Improved Approach to Quality Control of Telecommunication Service Providers

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Abstract: The modern development of telecommunications and telecommunication providers requires an increasing level of service provision. It is explained by the fact that the formation of a market for network services has increased attention to issues of quality control, both by regulators and by providers themselves. To ensure compliance with the specified level of quality of service provision, telecommunication providers develop algorithms and solutions to control the quality of service provision, based on different criteria, by themselves. However, these solutions are not universal for different types (quantitative, qualitative, etc.) of service quality indicators. This article proposes an improved approach to quality control of telecommunication service providers. The implementation of the proposed approach is performed using the ontological model of service quality indicators given by the provider and the dynamically changing workflow, which provides versatility and computer-aided quality of service control. The proposed approach allows to make the process of quality control of service delivery transparent and reduce the involvement of expert analysts in this process.

1 INTRODUCTION

In the modern world, there is growing number of providers which provides services of various types: from Internet access and telephony to content providers, over the top services etc. This growth is due to the fact that digital services are gaining more relevance and demand, also the competition in the environment is increasing. This is a reason why it is necessary to calculate the quality of service provision, to standardize it and to comply with the rules dictating the competitive environment.

The purpose of the standard is to determine a unified approach for providers and other stakeholders to evaluate the quality of communications services based on user opinions and to calculate some technical indicators. Based on this standard, business entities operating in the field of telecommunication services can develop their own (internal) regulatory algorithms for controlling the quality of telecommunication services, taking into account different parameters of the service delivery system. The results of the control of the quality of telecommunication services are used in the analysis of the effectiveness of the functioning of the quality management system, certification of services, making management decisions on improving the quality of telecommunication services.

Considering that there are many factors that affect the quality of service which are interconnected in different ways, it becomes necessary to computer-aided control process.

There are two types of parameters related to the service quality control: parameters (indicators) of the quality of network operation (Network Performance, NP) and indicators quality of service (QoS). NP is determined by the performance of individual network elements or the performance of the entire network as a whole. QoS parameters characterize the quality of services provided from a user perspective and may not always be expressed in technical terms.

Considering the above factors, numerous studies are being conducted in the world, aimed at the tools development and optimization of the quality of service control processes.

Therefore, in the context of the topic of analysis of quality of service, it's an important question how to realize the process automation and encapsulation of complex algorithms from the end-user in order to provide a more accurate control of the parameters of the quality of service and increase the efficiency of the provider company by simplifying the work with this process.

This paper is organized as follows. After the Introduction, section 2 contains the state of the art of the approach to control the quality of services provided by the telecommunications provider. Section 3 is devoted to the formalized description of computer-aided business process design based on ontology meta-models. Also, the third section provides the solution to the problem and further research perspectives. Section 4 – conclusion – includes the summary and outlook on future work.

2 STATE OF THE ART AND BACKGROUND

Service quality research has been conducted on a number of occasions, using different methods and algorithms.

For example, taking QoS control into account, such groups of non-technical parameters as preliminary service information (integrity of preliminary information, price transparency, availability, time to look for information), provider-user contract (integrity of contract information, compliance with the contract, simple extension of the contract), provision of services (fulfilment of the term of service, speed of service, completeness of the contract, punctuality of delivery of devices [1]), replacement of service (service replacement time, punctuality, simplicity of replacement), technical support (complaints management, complaints response, complaints management effectiveness), etc. [2].

It is also worth noting that often to describe the quality of service, the technical indicators of the telecommunication system, such as download speed, upload speed, voice quality, network coverage, reliability, uptime, downtime, etc.[3], are explored.

Each of the parameters is described by a set of criteria, which in turn impose limits on the allowed parameter values and thus normalize the quality of service delivery. This means that in order to control such indicators, it is necessary to involve a telecommunications expert who possesses a certain set of knowledge and skills that is not always beneficial for organizations.

It is proposed computer-aided process of quality of telecommunication services control by forming and executing a workflow that is generated from the ontology of the research area. This will make the control process more encapsulated and therefore easier to use by the end-user without additional programming costs to save material and time resources.

3 PROBLEM DEFINITION

Based on previous research [4-6], the purpose of the work is to develop a solution for executing complex computational scenarios through coordinated interaction of web services (microservices) on the basis of service-oriented (microservice) architecture using an ontological knowledge base.

The main task is to modify the centralized form of service interaction ("orchestration") in such a way as to exclude low-level details of the description of interaction scenarios while maintaining the rules of service interaction in the knowledge base [7,8]. By orchestration, we mean centralized coordination of components of a distributed software system in order to organize a coordinated interaction to achieve the desired effect – the implementation of a given workflow to implement the appropriate process. We will consider a separate process in the context of a particular area, in this case – in the context of controlling the quality of service provided by a telecommunications provider. This will preserve the approach of some encapsulation since the end-user (for example, expert analyst, management of the provider organization) will be excluded from direct control process according to certain algorithms. Also, this solution can be used as a universal solution, because when you replace the main algorithms in the workflow, you don't need to replace other indicators.

