowledge action *invitation* typically is supported by the publication services `storage, content creation&change` and `privileges`, the discovery service `contact directory` and the collaboration services `email, calendar, phone, distribution list` and `news channel`.

Table 32. Hypotheses about the services that support the knowledge actions researched

It is not intended to refine the two additional propositions concerned with occasions and context factors to hypotheses. However, it can be stated that a large number of occasions was identified that could be used to illustrate the concept. They represent mainly task-oriented occasions as intended by the study and focused by the examples within the interview guideline. Though the different occasions partly are strongly related to specific variants, it can be assumed that an occasion does not inevitably result in a specific type of knowledge action. Also, overall 33 examples for context factors have been identified and used in order to refine the KWS context framework. Many elements of this framework could be illustrated with empirically grounded examples.

Besides the discussion of knowledge actions, additional structured data was gathered and analysed. A quantity structure has been created that shows that knowledge actions represent relevant aspects of knowledge work insofar that they are accomplished on average once or more times per week. Update, authoring and acquisition have been suggested as good starting points for technical support as they were noted to be accomplished most often. The characterization of work tasks based on structured statements led to the result that both, person-oriented knowledge and documented knowledge are relevant for the interview partners and that the characteristics of knowledge-intensive work are generally fulfilled.

Furthermore, similarities have been identified conceptually based on a comparison of the general categories of steps created during analysis and quantitatively based on the number of shared steps. Knowledge actions based on the same informing practice were found to be similar but also those not belonging to one and the same category such as expert search and acquisition as well as expert search and training. This represents an important foundation for the revision of the KWS concept (section 8.2).

Concerning technical support of knowledge actions, the services `storage` and `content creation&change` as well as `email` and `phone` have been identified to occur more frequently compared to other services. Possible explanations have been provided. It also turned out that some services are strongly tied to selected steps and thus share a one-to-one relationship whereas others have one-to-many or many-to-many relationships. It has been suggested that versatile steps should be adapted based on information about the user's context. Specifically collaboration services such as email have been found to represent rather basic infrastructure services than advanced knowledge services.

Based on recording the number of application interfaces used for accessing services it has been determined that integration on presentation level from a user perspective is relatively low. A comparison on organisational level revealed that five organisations have been rated to offer enhanced support and the remaining four to only provide a basic IT infrastructure. However, this distinction does not directly influence the steps of knowledge actions accomplished. The discussion also included an overview of related work which clarified that knowledge actions in the context of KM yet are not sufficiently empirically explored but only by approaches that do not explicitly refer to a systematic KM.

In conclusion, the qualitative data collected and the way of analysis chosen turned out as a fruitful foundation for an empirical exploration of KWS. Results are not only the hypotheses defined, but also a rich picture consisting of occasions triggering KWS, steps of knowledge actions following from them, services used to support these actions and context factors influencing both of them. Among the other results of this work, this provides a foundation for the redefinition of KWS in the next chapter.

8 Revision

Since the definition of the KWS concept in section 3.4, further foundations have been provided and results have been achieved. This not only concerns the modelling of knowledge work (chapter 4) and its support by EKI (chapter 5) but particularly the empirical exploration of the concept (chapters 6 and 7). Consequently, the KWS concept is critically reflected upon and revised based on the insights gained.

8.1 Overview

Figure 67 provides an overview of this chapter. The following section redefines the KWS concept based on results of previous chapters (section 8.2). The revision and enhancement does not only concern the level of concepts but rather all of the levels focused by this work. Hence, the modelling of KWS will be discussed afterwards (section 8.3), which is followed by the discussion of how KWS can be supported based on EKI (section 8.4).

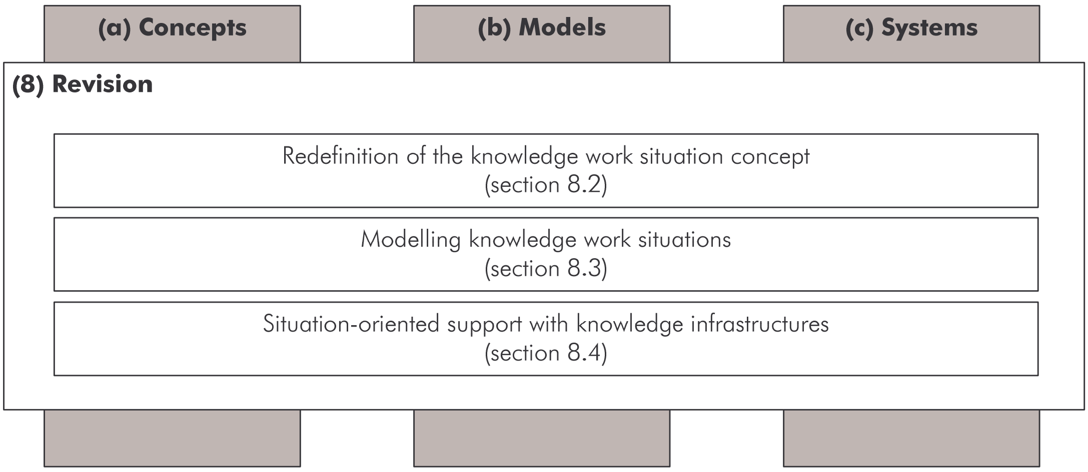

Figure 67. Overview of the chapter *Revision*

8.2 Redefinition of the knowledge work situation concept

The redefinition of the KWS concept particularly concerns the knowledge actions investigated during the empirical study. Thus, firstly the set knowledge of knowledge actions proposed is revised and their mode is reconceptualized. Afterwards, occasions and the KWS context as the remaining components of KWS are addressed within this section.

Knowledge actions

The four informing practices expressing, translating, monitoring and networking turned out to represent appropriate starting points for the conceptualisation and investigation of knowledge actions. In contrast to the frequently cited sets of KM activities reviewed in section 2.6, they have a strong empirical foundation. The KM activities vary depending on the level of granularity focused, aspects perceived to be relevant and conceptions of knowledge preferred. Though they are proposed for the classification of steps of knowledge processes (Remus 2002b, 121), which also is applied by modelling approaches such as GPO-WM (section 4.5.2), they are only of limited help due to their high level of abstraction. Furthermore, in some cases it is relied on the process metaphor that implies a sequential ordering of activities and contradicts the characteristics of knowledge work. Without any empirical grounding, it can be expected that no consensus about relevant individual and also organisational KM activities will be reached.

Consequently, more meaningful and concrete descriptions are required for the support of individual knowledge work. The proposition and empirical investigation of the eight knowledge actions authoring, co-authoring, training, acquisition, update, feedback, expert search and invitation (section 3.4.4) targeted making a contribution to the resolution of this challenge. Their empirical exploration resulted a number of variants. These results can be used in order to revise the set of knowledge actions proposed. For this task, Figure 68 visualises the relationships between the initial knowledge actions and the variants identified. The former are indicated by dashed circles that overlap if the corresponding actions share a substantial number of steps, i.e. if r_{ij} in section 7.6.1 was computed as 0.5 or larger.

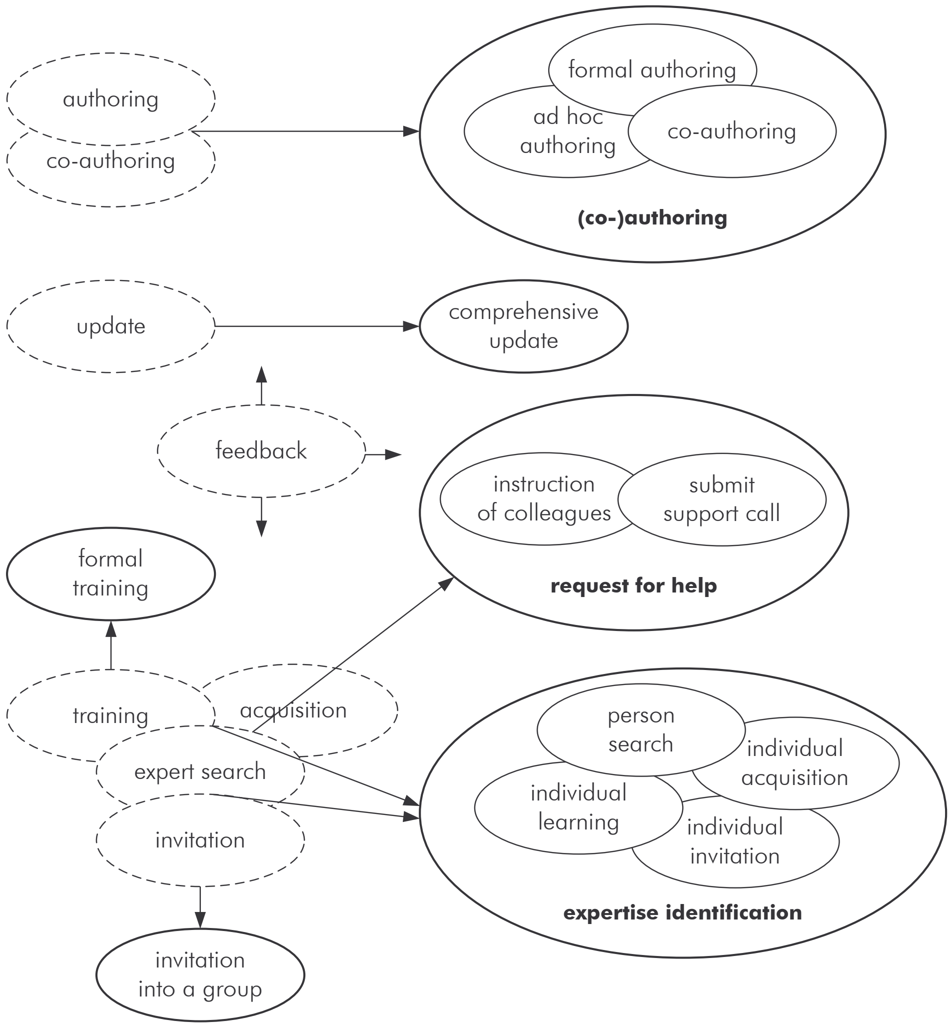

Figure 68. Relationship of proposed and revised knowledge actions

Some of the proposed knowledge actions are directly reflected by a variant identified, i.e. update by comprehensive update, training by formal training as well as invitation by invitation into a group. Hence, these three variants can be included within the set of revised knowledge actions. Authoring and co-authoring led to the variants ad hoc authoring, formal authoring and co-authoring which are subsumed under the revised knowledge action (co-)authoring. The reason is that these variants share a large number of steps and cannot be cleanly separated from each other (section 7.6.1).

