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# APPLICATION OF UNCONDITIONAL OPTIMIZATION METHODS IN THE DEVELOPMENT OF INTEGRATED BUSINESS - MODELS OF PRODUCTION AND CONSUMPTION OF INFOCOMMUNICATIONS

**Abstract.** The **subject matter** of the article is information processing in the production and consumption of infocommunication services in multiservice networks. The **goal** of the study is to investigate the process of information processing in multiservice networks and to identify the quality class management tasks of infocommunication services production and consumption could be connected by methods of the several variable functions unconditional optimization. **The tasks** to be solved are: to analyze the processes of production and use of infocommunication technologies, taking into account the possibility of their optimization according to the *QoS* procedure; to propose a formulation of the *QoS* procedure optimization problem in a form suitable for solving by unconstrained optimization methods; to investigate the unconditional optimization application possibility of the methods according to the *QoS* procedure in the production and consumption of infocommunication services. General scientific and special **methods** of scientific knowledge are used. The following **results** were obtained: On the basis of the analysis of production processes and use of information communication services in different segments of the service market the possibilities of infocommunication services optimizing for QoS procedures were identified. The problem of optimization in multiservice networks providing QoS to be formulated as a problem of unconditional optimization of the two variables function. The possibility of applied use of methods of crazy optimization of QoS procedure is shown on the application of integral business model of convergent production and implementation of information communication services. **Conclusions.** The production and use of infocommunication services today is convergent. The definition of a single variable for the coordination of processes in the entire chain of production and consumption of infocommunication services on a unified criterion will support *QoS* convergent production and implementation of infocommunication services. Really, the analytical method is practically not implemented in multiservice networks, as it is difficult to approximate the second derivative. If a simple approximation of the first derivative is possible, use gradient methods. The simplest to implement method is considered to be the method of fragmentation of the step. The definition of optimization paths by the *QoS* procedure will provide in the multi-service networks in the field of state regulation the necessary reliability, security and efficiency, in particular by optimizing the time of packets.

**Keywords:** Quality of Service, multiservice networks, numerical optimization methods, infocommunication services.

## Formulation of the problem and research tasks

The different types of economic activities of infocommunication functioning varies in their organizational structures, business processes, development patterns and causes the need to implement different ways to improve the properties of the production and consumption of infocommunication services. (ICS). The emergence of new players in this services market segment, the allocation of the service sphere of infocommunication and increasing role dictate the need to develop new science-based approaches to create business models based on costs and results of all market participants.

With the replacement of traditional communication services by new multiservice and stiff competition on the part of mobile ICS, a contradiction arises between the increasing needs for information transfer and the diminishing capabilities of communication operators. The simultaneous provision of access to different services (standard telephony, IP telephony, WEB services, organization of virtual private networks) requires the development of methods for ensuring end-to-end guaranteed quality of communication services (Quality of Service, QoS) for the transmission of different types of traffic through the interacting networks of different operators. Given the abundance of QoS routing methods and QoS architectures, it becomes necessary to harmonize (harmonize) the latter.

In this regard, the development of business processes, methods, technological procedures and algorithms, optimal by one or more criteria for the compatibility of existing and prospective means of providing QoS of multiservice networks **seems relevant.**

**Analysis of recent research and publications.** indicate the relevance of the research. The eTOM (electronic Telecom Operation Map) architecture harmonizes the processes and functions in different systems of operational support for telecommunications operators through the same schemes [1].

This approach does not fully meet the goals of ensuring end-to-end QoS, since the presence of the same functions does not guarantee the compatibility of the mechanisms for implementing these functions, for example, at the compatibility level of the QoS feature lists.

The analysis in the source [2] allows us to conclude that there is currently no universal routing algorithm with QoS. Taking into account the technical and structural complexity of existing communication networks, the development of a universal algorithm is a difficult task to formalize.

The concept of quality metrics presented in [2] gives a certain formalization of traffic transmission quality assessment by several parameters (delay, delay jitter, cost of missing the load), but the mechanisms of its optimization are not fully disclosed.

