ABOUT THE PROBLEM OF DEVELOPMENT OF MESSAGES STREAM MODEL IN THE CONVERGENT TELECOMMUNICATION NETWORK

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***Annotation**: Differences between calls stream and messages stream are formulated. Problem statement of development of the mathematical model of messages streams circulating in the convergent telecommunication network is carried out.*

***Keywords**: convergent telecommunication network, messages stream, calls stream.*

***Keywords classification of ACM**: H. Information Systems - H.1 MODELS AND PRINCIPLES, C. Computer Systems Organization - C.2 COMPUTER-COMMUNICATION NETWORKS.*

« … there is no completeness
without sadness and longing,
for without them there is
no sobriety, no kindness.
Wisdom without kindness
and knowledge without sobriety
are useless … »

C. Castaneda

Introduction

Convergent telecommunication network (CTN) is new object of research. It can't be carried directly to such known classes of networks as data transfer networks, telephone and data-processing networks, etc. [1] Accordingly, models of the processes proceeding in existing telecommunication networks (TN) and based on them methods of calculation of various parameters including the network equipment in their initial kind are not suitable now for the decision of problems of CTN research and designing. The existing TN intended for rendering service for users in the definite accurately limited area, i.e. user are being serviced by one or narrow spectrum of several services. Concept of CTN provides granting of unlimited spectrum of services and, besides it, assumes technical possibility of new network services' realization for provision of the network profitability in the future.

As it's shown in [2] under CTN we understand set of architecturally-technological methods and hardware-software tools of the information transfer to territorially remote users, allowing on uniform digital basis to provide various types of service on processing and delivery of the heterogeneous information, at provision of users requirements to timeliness, quality of delivery and preservation of value of the multimedia user information.

Common statement of the problem

The streams arriving and circulating into CTN are complex by their nature and structure. These streams represent heterogeneous, from the point of view of the information sources, aggregated, from positions of network technologies and protocols, traffic of the integrated information reflecting processes of interosculation and confluence of infocommunications.

Object of research within the limits of the decision of problem of the CTN messages streams model's development are two processes: process of interaction between the CTN and information metastructure and

process of the network servicing, proceeding in definite time intervals in definite points of space of CTN as big system. Subject of research - models and methods of the description of messages streams' structure in CTN. The research's goal provides increasing of efficiency of CTN performance by means of correction of messages stream model in CTN.

In aggregate it's necessary to research processes of information processing and delivery between two users, instead of points of CTN input/output. From this point of view we capture some functions of information networks processes as object of the research. But as it's only a small part of the functions defining difference of the TN from information networks, nevertheless we will leave processes passing in CTN as object of the research.

Information handling process is being investigated only from the point of view of the functions necessary for its delivery in CTN. We don't investigate processes of application, presentation, session layers of Open Systems Interconnection (OSI) model. The only exception is the decision of problem of determination and accounting of the information value's function. That is, we research the information processes which are pledge of successful performance of OSI model's three top levels' functions. However we don't research functioning of CTN hardware-software tools and surrounding it environment at these levels, if the pointed performance directly doesn't influence quality of delivery and value of the information. Thus, functioning of terminal equipment, switching nodes (SN), CTN data centres and external information metastructure in the course of delivery and handling of the information at session, presentation and application layers of OSI model is accepted as inertialless, clear and/or absolutely reliable.

Net-generatrix process of CTN representing essence of system functioning is process of the information transformation, realized by one or set of the information technologies, consisting of: computing process of the information transformation in space (input, output, storage and data processing) and information process of the information transformation in time (collecting, distribution, transmission, switching of streams). Thus it seems expedient to authors to consider other processes as external effects.

The quantitative side of network processes of the information transformation is object of research of the fundamental theory - teletraffic theory. For a long time teletraffic theory represented basic tool of TN research. However, the analysis of results of foreign and native scientists' researches of last two decades [3-9] points out impossibility of direct usage of existing teletraffic theory tool for TN research in view of the fact that it doesn't meet features of these networks which have been folded in last years. The same reason leads to impossibility of usage of earlier developed models and methods of the teletraffic theory in their initial kind at the CTN research.

Thus there are no alternative decisions in known publications. There are some decisions, however they have particular highly specialized character. Subject of interest is creation of the apparatus adequate to the actual state of affairs in infocommunication sphere, as a whole, and in CTN, in particular, on depth of study as much as possible close to mathematical apparatus of teletraffic theory.