The two pairs of knowledge actions expert search and acquisition as well as expert search and invitation also share many similar steps. They led to the identification of four similar variants, i.e. person search, individual invitation, individual acquisition and individual learning. These either target the direct knowledge sharing with people, the localization of documented knowledge or both. Thus, they are subsumed under the revised knowledge action expertise identification. Furthermore, the investigation of the two knowledge actions expert search and acquisition resulted in the identification of the variants submit support call and instruction of colleagues. These are subsumed under the revised knowledge action request for help. Both of them target the obtainment of support in order to resolve a problem but unlike the revised knowledge action expertise identification, the way in which assistance is actually provided is not relevant, e.g., who answers the request.

The knowledge action feedback is not included separately any more but as a part of other knowledge actions. Based on the empirical findings, it is subsumed under the revised knowledge actions (co-)authoring for the revision and enhancement of documented knowledge, request for help that includes the evaluation of assistance received and formal training that includes the evaluation of the individual learning success or of learning resources. Consequently, the revised set of knowledge actions consists of the following six elements: (co-)authoring, comprehensive update, expertise identification, formal training, invitation into a group and request for help.

Mode of knowledge actions

The *mode* was conceptualized above as a general orientation of a knowledge action and was classified based on the four informing practices (section 3.4.1). However, it can be observed that single knowledge actions involve steps related to multiple informing practices. Consequently, the mode of knowledge actions needs to be revised. It is re-conceptualized to classify single steps of the overall knowledge actions.

The mode can be detailed with the help of the groups used to structure and compare knowledge actions (sections 7.4 and 7.6.1). Table 33 lists these groups and indicates their association to the revised set of knowledge actions. Some of these groups are similar to the generic KM activities summarized in section 2.6. In contrast to them, they have a strong empirical foundation and are detailed by specific steps. The group administration identified in relation to formal training and comprehensive update is left out as it subsumes clerical and mostly routine steps that do not deal with knowledge at the first place. Nevertheless, this shows that knowledge actions may transcend the process-oriented and learning-oriented perspective on knowledge work and include knowledge actions on the level of goals as well as operations on the level of conditions.

mode	(co-)authoring	comprehensive update	expertise identification	formal training	invitation into a group	request for help
access		x				
collect					x	
converge	x					
coordinate	x					
create	x					
discuss			x		x	
distribute	x	x	x	x	x	
evaluate			x	x		x
identify			x		x	
inquire			x	x		
network		x		x		
prepare	x		x	x	x	
request			x			x
review	x					

Table 33. Overview of groups representing the mode of knowledge actions

The groups of steps are summarized shortly in the following based on the empirical results. Some of them are closely related to documented knowledge, some of them focus on knowledge sharing by means of direct communication and others reflect both aspects. It thus can be stated that they reflect the two basic KM orientations towards codification and personalisation.

Access. Access refers to the regular check of internal and internal sources of information and is typical for the knowledge action update. It may be oriented towards the access of codified knowledge as well as towards the use of communication media such as email.

Collect. Collection is concerned with the gathering of potential topics of meetings as well as of meeting registrations. It is relevant for creating an agenda of individual meetings and of a group as a whole.

Converge. Converging is concerned with the creation of consistent results within a group. It is characteristic for (co-)authoring where individual contributions need to be merged into a coherent whole.

Coordinate. Coordination generally focuses on the arrangement of task-oriented activities and the allocation of resources in the best possible order (Borghoff & Schlichter 2000, 125). It was observed in relation to the organisation of the co-authoring process, which includes the communication with co-authors as well as the management of shared repositories used for storing preliminary and final versions of joint results.

Create. Creation deals with the generation of documented knowledge. It focuses on the actual writing activities as one aspect of the knowledge actions (co-)authoring. It may be based on templates or similar documents and also includes the editing, annotation and generalisation of contents.

Discuss. Discussion is the direct communication of one or more individuals targeted at knowledge sharing, e.g., in order to resolve a problem related to work tasks. It may also involve preliminary steps such as making appointments as well as the creation of contents though this is primarily oriented towards documenting the communication process.

Distribute. Distribution is concerned with the dissemination of documented knowledge. It involves the classification, storing, forwarding and release of various types of contents as well as the systematic use of storage systems, e.g., by maintaining storage structures and access privileges.

Evaluate. Evaluation is the appraisal of knowledge, e.g., through the conduct of examinations, the assessment of agent results, the help received in support calls or the quality of training courses.

Identify. Identification is the search and detection of people that are characterized by specific competencies required or by interests that make them potential candidates for their invitation into a group.

Inquire. Inquire is concerned with the identification, retrieval and use of documented knowledge, e.g., electronic training units, contents acquired from internal knowledge sources or identified with the help of a general Internet search.

Network. Networking is the establishment and development of contacts with other people with the goal of knowledge sharing. This includes informal networking, e.g., with other participants of a training course, as well as the participation of more formal or regular meetings.

Prepare. Preparation was used above as a general group that deals with setting up a knowledge action. In this context, it is defined as the specification of criteria and the acquisition of resources that are relevant for the conduct of a knowledge action. This includes, e.g., the determination of learning goals, of competencies required and also of potential co-authors.

Request. Request is concerned with getting help and advice from other people. This may involve the identification of specific individuals or the opening of support tickets that specify a problem to be solved.

Review. Review deals with the evaluation and enhancement of documented knowledge. In contrast to evaluation, it is typically part of an authoring process and also involves the request of feedback about contents and their formal release.

Current approaches in PKM strongly rely on the *process metaphor* for the description of knowledge work (section 2.6). It has been highlighted that processes are not always suited for this task, specifically in relation to the portions of knowledge work that deal with the generation of knowledge. Nevertheless, the process metaphor may be suited especially for routinized knowledge actions that are characterized by a recurring sequence of steps. Hence, processes can be applied to model knowledge routines as also addressed by a specific KM instrument (section 2.6). Based on this, process services as well as more flexible case handling services are proposed for the support of KWS, which will be discussed in more detail below (section 8.4).

Apart from technical support, it is proposed that KWS and specifically knowledge actions may be used as an organisational guideline that defines required or desirable behaviour in specific situations, e.g., selected roles could be held accountable to undertake specific authoring steps related to defined occasions. The comprehensive analysis of steps undertaken in response to certain situations may also act as a foundation for a "bottom-up" definition of knowledge actions that may reflect a good practice of knowledge work within an organisation. For example, the best way of publishing ideas for improvement could be described in terms of required steps and specified further by means of typical occasions and the KWS context. This may be viewed as a systematic and organisation-wide routinization of knowledge actions because individuals obtain guidance for the accomplishment of selected actions based on prior experience. This is also addressed by routinization services targeting the creation of composite services appropriate for selected knowledge actions.

Occasions

Though the modelling of knowledge processes in addition to business processes is proposed in the context of PKM, e.g., in order to structure the activities necessary to implement KM instruments (Bach, Österle & Vogler 2000, 71ff; Remus 2002b, 162; Remus & Schub 2003), the relation between these two types of processes so far has not been established clearly. Heisig (2003, 33ff) does a first step into this direction by proposing an assessment of single process steps (section 4.5.2). This relates to the question on which parts of business processes KM should focus on in order to formulate interventions.

Two general orientations can be distinguished in this context: a focus on weak points and a focus on hot spots. *Weak points* are areas in business processes where knowledge processing is inhibited by personal, organisational, technical or cultural barriers and where potential for improvements is high. Examples are redundant generation of knowledge, media breaks, missing actualization of knowledge, knowledge monopolies or dissatisfied demand for knowledge (Allweyer 1998; Gronau & Weber 2003). Approaches focusing on weak points tend to apply pre-defined schemes or patterns for process analysis such as a set of required knowledge-oriented steps (Heisig 2003) or anti patterns (Bahrs, Bogen & Schmid 2005). *Hot spots* in contrast describe areas that potentially are of high importance for KM. They are areas in business processes where knowledge-processing is critical for the results of the processes, where learning takes place and where new knowledge is created relevant for the organisation's success, e.g., about innovations, process enhancement, cost savings and quality assurance. Hot spots depend on operational and strategic goals of the organisation and of KM since they determine where learning needs to take place and in which areas new knowledge should be created.

Current PKM approaches emphasize the identification and correction of weak points in business processes, which became obvious in relation to the starting points suggested in the context of knowledge-oriented modelling of business processes (section 4.6). In this regard, they are closely related to business process enhancement approaches proposed in the context of business process management (section 2.5). The KWS concept suggests focusing on occasions and thus using hot spots as primary starting points. This enables to include the generation of relevant knowledge and ultimately the learning-oriented perspective on knowledge work. This does not necessarily mean that weak points are excluded from analysis since KWS also embrace the application of existing knowledge.

During the empirical study, occasions turned out as an appropriate means to address the switch from a mainly task-oriented towards a learning-oriented and curiosity-driven mode of work. The empirical study did not target the formulation of hypothesis about occasions and thus the general distinction between task-oriented and learning-oriented occasions proposed was not further detailed (section 3.4.2). A large share of the examples for occasions collected can be characterized as being task-oriented. This was intentionally focused by the empirical study in order to maintain a close relationship to the work tasks of the respondents. Nevertheless, the dependence on individual interests and learning goals becomes specifically apparent in relation to the action expertise identification.

Context

Figure 69 summarizes the framework of the KWS context that is based on the six dimensions of context information and six categories of meta-information proposed in section 3.4.3. It was detailed based on the examples for context factors identified in relation to the empirical study (section 7.5.1). An advantage of this framework is that it does not only reflect the three media of knowledge, i.e., product, process and person (section 2.2), but also the four perspectives of modelling in KM and their relationships, which are detailed within the figure. Furthermore, it enables to include information from the process-oriented and learning-oriented perspective integrated by KWS. Nevertheless, further research is required in order to guide the choice of the aspects of the context to be described based on this comprehensive framework.