An ontological data model is proposed as a domain data model that can be represented as a tree structure.

In general, an ontology means a system of concepts of some domain, which is represented as a set of entities connected by different relationships. Ontologies are used for the formal specification of concepts and relationships that characterize a particular area of knowledge. The advantage of ontologies as a way of presenting knowledge is their formal structure, which simplifies their computer processing [9,10].

In the general case, the ontology domain is formally represented by an ordered three:

$$O = \{X(w, s, q), R(w, s, q), F\}, \quad (1)$$

where X, R, F – the finite sets appropriately: X – the set of registries (X_w – workflow registry, X_s – services registry, X_q – query registry,), R – the set of relationship between registries, F – the set of the interpretation functions X and/or R.

The ontological structure allows working with heterogeneous, unstructured data.

In order to create an ontological structure, it is necessary to analyze the domain, identify the basic structural bases and describe them.

For example, four major registries have been identified to build a solution for the quality of service control by telecommunications providers:

- Services registry;
- Microservices registry;
- Workflow registry;
- Query registry.

Services registry is an ontological structure that contains a list of all services provided by a telecommunications provider.

The registry lists the main services of the provider: they are divided into classes (Internet, TV, Over-The-Top Content (OTT)), the level of service (top lever offers, second-level offerings), the service characteristics, type of users, valid values, etc. are specified. All service data can be viewed in a structured manner using an object ontology.

Microservices registry is an ontological structure that is a tree of services that will be used to control complex technical parameters, which in turn are part of an overall assessment of service quality.

To describe each microservice, a mathematical model, represented as (2), was used:

$$M_i = \{Ip_{i..j}, Op_{i..j}, A_i, T_i, P_{i..j}\}, \quad (2)$$

where $Ip_{i..j}$ – input data which requires for the microservices; $Op_{i..j}$ – output data; A_i – algorithm of microservice; T_i – the type of microservice output data (quantitative, logical); $P_{i..j}$ – processes which should provision before current microservice.

Following this description for each microservice, it is necessary to take into account all the indicators that will be required when performing the algorithm of controlling a certain quality indicator.

In the developing solution, all microservices will play the role of a "black box", which means that the expert creates such a microservice once and uses it in further calculations without going into detail.

Workflow registry is an ontological structure containing a set of computational scripts to execute a workflow with the described parameters.

Workflow consists of an orchestrated and repetitive structure, which is provided by the systematic organization of resources into processes that transform materials, provide services or process information. This can be depicted as a sequence of operations, the work of a person or group, the organization of the work of staff, or one or more simple or complex mechanisms. From a more abstract or higher level, a workflow can be considered as a kind or representation of a sequence of execution, taking into account the content of the stages of real work [11]. The described flow may refer to a document, service, or product that is transmitted from one step to the next. Workflow can be seen as one of the main components that must be combined with other parts of the organization such as information technology, teams, projects and hierarchies [12]. In this case, the workflow will consist of microservices and describe their sequential or parallel execution.

The mathematical model presented in (3, 4, 5) is used to describe each workflow.

$$W_i=\{Ip_w, Op_w, D_w, Dg_w, Pr_w\}, \quad (3)$$

where Ip_w – input workflow data; Op_w – output workflow data; D_w – diagrams description; Dg_w – BPMN diagram which connected with specific workflow and its representation; Pr_w – priority of workflow provisioning.

$$Ip_w = \cup_{M_n}^{M_k} Ip_{i..j}, \quad (4)$$

where Ip_w – input workflow's data, which represented as the intersection of all input data $Ip_{i..j}$ by all microservices $M_n...M_k$.

$$Op_w = \cup_{M_n}^{M_k} Op_{i..j}, \quad (5)$$

where Op_w – output data for workflow which represented as the intersection of all output parameters $Op_{i..j}$ by all microservices $M_n...M_k$.

As indicated in (3), an important component of the workflow registry description is the BPMN diagram, which is a representation of the workflow execution process. Business Process Model and Notation (BPMN) is a notation system for modelling business processes [13]. BPMN is a standard for business process modelling, providing graphical notation for defining a business process in the form of a Business Process Diagram (BPD). Such a diagram is based on a business process representation in the form of a flowchart that is semantically similar to an activity diagram [14].

BPMN aims to support the modelling and management of processes or microservices. At the same time, a unified business process model should be clear to all users (stakeholders). Nevertheless, the notation makes it possible to define complex semantics of processes [15, 16].

Workflow registry provides a description of each workflow step in the form of a BPMN diagram showing the sequence of microservices execution and the dependency between them, which is to some extent the orchestration of services.

Query registry is an ontological query structure, presented in the form of query descriptions and their corresponding workflow. The mathematical model of the query registry is presented in (6).

$$Q_i = \sigma_C(W_i), \quad (6)$$

where Q_i – query, which should be entered by the user; σ_C – the function of selection appropriate workflow by the condition C; W_i – appropriate workflow.

Each query is matched to the corresponding workflow and causes its execution.