The **goal** of the study is to investigate the process of information processing in multiservice networks and to identify the quality class management tasks of information and communication services production and consumption could be connected by methods of the sev-

 

eral variable functions unconditional optimization. This goal defined the following research **tasks**:

– to analyze the processes of production and use of infocommunication technologies, taking into account the possibility of their optimization according to the *QoS* procedure;

– to propose a formulation of the *QoS* procedure optimization problem in a form suitable for solving by unconstrained optimization methods;

– to investigate the unconditional optimization application possibility of the methods according to the *QoS* procedure in the production and consumption of infocommunication services.

General scientific and special **methods** of scientific knowledge are used.

## 1.Analysis of IC processes and the possibility of their optimization by *QoS* procedure

The production and use of infocommunication services today is convergent. The modern user of ICS consumes both communication services and information service in the form of content and applications, manufacturers and providers of services can be completely different in terms of both types of communication and services offered. In this case, the business related to terminals, content and applications, as well as direct customer service (contract, payment, service), can be an independent link in the chain of production and consumption of ICS. Different manifestations of convergence suggest that the convergence of different communication networks is functional in order to provide the client with the full range of services in one place from different terminals and access points.

The implementation of such goals is possible within the framework of the integrated business model, as it would reduce those ICS processes and optimize them for the purpose of the QoS procedure. When transferring tribute from multiservice fenders, call the service provider to assess the following key parameters:

– Bandwidth – the transmittance, characterizes the width of the channel;

– Delay – level of delay in sending the package;

– Jitter – number of receptions when sending packets;

– Packet Loss – the number of packets, characterizing the number of packets appear in the lower transmission.

The quality of the number control of the parameters is surrounded by the possibilities of the hedgehog possession. *QoS* detection is a whole mechanism that allows information to be given a smog throughput, lowering the level of jitter and catching up, gaining important packets from being lost [3].

In the process of data processing and transmission in the nodes of multiservice networks, in the general case, a fairly large set of optimization problems is considered. This set of tasks is formed, as a rule, network, transport and session levels of the reference model of open systems interaction (OSI), for example, in routing, traffic management, data processing, etc.

Note that the solution of the optimization problem involves the presence of an analytical function and the search for its minimum or maximum, ie the definition of a variable that would correspond to the quantitative value of the parameter of service quality. In the simplest case, this may be the time or number of packets or the time of a particular operation, such as the passage of a packet along a certain route.

This formalization will allow optimizing the quality of service in multiservice networks using a mathematical apparatus for studying functions within the differential calculus.

That is, the definition of a single variable for the coordination of processes in the entire chain of production and consumption of ICS on a unified criterion will support *QoS* convergent production and implementation of infocommunication services. This is very possible, as most ICSs are fairly deeply standardized and interchangeable. For example, communication or transmission channels of IP traffic are organized in different transmission systems and therefore can be interchangeable.

Thus, such a class of tasks can include the estimation of the time of a single packet passing through the return route in a multi-service network of an integrated model of the information communication business.

However, not all optimization tasks that arise in the process of information processing in MSS are reduced to finding extremes of single-valued functions.

In practice, the investigated system characteristics often depend on two or more parameters, i.e. the optimization problem is reduced to finding the extremum of a function with several variables.

A problem of this class in any case has considerable computational complexity and therefore the main emphasis when selecting methods of its solution is suitable to do exactly on the time of finding the solution, sometimes even at the expense of accuracy of the obtained result. Nevertheless, the mathematical apparatus of the analysis of functions, especially the crazy optimization of the function of several variables on the basis of differential calculus, can be used for solving problems of this class [4].

Thus, when considering real routing tasks, to analyze the packet transit time, one parameter is not enough, often several parameters of different sizes are analyzed, between which the valued coefficients are not set.

## 2. Ways to solve the optimization problem when providing *QoS* for multiservice networks

**2.1. Analytical optimization problem solution.** Let us consider the simplest case: dependence of the packet transit time on two parameters $x_1$ and $x_2$.

Analysis of the packet transit time in the multiservice network showed that it depends on two parameters ($x_1$ and $x_2$) which form a vector of parameters and can be reduced to the following analytical expression:

$$T = f(\bar{x}). \quad (1)$$

Therefore, the optimization task of providing *QoS* for multiservice networks can be formulated as follows:

to find *f**, which provides an estimate of the minimum packet time

$$T = f(x_1, x_2) \to min \quad (2)$$

and the corresponding parameter values

$$\bar{x}^* = \left(x_1^*, x_2^*\right). \quad (3)$$

If the optimized function can be given in analytical form, and there are its second derivatives on all arguments, the optimal solution can be found using standard methods of mathematical analysis of the function of several variables.