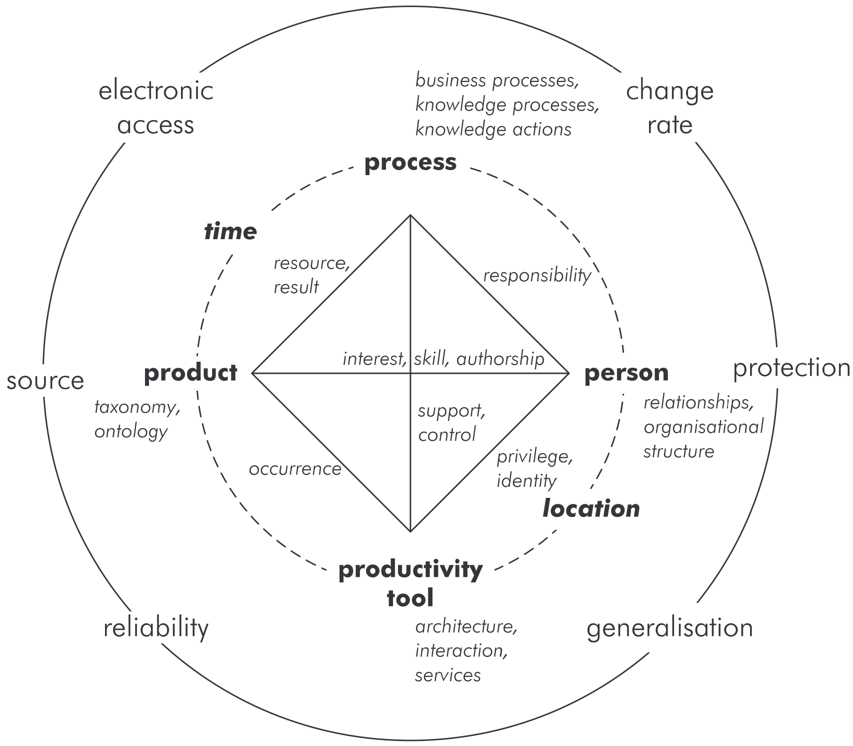

Figure 69. Refined framework of the KWS context

8.3 Modelling knowledge work situations

A well-founded modelling language needs to be created, evaluated and revised iteratively within its application domain and ideally has a strong empirical foundation. It is out of scope of this work to create a new language for modelling KWS. However, the insights gained in this work can be used in order to define a meta-model that represents a first step towards the definition of a modelling language suited for the description of KWS and their technical support. It may act as a foundation for the formulation of a new modelling approach or for the extension of existing modelling approaches. An advantage of the last alternative it that some modelling approaches are already widely known and supported by specialized software tools, e.g., ARIS-KM or PROMOTE (sections 4.5.1 and 4.5.5). This section firstly describes the meta-model and then discusses possible ways of its refinement.

Proposition of a meta-model

Figure 70 depicts the meta-model proposed. Each one of the four perspectives product, process, person and productivity tool is represented by at least two concepts. The relation to a perspective is indicated by the same shades of grey as within the meta-models included in section 4.5.[191] It is designed to include all important relationships within and between the perspectives and reflects all three media of knowledge, i.e. products, processes and people (section 2.2).

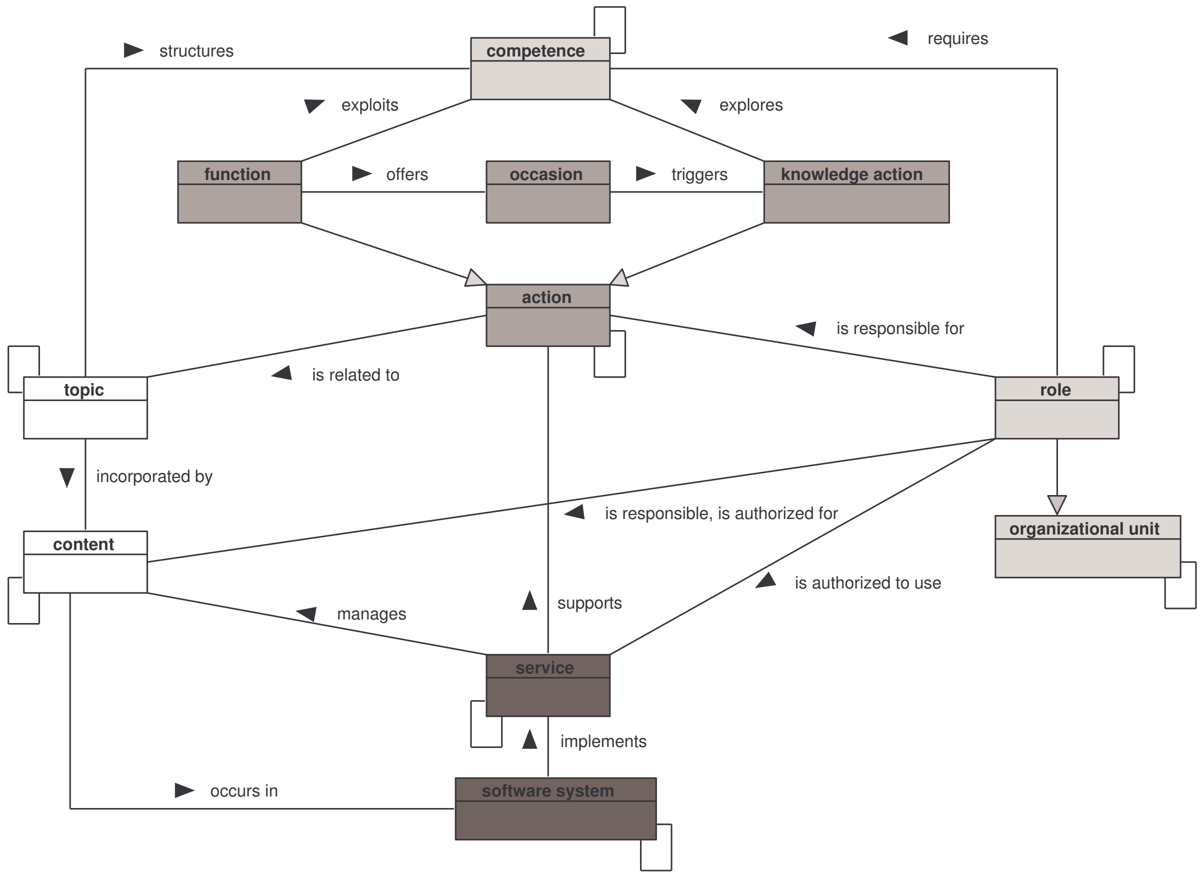

Figure 70. Meta-model for modelling KWS

Topics are used to represent the structure of knowledge and thus correspond to concepts modelled within ontologies (section 2.2). It can be assumed that hierarchical taxonomies in many cases will be sufficient for their representation. Ideally, they are formalized by ontologies and thus should be complemented particularly by constraints and rules about them (Daconta, Obrst & Smith 2003, 166f). This allows inferring relationships not explicitly modelled and thus may substantially enhance the value of the electronic representation of the relevant domain. The recursive relationship can be refined to different types of associations, e.g., generalisation/specialisation and aggregation. This enables the representation of hierarchical relationships, e.g., between more general and more specific topics.

[191] The caption is depicted in Figure 21 on page 114.

Topics are incorporated by *contents*. The represent documented knowledge and are defined as any set of meaningfully arranged data that can be addressed and manipulated by a human or a system as a discrete entity (section 2.2). In this context, the focus is on electronic contents as well as on semi-structured data as opposed to structured data managed with traditional IS such as relational data bases. The recursive relationship can be applied in order to model aggregation relationships relevant to represent, e.g., compound documents that may contain multiple other content parts in varying technical formats or learning units that are composed of several learning objects (section 5.5.4).

Actions either represent *functions* directed at the fulfilment of tasks in business processes or *knowledge actions* targeted at knowledge creation and learning. The recursive association of the concept action can be detailed in different ways. In relation to functions, it primarily represents their hierarchical de-composition into single tasks as well as possible predecessor-successor relationships. This also includes common operators such as split and join used in order to model the control flow of structured processes or workflows. Concerning knowledge actions, it represents the routinization of actions and thus the relation to operations used to accomplish a knowledge action. Both types of actions are associated with topics that indicate related subjects and that can be used in order to link them to specific contents. As defined above, functions offer typical *occasions* for knowledge creation and learning that in turn trigger knowledge actions (section 3.4.1).

Competences represent individual knowledge, abilities and skills, i.e. a person's implicit and explicit knowledge, its cognitive, mental and physical predispositions as well as learnable and observable proficiencies (section 2.2). The recursive relationship indicates that a specific competence may be composed of multiple other competences, which can be used in order to model the relationship between more general and more specific competencies as well as between task-oriented competences and more basic qualifications. Competences can be structured with the help of topic concept. The association between competences and the two types of actions reflects the two basic orientations of exploitation and exploration of knowledge (section 3.2). Available competences are applied and thus exploited in order to accomplish functions. They are developed further by means of knowledge actions that have the goal to explore knowledge.

Roles represent consistent bundles of expectancies towards the holder of a defined position, which includes privileges as well as obligations (section 2.4). This comprises formal roles defined as part of the organisation structure, KM roles such as knowledge broker, community or network manager and subject matter specialist (section 2.4) as well as informal roles that are identified as part of the division of labour of an activity system (section 3.2). The recursive association can be detailed to formal relationships between roles as well as to informal links between people such as communication or advice relationships. The latter acknowledges the relevance of social networks for KM. The link between roles and actions indicates the responsibility for specific actions. The authorship of as well as the responsibility for specific contents can be modelled with the relationship between the two concepts role and content.

Roles require specific competences. This is indicated by a corresponding association between these two concepts. It should be noted that competences of concrete individuals are not included within this meta-model as it focuses concepts that are modelled on type level. Individual competences are surely relevant during run-time of a system, e.g., for identification of domain experts based on the knowledge action expertise identification, and thus should be included in instance-level models. Roles belong to *organisational units* that can be used in order to represent all elements of the formal organisational structure such as teams, departments or business units. As in the case of roles, the recursive association related to this concept can be detailed to formal relationships between organisational units as well as to more informal links such as communication or advice relationships.

Services represent a distinctive, reusable functionality of a component that typically encapsulates a high-level business concept (section 5.2.1). In this context, this concept particularly relates to the knowledge services offered by an EKI, i.e. publication, discovery, collaboration and learning services. The meta-model intentionally refers to service-orientation as this offers means for the structured and ideally the flexible composition of services that target the support of specific knowledge actions. The recursive association linked to services consequently can be detailed depending on the form of service composition (section 5.3). Services are applied in order to manage specific types of contents. Privileges for the use of technical infrastructures can be modelled based on the association between services and roles. *Software systems* implement the components that expose services and that are used for the storage, processing and communication of information (section 2.4). The recursive association can be detailed in order to describe the architecture of the component infrastructure. Software systems store electronic contents. This relationship is included by means of an association that indicates the occurrence of contents in specific systems.