So, in sum, all four registries are semantically interconnected. Because the query registry is a set of queries that can be entered by the user and invokes the corresponding workflow from the workflow registry. In turn, the workflow starts orchestrating the microservices in the order that is reflected in the workflow using the service registry. And running microservices can query the service registry for more information about a particular service and its data. Figure 1 shows a flowchart for the process described.

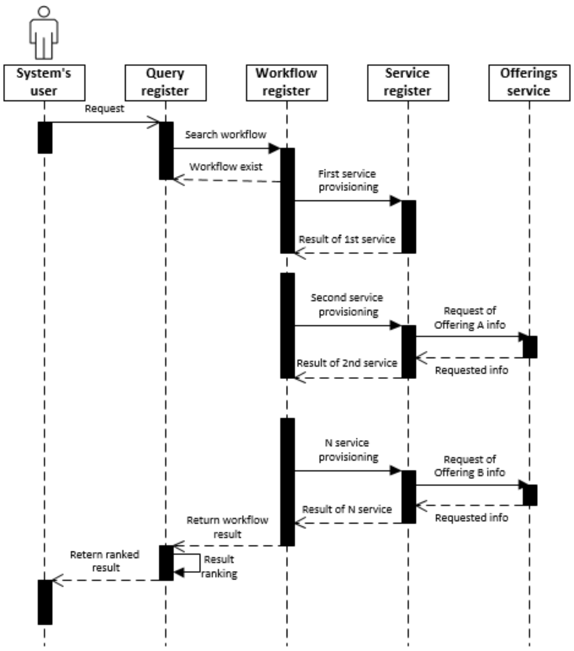

Figure 1: The sequence diagram of the solution's registries.

As a result of the algorithm, if the user prompts a query to calculate the quality of service, the system, having received the result, is forced to rank it by certain criteria. Therefore, the following criteria were developed to evaluate the result (Table 1).

Table 1: Criteria for ranking the quality of service delivery.

Mark	Description
-3	The quality of service is quite poor. Most of the technical indicators are much lower, user reviews are negative. The deviation of the real indicators from the norm exceeds on average 20%.
-2	The quality of service is not satisfactory. Technical indicators are lower than normal, average deviation within 10-15%. There are complaints from users. The information provided to users is in a difficult place.
-1	The quality of service is not satisfactory. Technical indicators are lower, by an average of 5-10%. There are complaints from users. Very little information is provided to users.
0	The quality of service is neither unsatisfactory nor satisfactory. There was no quality assessment or no input to get started.
1	The quality of service is low but satisfactory. The deviation from the norm of some technical indicators is in the range of 0-5%. There are almost no complaints from users. All the information that the user needs is publicly available and several queries are required to use it.
2	The quality of service is medium and satisfactory. The deviation from the norm of technical indicators is quite small, in the range of 0-3%. There are no complaints from users about the quality of services. All the information that the user needs is publicly available and several queries are required to use it.
3	The quality of service is high and satisfactory. Deviation of technical indicators from the norm is almost not observed. All parameters are within the range of acceptable values. There are no user complaints. All information the user needs is publicly available.

Thus, an approach to determine the quality of service by telecommunication providers is proposed. The essence of it is to formalize the 4 main entities (service registry; microservice registry; workflow registry; query registry) involved in the process of their control, as well as the universal mechanism of formation workflow when determining the quality of service, taking into account the specificities of the contract of a particular user.

The proposed approach has the following advantages over the known ones:

- Versatility of use in any subject area, by downloading the relevant data in the registries.
- Computer-aided process of quality of service control, which contains a large number of heterogeneous parameters, which, in turn, are calculated by complex algorithms.
- Encapsulation of the solution, enabling the use of the presented solution by employees of any level, without the involvement of an expert analyst.
- Ability to computer-aided workflow modification when performing quality of service control procedures in accordance with an ontological structure that describes service requirements.

CONCLUSIONS

Development of software components for executing complex computational scenarios through coordinated interaction of web services (microservices) on the basis of service-oriented (microservice) architecture with the use of ontological knowledge base will allow computer-aided process of quality of services control by telecommunication providers.

This approach is universal and takes into account the peculiarities of the domain due to the fact that each procedure for the control of a specific indicator is implemented in the form of microservices, and workflow is dynamically formed from a set of microservices that correspond to those involved in the process of quality control indicators described in the ontological model.

The proposed approach to the computer-aided business processes design and their components (microservices, communications, and interaction rules) based on computer-aided generation of a set of services that are components of workflows, as well as computer-aided formation the sequence of their execution through the use of ontology – a meta-model of workflow, domain, logical rules, services that establish relationships between functional services.

Using the described approach to computer-aided workflow construction allows to choice of a functional input processing service, and this is a very important factor in real-time systems because depending on the data, the most efficient method for processing in the shortest period of time can be selected.

Using the domain ontology as a registry of functional services will help computer-aided business process building and identify a functional service from many other services that most closely matches the conditions of use that are determined by the incoming data stream.

Further research will be devoted to a more detailed consideration of the computer-aided workflows design from microservice sets and, in part, the program code computer-aided generation for the workflows' execution.

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