**2.2 Algorithm for solving the problem for two variables in a general form.** If two differentiated by all arguments, then f* can be found using the following algorithm:

A. We find stationary points of the function by equating its gradient to zero,

$$\left(\frac{\partial f}{\partial x_1}, \frac{\partial f}{\partial x_2}\right) = 0, \quad (4)$$

which is a necessary condition for the existence of a local extremum.

B. To determine the type of stationary point (a sufficient condition for the existence of a local extremum) it is necessary to construct its Hess (matrix of all partial derivatives of the function):

$$G\left(\bar{x}\right) = \begin{pmatrix} \frac{\partial^2 f}{\partial x_1 \partial x_1} & \frac{\partial^2 f}{\partial x_1 \partial x_2} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{d^2 f}{\partial x_2 \partial x_2} \end{pmatrix}. \quad (5)$$

C. To calculate the eigenvalues of Hessian as follows

$$det\left(G(\bar{x}) - \bar{\lambda} I\right) = 0 \quad \left(\bar{\lambda} = (\lambda_1, \lambda_2)\right). \quad (6)$$

If all Hessian eigenvalues are positive ($\lambda > 0$), then the stationary point is the local minimum of the studied function.

If all Hessian eigenvalues are negative ($\lambda < 0$), then the stationary point is the local maximum of the studied function. If the eigenvalues of the Hessian have different signs (or there are zero values), then the stationary point is the saddle point (for two variables, it is the saddle point of the surface that characterizes the studied function).

**2.3. Gradient method with step crushing.** Really, the analytical method is practically not implemented in multiservice networks, as it is difficult to approximate the second derivative.

However, if a simple approximation of the first derivative is possible, use gradient methods (more accurate than scanning, but also more expensive), for example:

- step splitting method;
- method of the fastest descent;
- Newton's method, etc.

According to the authors, the simplest to implement method is considered to be the method of fragmentation of the step [4].

## 3. Investigation of the unconditional optimization application possibility of the methods according to the *QoS* procedure in the production and consumption of infocommunication services

If necessary, at the junctions between communication networks that support different QoS algorithms, the tasks of generating and planning traffic flow can be solved, which partially allows to adapt the existing routing algorithm c *QoS* to the routing algorithms of the corresponding party. These include, for example, methods of reducing the effects of congestion, aggregation of homogeneous traffic flows on the best routes, re-routing of traffic in case of failure of communication equipment, and so on (Fig. 1).

Exceptions are services that are in the field of state regulation. Note that the expansion of the proposed optimization methods in the production and consumption of infocommunication services can be effective, as the integrated model of convergent production and implementation of ICS is inherent in the field of state regulation with precision to tariff policy [6].