Knowledge work situations are not included as a separate concept within the meta-model. This is not required as they can be completely specified by means of the concepts available. The meta-model includes functions, occasions and knowledge actions. Information about the KWS context dimensions product, process, person and productivity tool as well as about their relationships can be described with the help of diagrams that contain concepts from the corresponding modelling perspectives. Since the dimensions time and location are linked to all dimensions of the KWS context as well as to the relationships between them, they should be modelled as attributes of these concepts. The same applies for the meta-information about the KWS context such as electronic access, source or the need for protection which is particularly relevant for the design and implementation of knowledge services. When being concerned with the definition of a concrete modelling language, it is proposed to include KWS as a model type aggregates information relevant to describe relevant situations, e.g., by means of typical occasions that lead to a KWS, a number of knowledge actions appropriate in this relation as well as services that support these actions.

Further refinement of the meta-model

The meta-model so far resides on a high level of abstraction. One may argue that this leads to high flexibility because a large variety of different specializations can be subsumed under each concept. However, abstract concepts do not provide much guidance for modellers that require constructs as specific as possible for the description of the relevant aspects of the modelling domain. Hence, the generic meta-model proposed should be detailed with a set of more specific types.

Frank & van Laak (2003, 40ff) distinguish the following alternatives for introducing new types in a modelling language: (1) Types are further described by means of selected *attributes* of concepts, e.g., a resource is classified as a printer by assigning the value "printer" to an attribute "resource type". This approach may be unsuited as new types in fact are described by means of specialized instances. This leads to several disadvantages, e.g., automatic evaluations of new types and related integrity constraints are not possible. (2) UML offers a way for extending the modelling language by means of so-called *stereotypes*. They can be used to specialize existing language constructs on a meta-level, e.g., by definition of additional attributes and constraints (Hitz et al. 2005, 336). (3) Another possibility is to allow the *specialization of generic types* by the language user. This has the disadvantage that only existent types can be extended. (4) Fourth way is to *include a dedicated language* for the specification of new types. This is very flexible but results are limited because the semantics of the modelling language can only be extended within limited boundaries. (5) The most powerful alternative is to allow users *modifying the meta-model* of the language. However, this requires the provision of a meta-language and users are required to have specialized modelling competencies. This alternative also includes the danger of the language becoming inconsistent due to inappropriate modifications.

All alternatives have different strengths in terms of flexibility, semantic level and convenience. Frank & van Laak (2003, 43) conclude that a modelling approach ideally should offer multiple different ways for extensions. It is proposed here that the generic meta-model should be firstly extended by a set of types identified based on theoretical and empirical findings. Ways such as the inclusion of a language for the definition of types as well as the modification of the meta-model of the language seem most appropriate but decisions on this are left to attempts that deal with the development of a modelling language.

Some of the results of the conceptual and empirical parts of this work can be used for the refinement of some of the concepts included. It is proposed here to distinguish between task-oriented *occasions* and learning-oriented occasions as suggested in section 3.4.2. The concept *knowledge action* can be refined based on the revised set of knowledge actions (section 8.2), i.e. (co-)authoring, comprehensive update, expertise identification, formal training, invitation into a group and request for help. The mode of single more fine-grained knowledge actions can be classified into access, collect, converge, coordinate, create, discuss, distribute, evaluate, identify, inquire, network, prepare, request and review. The *service* concept can be detailed based on the basic categories for knowledge services publication, discovery, collaboration and learning. Knowledge actions and services principally can be further detailed based on the single steps and specific services identified. However, the findings yet have not been generalized based on a quantitative empirical study. Further refinements thus are not proposed so far. In conclusion, this section proposed a meta-model that strongly builds on conceptual foundations of PKM, the concepts included in the modelling approaches investigated as well as the results of the empirical study.

8.4 Situation-oriented support with knowledge infrastructures

Service composition has been highlighted as a possible means for the integrated support of knowledge actions (section 5.3). This motivated the introduction of a composition layer in the EKI architecture (section 5.4.2). Consequently, this section discusses service composition for the support of KWS in more detail. Furthermore, the application of KWS as a metaphor for the design of portal interfaces will be described.

Service composition

The EKI composition layer distinguishes between process services based on the BPEL standard that target the support of knowledge routines and case handling services for the flexible support of knowledge actions (sections 5.3). Furthermore, the context-ware support of knowledge actions has been pointed out as a means for enhancing the efficiency of human-computer interaction in relation to the context-aware support with ICT (section 3.3.2), which motivated the inclusion of a context-handling service within the EKI architecture (section 5.4.2). However, this has not been concretized yet. Thus, context-aware support with process and case handling services each will be illustrated by means of an example. Both cases are based on the KWS related to a procurement process described in section 3.4.1 that resulted in the knowledge action expert search, or in terms of the revised knowledge actions: expertise identification. It is triggered by the occasion that no suitable supplier is known which is associated with the function order product. The composite service that aims to support this action is referred to as expert advice.

Example 1: Expert advice as process service. Figure 71 illustrates the process service expert advice that should support the routinized knowledge action expertise identification. The service is visualized based on the notation used for UML activity diagrams (Hitz et al. 2005, 173ff). UML activities represent operations offered by services. They are complemented with input information required by an operation. The operations are based on empirically identified steps (section 7.4.7), i.e. `define required competences`, `identify contact person`, `identify contact details`, `verify availability` and `discuss topic`, and they are exposed by the services accessed in relation to them, i.e. `keyword-based search`, `contact directory`, `email`, `phone` and `availability`. Compared to the empirical study, the functionality of the services has been extended in order to illustrate the automatic and context-dependent execution of the whole process service without the need for user intervention.

This refers to the operations `select person`, `select media` and `generate email`. The KWS is further specified by its context that is detailed within the figure for selected dimensions of the framework presented in section 8.2. All information is assumed to be electronically available by means of the run-time environment of a service. In the following, the flow of the process service will be described in more detail.

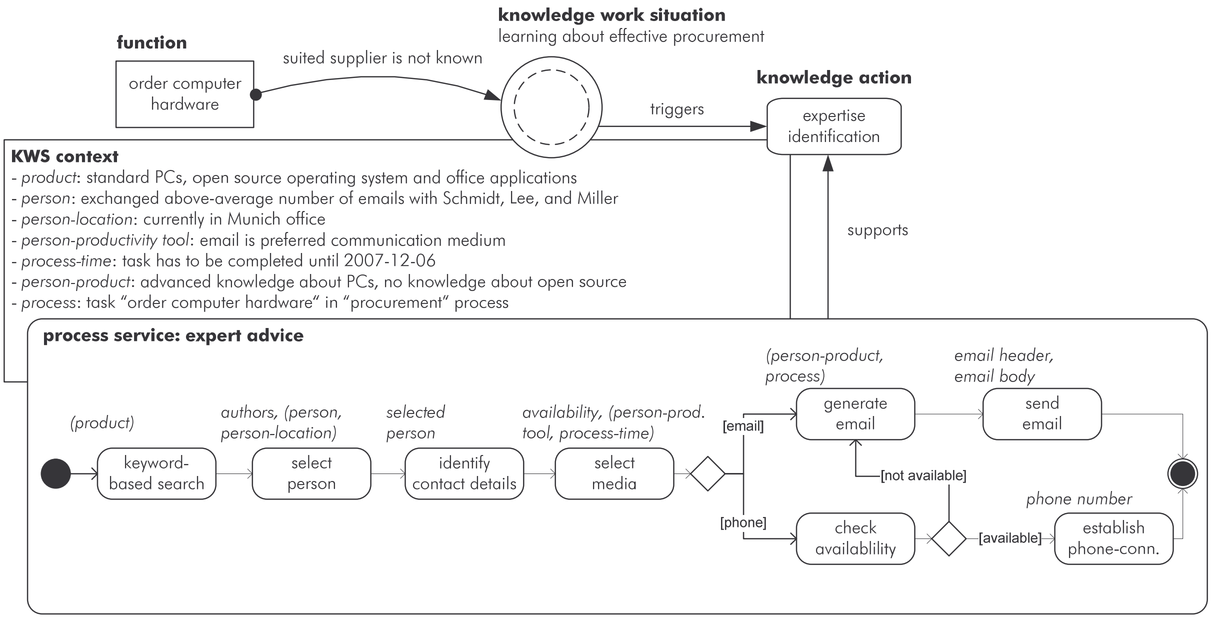

Figure 71. Example of process service expert advice

Keyword-based search as the first operation invoked upon the execution of the process service receives keywords such as "personal computer", "open source" and "supplier" that represent topics related to the current function within the procurement process. It is available from the KWS context and corresponds to the context dimension product so that the user is not required to provide this type of information to the service. This service is used to identify authors of related contents instead of a competence-based search service due to the lack of a competence management system. As any of the knowledge services included here, it might be offered by various application systems such as the department's file server, an organisation-wide DMS or the organisation's Intranet. Ideally, appropriate services are discovered and bound dynamically based on definitions of the service interface. However, at the current state-of-practice, the process service as well as the participating services are very probable to be hard-coded and then cannot be changed easily by end-users. After the keyword-based search delivered its results, a potential communication partner is selected based on criteria such as ranking within the search results, preferred communication partners (context category person) and distance to the user (category person-location). Contact information such as the email-address and phone numbers then is identified with the help of organisational contact directories.

Information such as individual preferences for specific communication media (category person-productivity tool) and due date (category process-time) can be used in order to decide whether synchronous or asynchronous media should be used to establish the contact. An email service is accessed in the case of asynchronous communication. In this case, information about the user's experiences with personal computers and open source software (category person-product) as well as about his task (category process) is used to automatically generate an email that informs the contact person about the current case. Subsequently, it is distributed by means of an email service. Otherwise, the availability of the potential communication partner is checked, e.g., based on his online status, and either a phone call is established with a phone service that may be based on the organisation's Internet telephony infrastructure or alternatively an email is sent out in case he is not available.

Human interaction is not part of the current version of the BPEL specification and thus is not included here. However, examples where this would be desirable can be easily found. For example, the user might like to intervene during the selection of a communication medium or he would like to revise the message before it is sent out. In the future, people activities can be included within orchestrated services as proposed by the BPEL4People extension (section 5.3.1). Service orchestration based on BPEL currently focuses strongly on inter-application integration and tightly-framed processes. The sequence of steps is static and thus a pre-defined way expertise identification is imposed on the user. This is not desirable though the process service already demonstrates a possible way for the integration of services well.

The example illustrates how context information can be used to automate support for knowledge actions. The assumption that all of the noted information is electronically available might be optimistic but is not unrealistic. A part of it can be stored in a static user profile, e.g., competences and preferences. Other parts are indirectly available, e.g., information about preferred communication partners can be determined by evaluating senders and receivers of emails in a user's email account, location information can be made available by means of GPS sensors connected to the user's hardware, by means of triangulation of location information based on the Global System for Mobile Communications or by determining the stationary computer where a user has logged on with his network account. Ontologies in this relation may represent a foundation for inferring and combining information about a user's context, e.g., based on domain ontologies that model relationships between competences and topics or geographical ontologies that relate locations and help to determine the user's current location. More challenging is the determination of information about current tasks, e.g., by analysing open documents, emails or current workflow instances. Users might also provide some information about the current occasion and their context manually, e.g., with the help of structured lists that present possible alternative occasions.

Example 2: Expert advice as case handling service. Figure 72 depicts a case handling service expert advice. Since case handling services may involve user interaction, the UML activities now are applied to model tasks conducted by humans or systems instead of service operations as in the first example. They directly reflect the steps from the empirical study already used above, i.e. define required competences, identify contact person, identify contact details, discuss topic and verify availability. Information required for a task again is indicated in relation to a step. It can either be gained by means of user input, from the KWS context or from a preceding step.

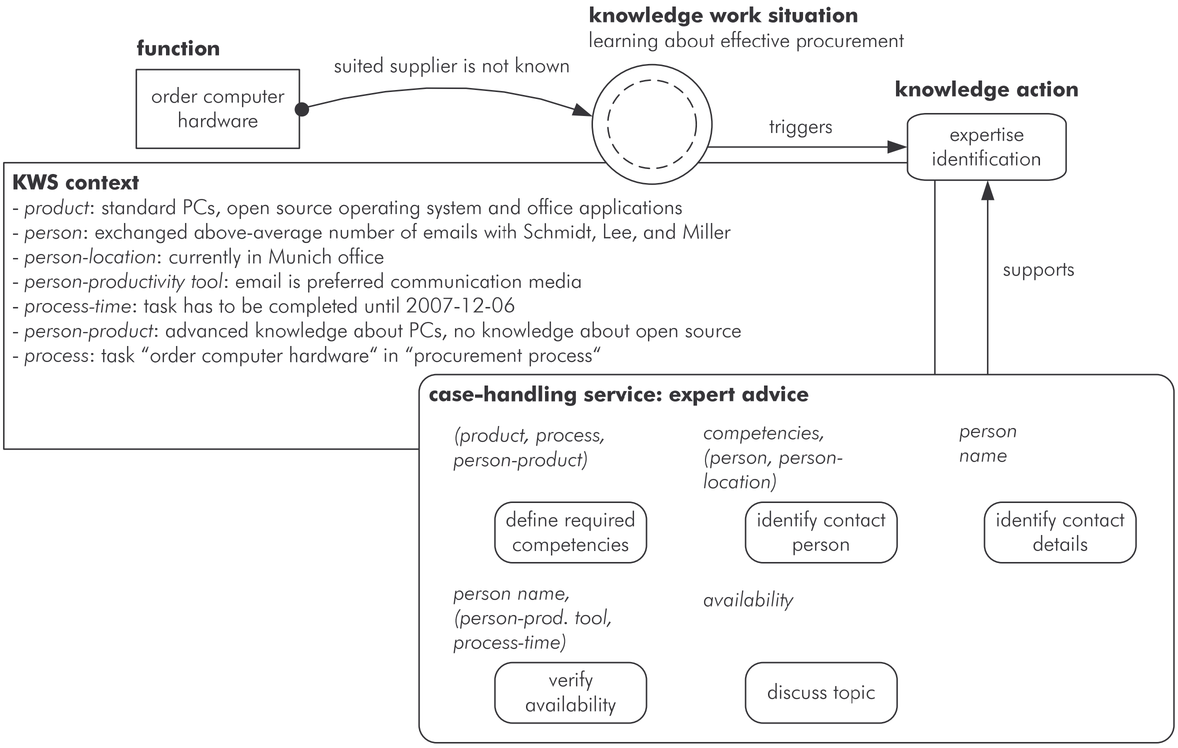

Figure 72. Example of case-handling service expert advice

The case handling service does not assume a fixed sequence of the steps. Rather, the user is allowed to choose from a set of steps offered by the composite service. The steps that are accomplished depend on the input data provided, i.e. the process is driven by data and based on implicit routing as explained in section 5.3.2. Multiple steps may be completed at once if the corresponding data is available. The service definition may include general predecessor-successor relationships between steps that might be suited to guide users through knowledge actions. The case handling approach allows to model optional steps based on skip roles or re-iterations of steps by means of redo roles. The case handling service thus may act as a general recipe for handling a knowledge action rather than imposing a pre-defined sequence of steps as done by the process service. The following description thus represents only one possible sequence of steps.

Firstly, a user might define the competencies required, which requires information about his individual skills (context category person-product), about the process (category process) and about the current topic she deals with (category product). This information might already be completely available from the KWS context. The competencies determined then can be used to identify a contact person, which takes information about typical communication relationships (category person) as well as the current location of the user (category person-location) into account. The degree of technical support for a step varies. In order to support the definition of required competences, no explicit technical service has been identified during the empirical study. On the other hand, the step identify contact person may be supported by means of various services such as keyword-based or competence-based search services that are involved upon the execution of a step. Afterwards, the relevant contact details of a potential communication partner can be identified which is supported by a communication directory. The step `discuss topic` can be based on different media and thus the availability of a person over a specific medium as well as the preference of selected media are relevant here (category person-productivity tool). This information can be determined in advance by means of a separate step that also takes the media preferred (category person-productivity tool) as well as the urgency of the current case into account (category process-time).

In conclusion, both examples show that composite services might provide a feasible means to design and implement technical support for knowledge actions. They represent a way to structure the conduct of knowledge actions and to combine and offer required knowledge services. Creation and revision of composite services is not necessarily a task to be accomplished only by specialists. EKI rather need to provide user-friendly ways in order to support all tasks over the whole PAIS life-cycle (section 5.3.1). Flexible support thus also includes ways to revise, extend or discard composite services as targeted by the routinization service (section 5.4.2).

KWS as a design metaphor

The technical support of KWS is not limited to composite services. It is proposed here that portals represent an appropriate way for the integrated support of KWS on the level of the EKI access layer (section 5.4.2). For example, the knowledge action comprehensive update which was noted to be accomplished repeatedly during one weak (section 7.5.2) requires access to various different information sources that can be offered by means of an integrated interface. In order to illustrate this further, a prototype for a portal will be outlined that shows how KWS can be applied as a design metaphor (section 5.4.2). The example is based on Bleek's (2002a; 2002b) idea to use the situations of life as a metaphor for the structuring of municipal Web portals or more specifically, those parts of the Web sites that offer public services to citizens. He defines a situation of life[192] broadly as a certain situation of an individual or of a family such as marriage, birth or unemployment (Bleek 2002b, 4). It is shared by many citizens, lasts for substantial amount of time and results in a number of specific actions. Some of these actions can be supported by appropriate electronic contents or governmental services. Bleek argues that situations of life enable users to intuitively discover required services and contents based on knowledge about their current situation.

Figure 73 shows a screenshot of a portal prototype (Hädrich & Priebe 2005a; 2005b; Priebe 2005). It provides four different so-called portlets, i.e. parts of a Web interface that group specific functions, contents or navigational elements. A portlet may represent an application interface used for the access of knowledge services or of composite services. In the example, four portlets are used to display Intranet articles, provide OLAP access to structured information stored in a data warehouse, represent a taxonomy-based topic browser and offer a text field where keywords can be submitted to a search engine. The prototype was developed to demonstrate integration on the interface level with the help of Semantic Web technologies, more specifically a shared ontology based on OWL. For example, if a user selects a topic within the navigation portlet, then is published to the other portlets that may change their contents accordingly. Furthermore, the search portlet is able add keywords about information displayed in other portlets to a search query submitted by the user.

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[192] Bleek uses the German term "Lebenslagen".

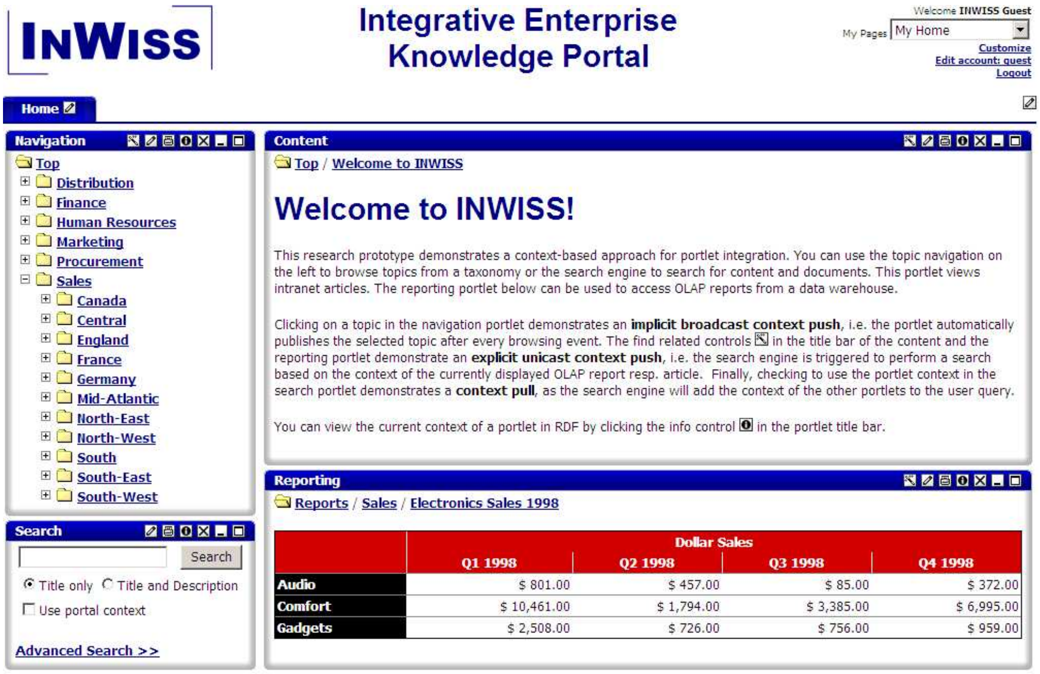

Figure 73. Portal prototype[193]

The relevant KWS context can be represented with an internal context model that is maintained by the system. If it is properly mapped to the ontology used for the integration of portlets, the system is able to offer context-aware information and services, e.g., a search for resources that are related to the current user context. The KWS metaphor can be added explicitly to the interface of the system. Figure 74 shows an example for a KWS portlet where the user can select business processes that he is concerned with as well as occasions that are related to them. This information can be defined in advance and principally can also be added during run-time. Upon the activation of one of the alternative knowledge actions displayed, an associated composite service is executed and the results are presented within the portal. For example, the activation of the option "ask a colleague" may lead to the execution of the case handling service expert advice as previously described in this section. The single steps of this action may obtain information about the KWS context and can be displayed within the portlet. The portal thus is able to guide a user through this action and to offer related knowledge services whose results are displayed in other portlets.