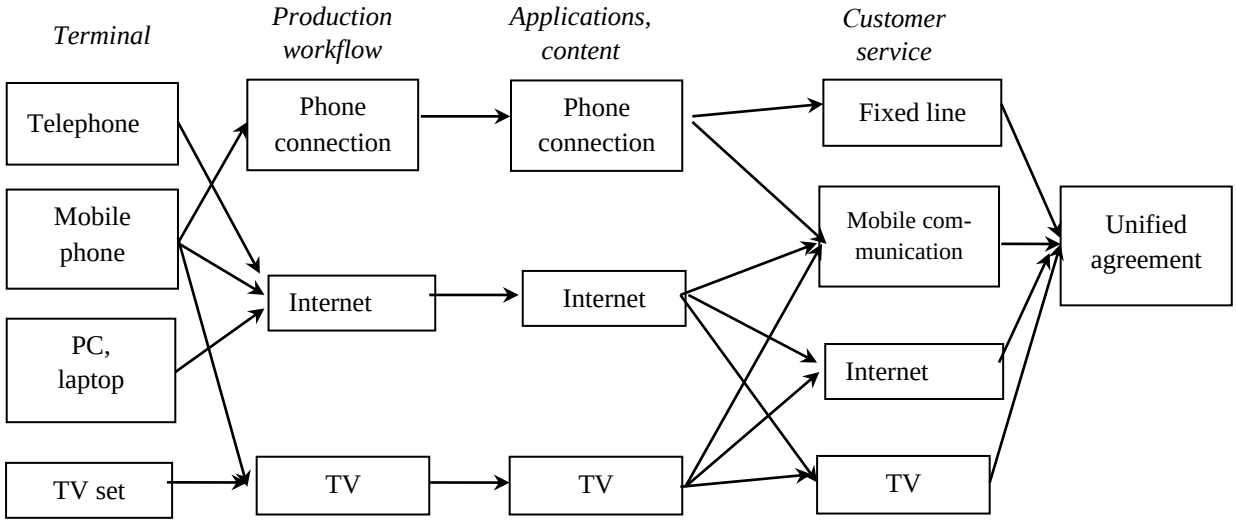


**Fig. 1.** Integrated model of convergent production and implementation of infocommunication services

Moreover, the definition of optimization paths by the *QoS* procedure will provide in the multi-service networks in the field of state regulation the necessary reliability, security and efficiency, in particular by optimizing the time of packets [7-9].

## Conclusions

1. The production and use of infocommunication services today is convergent. The definition of a single variable for the coordination of processes in the entire chain of production and consumption of ICS on a unified criterion will support *QoS* convergent production and implementation of infocommunication services.

2. Really, the analytical method is practically not implemented in multiservice networks, as it is difficult to approximate the second derivative. If a simple approximation of the first derivative is possible, use gradient methods.

The simplest to implement method is considered to be the method of fragmentation of the step.

3. The definition of optimization paths by the *QoS* procedure will provide in the multi-service networks in the field of state regulation the necessary reliability, security and efficiency, in particular by optimizing the time of packets.

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**Застосування методів безумовної оптимізації при розробці інтегральної бізнес - моделі виробництва і споживання інфокомунікаційних послуг**

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**Анотація. Предметом вивчення** в статті є процес обробки інформації при виробництві і споживанні інфокомунікаційних послуг в мультисервісних мережах. **Метою статті є** дослідження процесу обробки інформації в мультисервісних мережах та виділення класу задач управління якістю виробництва і споживання інфокомунікаційних послуг, які могли б бути розв'язані методами безумовної оптимізації функції декількох змінних. **Завдання дослідження:** проаналізувати процеси виробництва та споживання інфокомунікаційних послуг з огляду на можливості їх оптимізації за процедурою QoS; запропонувати формулювання задачі оптимізації за процедурою *QoS* у вигляді, придатному для розв'язання методами безумовної оптимізації; проаналізувати можливість прикладного застосування методів безумовної оптимізації за процедурою *QoS* при виробництві і споживанні інфокомунікаційних послуг. Методологічною основою дослідження стали загальнонаукові та спеціальні **методи** наукового пізнання. **Отримані наступні результати:** На онові аналізу процесів виробництво і використання інфокомунікаційних послуг у різних сегментах ринку послуг визначені та можливості оптимізації інфокомунікаційних послуг за процедурою *QoS*. Задача оптимізації при забезпеченні *QoS* мультисервісних мереж бути сформульована як задача безумовної оптимізації функції двох змінних. Можливість прикладного застосування методів безумовної оптимізації за процедурою *QoS* показана на прикладі інтегральної бізнес-моделі конвергентного виробництва і реалізації інфокомунікаційних послуг. **Висновки.** Виробництво і споживання інфокомунікаційних послуг сьогодні носить конвергентній характер. Визначення єдиної змінної для узгодження процесів в усьому ланцюзі виробництва і споживання інфокомунікаційних послуг за єдиним критерієм дозволить здійснювати підтримку *QoS* конвергентного виробництва і споживання інфокомунікаційних послуг. Визначення шляхів оптимізації за процедурою *QoS* надасть змогу забезпечити в мультисервісних мережах сфері державного регулювання необхідну надійність, захищеність та оперативність, зокрема шляхом оптимізації часу проходження пакетів. Оскільки застосування аналітичного методу передбачає апроксимацію другої похідної, що, своєю чергою, викликає ряд практичних труднощів, у мультисервісних мережах його застосування є ефективним.

**Ключові слова**: якість обслуговування, *QoS*, мультисервісні мережі, числені методи оптимізації, інфокомунікаційні послуги.