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[193] based on Priebe (2005)

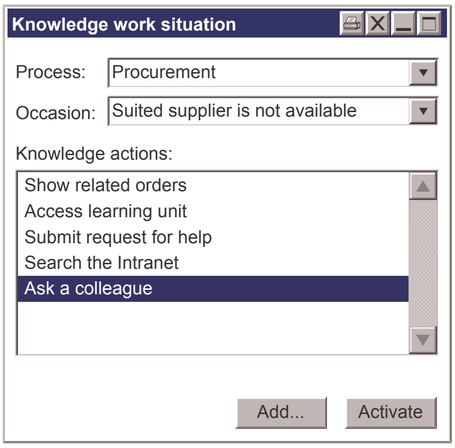

Figure 74. Example for a KWS portlet

8.5 Summary

This chapter has revised the KWS concept on the levels of concepts, models and systems. On a conceptual level, the components of KWS have been redefined based on the results of the empirical study. Table 34 gives an overview of the categories that have been included within the new version of the concept.

component	description
occasion	can be differentiated into task-oriented and learning-oriented occasions
context	is described with the four dimensions product, process, person and productivity tool and their relationships which can be specified further with regard to time and location as well as meta information about the context classified into source, electronic access, change rate, protection, generalisation and reliability
mode	classifies steps of knowledge-oriented actions into the types of access, collect, converge, coordinate, create, discuss, distribute, evaluate, identify, inquire, network, prepare, request and review
knowledge action	can be distinguished into the empirically grounded types (co-)authoring, comprehensive update, expertise identification, formal training, invitation into a group and request for help

Table 34. Components of the revised KWS concept

A meta-model has been proposed that structures the concepts included within a modelling language to be either defined from scratch or based on an existing modelling approach. It includes the interrelated concepts topic and content within the product perspective, action, function, knowledge action and occasion to model the process perspective, organisational unit, role and competence in order to describe the person perspective as well as service and information system in order to structure the productivity tool perspective. It has been proposed to refine some of these concepts based on the categories summarized in Table 34 though the findings should be generalized before they are included within the language, e.g., based on a quantitative empirical study. The technical support of KWS by means of composite services has been detailed by means of an example for a process service and one for a case handling service. The examples also illustrated how KWS context information may enhance the effectiveness of the human-computer interaction. Furthermore, it has been shown how KWS can be used as a design metaphor by applying it for the structuring of a portal interface. In conclusion it can be stated that this chapter was able to integrate selected results achieved related to all of the three levels concepts, models and systems into a revised version of the KWS concept.

9 Conclusion and outlook

The preceding chapters were dedicated towards giving an answer to the leading question of what is an approach that allows PKM to systematically structure relevant aspects of knowledge work for its goal-oriented support with knowledge services. Detailed findings already have been summarized at the end of each chapter. This chapter highlights the most important results of this work (section 9.1) and gives an outlook on further research (section 9.2).

9.1 Summary of results

Figure 75 depicts the results of this work on a high level of granularity structured based on the levels of concepts, models and systems. It is based on Figure 2 that was applied in section 1.3 to give an overview of the structure of this work. In the following, the main results are summarized concisely.

Level of concepts. On a conceptual level, two perspectives on knowledge work have been established in order to motivate the need for a new concept. As a foundation for the learning-oriented perspective, activity theory has been introduced and related to the topics of this work. Relevant features of situational approaches have been highlighted. Based the two perspectives and the discussion of the term situation, the KWS concept has been defined. It represents a theoretically informed metaphor that brings together business processes, knowledge work and knowledge services in a systematic manner. It has been detailed based on a classification of occasions, a set of dimensions describing the KWS context and by eight types of knowledge actions. Nevertheless, this work did not remain on the level of abstract classification schemes but identified twelve variants of knowledge actions composed of 69 steps. These results have been used in order to create a revised set of six knowledge actions. Furthermore, 14 types of modes for the steps of knowledge actions as well as a refined model of the KWS context have been suggested based on the findings.

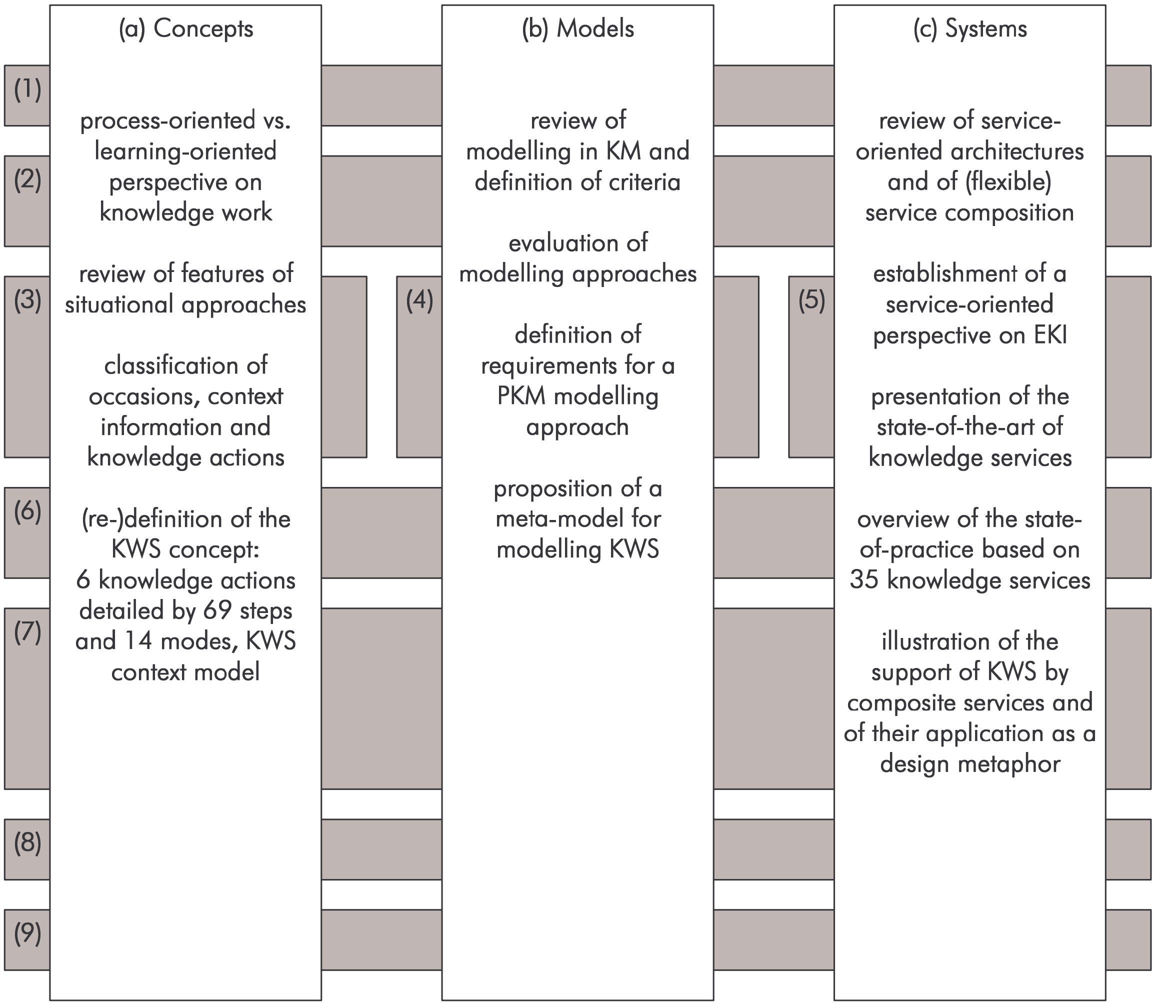

Figure 75. Overview of results

Level of models. On a modelling level, a contribution of this work is the definition of a set of criteria based on a review of the literature on modelling. They can be used in order to investigate modelling approaches applied in the context of PKM. However, the detailed review of every modelling approach and the comparison of the overall set of approaches was mainly targeted at the identification and comparison of the concepts used for the description of knowledge work, which have been structured by means of meta-models. Furthermore, possible strengths and weaknesses of each modelling approach have been discussed. This resulted in the description of requirements for PKM modelling approaches. A meta-model has been proposed that represents a foundation for the inclusion of KWS in existing approaches or the creation of a new modelling language. It was refrained from the definition of a more detailed syntax including a notation as the creation of a modelling approach requires an empirical evaluation which is a comprehensive research project on its own.

Level of systems. On a systems level, a review of the subjects service-orientation and service composition has been conducted that led to insights applied in order to establish a service-oriented perspective on EKI. The main extension is a layer of composite services that targets the support of specific knowledge actions by means of process or case handling services. Possible ways for the context-oriented and integrated support of knowledge actions based on these two types of services have been illustrated with the help of examples. The level of systems has been further specified by summarizing the state-of-the-art of knowledge services and by structuring related technical functions with the help of generic tasks to be supported by means of publication, discovery, collaboration and learning services. 35 concrete knowledge services accessed during the knowledge actions investigated have been identified and described in detail in terms of their functionality as well as the steps and knowledge actions they support. Last but not least, the application of KWS as a design metaphor of a portal interface has been demonstrated with the help of an example.

Overall, it can be concluded that a theoretically well-founded and empirically grounded concept has been developed as an answer to the leading research question. The KWS concept integrates knowledge work, business processes and knowledge services based on a situation-oriented approach and was detailed concerning the levels of models and systems. Practitioners can use this concept for the design and implementation of knowledge infrastructures. Scientists may use the results of this work as a framework for their research or focus on the further advancement of the concept developed. The following section formulates some emerging questions that should be investigated by future research.

9.2 Outlook

The questions that are proposed for future research again are structured based on the levels of concepts, models and systems. Research approaches may take into account one or multiple ones of these levels.

Level of concepts. As the most relevant task of future research that targets the advancement of KWS on a conceptual level the *generalization* of occasions, context factors, knowledge actions, steps and services as identified by the empirical study is proposed. A quantitative approach can directly build on the results of the explorative study conducted as a part of this work. Particularly relevant is the correlation of specific knowledge actions and services. Another field that should be investigated are relations between *context factors* and knowledge actions. A lot of theories and frameworks exist that can be used in order to formulate relevant associations. Last but not least, the KWS concept should be applied as a whole in order to evaluate its *practical applicability*, e.g., as a metaphor that guides the procedure of a KM initiative, electronic contents, user interfaces or corporate guidelines. Advancements on the level of modelling may represent a foundation for this.

Level of models. As the next step on the level of models, the *definition of a modelling language* based on the meta-model suggested is proposed. This particularly includes the specification of a syntax, semantics and of relevant modelling perspectives or model types respectively. The extension of an existing and well-accepted approach that already is supported by a modelling tool is regarded as a good starting point for such an attempt. It should be evaluated though to which degree the approach in question is consistent with the meta-model and the requirements defined. A modelling approach should have a strong empirical grounding, i.e. it should be continuously evaluated and refined empirically, e.g., based on an action research approach (Frank 1998, 16f). The development of a modelling language thus is not a trivial task. Unfortunately, none of the modelling approaches reviewed can claim to have such a foundation. Another possible direction of research that builds on a modelling language is the creation of an *advanced modelling tool* that assists modellers at capturing the aspects relevant and offers functions that seamlessly integrate the build-time and run-time use of models.

Level of systems. A promising direction is the building and evaluation of a prototypical system that supports KWS, e.g., based on a design science approach. The examples described in section 8.4 some ideas for this. A potential prototype may have two main foci. Firstly, it could focus on the *flexible support of knowledge actions* based on service composition. This should be based on commonly accepted standards as far as possible. Secondly, a prototype may focus on *context-aware support*. The representation and interpretation of the user context is not a trivial undertaking. The provision of the right context information to services accessed thus would need to start out at researching ways of how to gather, manage and interpret context information. Surely, an ideal prototype would combine both aspects and also include a workbench that enables for the identification and monitoring of KWS so that in the long run, appropriate actions and services can be proactively offered to the user based on identified occasions and typical configurations of context information. However, this represents a vision that cannot be fulfilled in the short-term.

These are only the most important starting points for future research. Many further ones could be defined. The fact that this work on the one hand was able to offer a comprehensive and theoretically informed picture and on the other hand leads to many new questions indicates that it faced a demanding research question. The enquiry of how to support and enhance the effectiveness of knowledge work will surely remain relevant in the near and far future and offers many challenging and relevant questions to solve whereof technical support is only one starting point. It can be assumed that enterprises will benefit largely from insights on this field due to the strong influence of knowledge work on their productivity and ultimately their competitive position. The creation of an infrastructure and environment that fosters the productivity of skilled people thus may also be taken as good way to appreciate their labour.

List of abbreviations

ARIS .... architecture of integrated information systems
BKM................ business knowledge management framework
BPEL4WS....... business process execution language for Web services
BPMN............. business process modelling notation
CAQDAS .... computer-assisted / computer-aided QDA software
CBR................. case-based reasoning
CBT .... computer-based training
CSCW............. computer-supported cooperative work
CMS................ content management system
CORBA .... common object request broker architecture
DMS................ document management system
EAI.................. enterprise application integration
ECM................ enterprise content management
EDM .... enterprise document management
EdNA .... education network Australia
EKI.................. enterprise knowledge infrastructure
EML .... educational modelling language
FTC .... federal trade commission
GEM .... gateway to educational material
GPO-WM....... Geschäftsprozessorientiertes Wissensmanagement
(German, translated: business process-oriented knowledge management)
GPS .... global positioning system
HRM............... human resource management
HTML............. hypertext markup language
HTTP.............. hypertext transfer protocol
ICT.................. information and communication technology
IDEF................ integrated definition methods
IEM .... integrated enterprise modelling
INCOME........ interactive netbased conceptual modelling environment
IR..................... information retrieval
IRC.................. Internet relay chat

IS .... information systems

IT .... information technology

IUM .... integrated enterprise modelling
(in German: Integrierte Unternehmensmodellierung

KADS .... knowledge acquisition and documentation structuring

KIT .... knowledge-intensive task

KM .... knowledge management

KMDL .... knowledge modelling and description language

KMP................ knowledge management process

KP .... knowledge process

KPR................. knowledge process reengineering

KWS................ knowledge work situation

LDAP.............. lightweight directory access protocol

LCMS.............. learning content management system

LMS .... learning management system

LOM .... learning object meta-data

MEMO............ multi-perspective enterprise modelling

MIS .... management information systems

ODMA............ open document management application programming interface

OLAP.............. online analytical processing

OPAC .... online public access catalogue

OWL .... Web ontology language

PAIS................ process-aware information systems

PDF .... portable document format

PKM................ business process-oriented knowledge management

QDA .... qualitative data analysis software

RDF................. resource description framework

RFC .... request for comments

RSS.................. really simple syndication, also: rich site summary and RDF site summary

SLA .... service-level agreement

SOA .... service-oriented architecture

SOAP .... simple object access protocol

SOM................ semantic object model

TEL .... technology-enhanced learning
TIFF .... tagged image file format
UDDI .... universal description discovery and integration
UML .... unified modeling language
URL .... unified resource locator
VoIP .... voice over Internet protocol
W3C .... World Wide Web consortium
WBT .... Web-based training
WCM .... Web content management
WCMS .... Web content management system
WebDAV .... Web distributed authoring and versioning
WfMS .... workflow management system
WS .... Web service
WS-BPEL........ Web services business process execution language
WSDL .... Web services description language
XML .... extensible markup language

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Appendix A: Interview guideline[194]

1. Personal data

first and last name, year of birth	
gender	( ) male, ( ) female
contact information	
department, organisation	

2. Education and professional experience

What is your highest graduate degree?
What is the denomination of your position?
How could your tasks be outlined based on some keywords?
How many years of working experience do you have?

3. Characterization of work tasks

The following statements characterize your work tasks. Please rate the degree to which they apply based on the given scale.

		no / strongly disagree 1	disagree 2	weakly disagree 3	undecided 4	weakly agree 5	agree 6	strongly agree 7
a)	My work requires me to autonomously familiarize myself with new topics multiple times per year, e.g., with new technologies or with new industry sectors.							
b)	I can reuse knowledge once documented, e.g., in check lists or slides, over and over.							
c)	My work constantly requires creative solutions where no documented solution paths exist for.							
d)	I always solve the most difficult problems in direct cooperation with my colleagues.							
e)	In the context of projects I always deal with comparable topics.							
f)	Sharing knowledge in a documented form is more important for my work than the dissemination of knowledge in direct conversation.							
g)	In order to attain new knowledge I use direct conversations rather than documented knowledge.							
h)	Information systems for me represent a container for knowledge rather than a medium for direct communication of knowledge.							

[194] The guideline was translated from German to English and the layout was reformatted. The illustration of a knowledge action (Figure 38 on page 210) originally was also included but is not repeated in order to save space.

4. Knowledge actions

4.1 Authoring

description	the creation of contents in order to share and transfer documented knowledge
beginning	you would like to create and publish contents
occasions (examples)	• you have an idea or a message and you would like to transfer it • a report or protocol needs to be created
end	the contents are accessible for others

4.2 Co-authoring

description	the creation of contents by multiple people in a reciprocal process
beginning	you (jointly) would like to create or revise contents
occasions (examples)	• a draft for internal or external customers needs to be created by multiple authors • you want to complement the contents of a Wiki
end	contents are transferred to your co-authors and you stay involved within the process

4.3 Training

description	the identification and use of a suitable training
beginning	you have either individually or in coorporation with your supervisor identified a need for learning or for a training
occasions (examples)	• you would like to acquire the basics in a certain area and therefore you would like to use an internal or external course or online training unit • you would like to visit a course in agreement with your supervisor or the human resources department
end	you have completed the learning as well as concluding processes

4.4 Acquisition

description	the evaluation, enhancement and brokering of an external knowledge source
beginning	you have identified a knowledge source relevant for you or for other people
occasions (examples)	• you discover an information portal on the Internet with relation to your occupation that also could be relevant for others • a person was able to assist you related to a problem and therefore you distribute his or her contact information
end	you made a knowledge source accessible for those interested

4.5 Update

description	the process of keeping up-to-date about activities and topics and of understanding them
beginning	you need to get an overview of activities and topics
occasions (examples)	• you return from holidays or pick up an activity after a longer time • you join a project and initially need to get an overview
end	you have a general overview and accomplished further steps in direct connection

4.6 Feedback

description	the use and subsequent evaluation of knowledge
beginning	you have applied knowledge and you would like to give feedback to others
occasions (examples)	• you discover that a document needs updating and thus you inform someone responsible for it • you found a contact helpful thus you pass it on to a colleague with an appraisal
end	knowledge is evaluated and accessible for others

4.7 Expert search

description	the search for people that with a high probability are knowledgeable in certain topic areas
beginning	you search for a person within a roughly known problem area or topic area
occasions (examples)	• you have a concrete problem in relation to your tasks and search for somebody that may help you • you familiarise yourself with a new topic – questions arise and you would like to know who is knowledgeable concerning this topic
end	you have communicated with a competent person which influences your tasks

4.8 Invitation

description	the invitation of an appropriate member to an event in the context of an informal network, e.g., for the communication about a topic
beginning	you would like to invite a person from a group of possible participants to an informal network or an event in this context
occasions (examples)	• you would like to invite and inform potentially interested people into a network, e.g., a working or interest group • an event is going to happen, e.g., a workshop, meeting, or presentation and you would like to invite interested people
end	a new member is part of the network or has visited the event respectively

5. Quantity structure of knowledge actions

knowledge action	description	quantity per week
authoring	the creation of contents in order to share and transfer documented knowledge	
co-authoring	the creation of contents by multiple people in a reciprocal process	
training	the identification and use of a suitable training unit	
acquisition	the evaluation, enhancement and brokering of an external knowledge source	
update	the process of keeping up-to-date about activities and topics and of understanding them	
feedback	the use and subsequent evaluation of knowledge	
expert search	the search for people that with a high probability are knowledgeable in certain topic areas	
invitation	the invitation of an appropriate member to an event in the context of an informal network, e.g., for communication about a topic	

6. Further characterization of occupation

The following statements characterize your work activities. Please rate the degree to which they apply based on the given scale.

	no / strongly disagree	disagree	weakly disagree	undecided	weakly agree	agree	strongly agree
	1	2	3	4	5	6	7
Organisation							
a) I always work together with many changing cooperation partners.							
b) Number of roles that I simultaneously fulfil, e.g., project manager, administrator, trainer:							
c) Number of project teams I am currently a member of:							
d) Number of other work-related (informal) groups I am currently member of:							
e) Very often, I work together with cooperation partners external to my organisational unit.							
f) My work is mainly evaluated based on quantitative measures, e.g., turnover.							
Work tasks							
g) A long time for training is necessary to independently conduct my work (>> 0.5 years).							
h) I have a large room for decisions concerning the way how I do my work.							
i) Sharing knowledge is a vital part of my tasks, e.g., on the phone, in trainings.							
IT support							
j) The largest share of my time I work with mobile information technologies, e.g., personal digital assistant, notebook – cellular phones excluded.							
k) Semi-structured data & information, e.g., presentations, text documents, are more relevant for my work than structured data & information, e.g., forms, figures.							
l) It is absolutely necessary for my work to always have network access, e.g., to the Intranet, Internet.							

Appendix B: Frequency of steps

Table 35 lists the number of interviews where a type of step was identified as absolute and as relative value in relation to the number of interviews about a specific knowledge action.

	authoring		co-authoring		training		acquisition		update		feedback		expert search		invitation		sum
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.
expressing																	
archive contents			2	0.18													2
annotate contents	1	0.08									1	0.09					2
maintain access privileges	2	0.15	1	0.09													3
assure quality of contents	1	0.08	2	0.18													3
release contents	1	0.08	3	0.27													4
generalize contents	2	0.15	1	0.09							1	0.09					4
create personal draft	3	0.23	1	0.09													4
consolidate final version			4	0.36													4
assign or maintain meta-data	4	0.31	2	0.18													6
coordinate co-authoring	1	0.08	6	0.55													7
assign responsibilities	1	0.08	6	0.55													7
use similar content as starting point	5	0.38	4	0.36													9
select storage location	6	0.46					1	0.09					1	0.08	1	0.08	9
request approval of contents	4	0.31	5	0.45													9
share contents with co-authors			11	1.00							1	0.09					12
select and use standard template	5	0.38	7	0.64													12
structure repository	6	0.46	5	0.45	1	0.09	1	0.09									13
request feedback about contents	7	0.54	7	0.64			1	0.09									15
store contents	9	0.69	2	0.18	5	0.45	7	0.64			1	0.09	1	0.08	7	0.58	32
forward contents	9	0.69	4	0.36	2	0.18	7	0.64	1	0.08	1	0.09	3	0.25	6	0.50	33
create or change contents	13	1.00	11	1.00	1	0.09	1	0.09			2	0.18	3	0.25	2	0.17	33
sum	80		84		9		18		1		7		8		16		223
translating																	
request approval of training					1	0.09											1
book course					1	0.09											1
report on course					2	0.18											2
participate in Webinar					3	0.27											3
instruct information agent							3	0.27									3
order textbook					3	0.27	1	0.09									4
use training materials					4	0.36											4
take examination					5	0.45											5
investigate internal knowledge base					1	0.09	3	0.27	1	0.08							5
determine receivers					1	0.09	4	0.36									5
conduct Internet inquiry							4	0.36	2	0.17							6
use CBT/WBT					5	0.45					1	0.09					6
organise journey					7	0.64											7
notify about contents	2	0.15			1	0.09	4	0.36									7
determine learning goals					7	0.64											7
identify training					11	1.00											11
check selected external sites					5	0.45	3	0.27	5	0.42			1	0.08			14
sum	2				57		22		8		1		1				91

Table 35. Overview of the number of steps identified

	authoring		co-authoring		training		acquisition		update		feedback		expert search		invitation		sum
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.
monitoring																	
request performance feedback											1	0.09					1
check audio messages									1	0.08							1
rate contents											2	0.18					2
filter information							3	0.27									3
evaluate support							1	0.09					2	0.17			3
evaluate agent results							3	0.27									3
check reports									4	0.33	1	0.09					5
participate in Jour Fixe									6	0.50					2	0.17	8
maintain task list									8	0.67							8
maintain appointments									8	0.67							8
forward corrections									1	0.08	7	0.64					8
evaluate training					8	0.73											8
access internal news									8	0.67							8
check email									10	0.83							10
stay aware about content changes	1	0.08	8	0.73					2	0.17							11
sum	1		8		8		7		48		11		2		2		87
networking																	
register at workspace															1	0.08	1
define required competences													2	0.17			2
collect meeting topics															2	0.17	2
maintain competence directory					1	0.09							2	0.17			3
identify information agent							3	0.27									3
verify availability							1	0.09					3	0.25			4
collect meeting registrations															4	0.33	4
acquire meeting resources															5	0.42	5
open support ticket							2	0.18			1	0.09	3	0.25			6
establish contact					4	0.36	1	0.09					1	0.08			6
advertise meeting															6	0.50	6
navigate through network													5	0.42	2	0.17	7
make appointment													5	0.42	7	0.58	12
identify contact details			1	0.09			1	0.09					7	0.58	4	0.33	13
discuss topic					1	0.09	1	0.09			1	0.09	11	0.92	3	0.25	17
identify contact person	1	0.08	2	0.18	1	0.09	2	0.18					11	0.92	8	0.67	25
sum	1		3		7		11				2		50		42		116
number of interviews	13		11		11		11		12		11		12		12		93

Table 35. (*continued*)

Appendix C: Frequency of knowledge services

Table 36 lists the number of interviews where a type of service was identified as absolute and as relative value in relation to the number of interviews about a specific knowledge action.

	authoring		**co-authoring**		**training**		**acquisition**		**update**		**feedback**		**expert search**		**invitation**		**sum**
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.
publication																	
transformation	1	0.08									1	0.09					2
library					1	0.09	2	0.18									3
privileges	2	0.15													3	0.25	5
check-out	2	0.15	4	0.36							1	0.09					7
annotation	2	0.15	4	0.36					1	0.08	3	0.27					10
versioning	4	0.31	8	0.73													12
storage structure	4	0.31	4	0.36	1	0.09	1	0.09					1	0.08	1	0.08	12
template	6	0.46	7	0.64													13
content creation&change	11	0.85	11	1	1	0.09	1	0.09			3	0.27	2	0.17	3	0.25	32
storage	12	0.92	11	1	5	0.45	6	0.55	5	0.42	3	0.27	2	0.17	6	0.5	50
sum	44		49		8		10		6		11		5		13		146
discovery																	
query	2	0.15	1	0.09									1	0.08			4
knowledge map					1	0.09							3	0.25	1	0.08	5
competence-based search	1	0.08	1	0.09	1	0.09							7	0.58			10
notification agent			3	0.27	2	0.18	1	0.09	4	0.33			2	0.17			12
contact directory			2	0.18	1	0.09	3	0.27			1	0.09	8	0.67	5	0.42	20
full-text search	2	0.15	2	0.18	6	0.55	6	0.55	2	0.17			3	0.25			21
Web request	2	0.15			5	0.45	7	0.64	3	0.25	1	0.09	5	0.42			23
sum	7		9		16		17		9		2		29		6		95
collaboration																	
text chat					1	0.09											1
video					1	0.09									2	0.17	3
availability							1	0.09	1	0.08			2	0.17			4
application sharing	1	0.08			3	0.27					1	0.09					5
support ticket							2	0.18			2	0.18	3	0.25			7
distribution list			2	0.18			2	0.18	1	0.08					3	0.25	8
discussion forum	1	0.08			2	0.18	3	0.27					1	0.08	1	0.08	8
task list	1	0.08	1	0.09					7	0.58							9
poll					4	0.36					3	0.27	2	0.17			9
news channel	1	0.08			1	0.09			9	0.75					3	0.25	14
calendar	1	0.08	4	0.36	6	0.55	1	0.09	9	0.75			6	0.5	8	0.67	35
phone	4	0.31	2	0.18	3	0.27	6	0.55	5	0.42	3	0.27	11	0.92	7	0.58	41
email	10	0.77	10	0.91	7	0.64	11	1	11	0.92	8	0.73	11	0.92	11	0.92	79
sum	19		19		28		26		43		17		36		35		223
learning																	
evaluation					2	0.18											2
learning authoring	1	0.08			1	0.09											2
course request					4	0.36											4
training provision					6	0.55					1	0.09					7
training directory					9	0.82											9
sum	1				22						1						24
number of interviews	13		11		11		11		12		11		12		12		93

Table 36. Overview of the number of knowledge services identified

Appendix D: Services and application front-ends

Table 37 for every interview lists the quotients of the number of services and the number of application front-ends classified according to the organisations and knowledge actions surveyed.

	authoring	co-authoring	training	acquisition	update	feedback	expert search	invitation
O.01	1.50, 2.00	2.00	1.33	1.00	2.00, 2.00	1.00, 1.00	1.33, 1.00	1.60
O.02	0.50	1.00, 2.33	0.80, 0.91	1.40	0.60	1.00	3.00	1.67, 1.60, 1.00
O.03	1.00	1.20, 1.33	1.25	0.67	1.48	1.00	1.00	0.75
O.04	1.20	2.00	0.60	1.50, 1.50	1.50, 2.00	1.00	1.40, 1.00	1.33, 1.50
O.05	1.00	1.20	1.40, 1.00	1.17	1.00	1.00	2.50	1.50
O.06	2.67, 2.25	1.17	2.25	2.00	1.00	1.20	1.60	1.75
O.07	1.67	2.60	2.00	1.25	1.25	1.00	1.00	1.00
O.08	1.00, 1.00	1.50	1.00	1.00, 1.20	1.50, 2.00	1.00, 1.00	1.50	2.00
O.09	1.25	1.25	2.20	1.25	0.88	2.00	1.50, 1.50	1.50

Table 37. Quotients of the number of services and the number of application front-ends