Messages streams in the convergent telecommunication network

One of key elements of the teletraffic theory is the concept of the calls stream. The call represents the requirement of service. Taking into consideration that initially teletraffic theory represented the mathematical theory of network service processes mainly in the telephone networks characterized by method of channel switching and position multiplexing and also in the data transfer networks characterized by method of packets switching and label multiplexing, specifying of input stream was carried out by one of three ways: sequence of the call moments t_1, t_2, …, t_n, sequence of time intervals between the call moments z_1, z_2, …, z_n and sequence of numbers k_1, k_2, …, k_n, of the calls arriving during definite intervals of time $[t_0, t_1)$, $[t_0, t_2)$, …, $[t_0, t_n)$. Thus determination of parameter $\lambda(t)$ (limit of the relation of call receipt probability for time $[t, t + \tau)$ to the length of this

interval of time τ during the moment t) and intensity μ (mean of number of the calls arriving in unit of time) as basic characteristics of calls stream was sufficient.

Considering that technological basis of the information transportation regulated within the limits of architecture of Next generation networks (NGN) is its unified representation based on label multiplexing at switching of packets, cells or frames, as it's provided within the limits of CTN concept, the concept of the calls stream isn't proper approach for the mentioned networks research. This can be proved by following reasons.

It's not enough to speak only about requirement for information delivery: it's necessary to know what this information is (both with quantitative and from qualitative positions), what information content should be transmitted and in what way its transportation will be carried out. It is important to have such knowledge from the point of view of information transformation both in time and in space. Thus, it seems expedient to determine the concept of messages stream circulating in the network for the information transfer, as one of the basic at research of CTN and, established on the basis of CTN, NGN.

The analysis of the question research has shown that now there is no common theory of distribution and calculation of qualitative and quantity characteristics for messages streams in CTN [10-13].

The call is only the requirement of service by the network to provide the message transfer, and the message - that converted to electromagnetic signals information which is subject of transportation. According to this messages stream circulating in CTN, besides the distribution in time (of the calling moments, intervals between the calling moments, quantities of calls), should be defined by the information volume, concluded in separate messages. Thus the length of each of the messages coupled to one process of the user information transmission can be constant or change under certain laws, or uncertain random variable.

It's necessary to note that condition of the messages successful delivery is transportation also of service information, besides the users'. It leads to necessity of development of the formal apparatus for determination what exactly should be understood as service information and from what elements it consists. For this purpose it's necessary to provide analysis of all data, which is called control, with the subsequent allocation of the most from them, in view of practical impossibility of the account of all great many existing information transportation technologies' features. Besides it separate messages can be as a part of the whole semantic information volume, and to represent the finished semantic load within one message. The pointed dualism also should be formalized and considered at development of the CTN messages streams model.

The messages stream mode is defined by distribution of the moments of separate messages receipt or time intervals between these moments, by information content in each message and by number of other factors. According to [14] for the description of streams variety and information content in them it seems expedient to implement concept of user information message (UIM), representing the final sequence of the data formed for transmission and having finished semantic value. In network UIM are transmitted in the form of switched information units (SIU): packets, datagrams, frames, cells etc. Thus, proceeding from a ratio of quantity of elements in UIM and SIU, it's possible to implement suitable modifications of messages stream and to characterize stream volume by means of quantity SIU containing in it.

Besides it it's possible to allocate the determined, stochastic and mixed messages streams. At the determined stream each message appears during definite in advance time moments and has beforehand dedicated volumes. At stochastic streams moments of messages occurrence or intervals between them and volumes of separate messages are stochastic.

Requirements to messages delivery. One of the most important indicators is time of messages delivery t_D – time from the moment of originating of requirement for information transfer till its reception by the user. Here it takes place the information component of the information delivery process - information handling by the

recipient's terminal equipment, for example, process of gathering of separate messages in one ordered messages stream identical to the sent one. The telecommunication component of the information delivery process is limited to information receipt in CTN terminal node.

Also it is possible to set admissible time of delivery T_D^A and to implement the characteristic of probability of the message delivery in time:

$$p\left(t \le T_D^A\right) = \int_0^{T_D^A} \omega(t_D)dt ,$$

where $\omega(t_D)$ – density of message delivery time distribution function.

Taking into consideration features of the problem statement of this research, such characteristics as: response time, connection setup time, delay time and message transfer speed are excessive from the point of view of CTN messages streams' delivery time, as resulting criterion of requirements to messages delivery. In this connection the account of the pointed characteristics is optional.

In case of stochastic nature of time characteristics it's true to regulate dispersion of corresponding value.

Requirements to admissible probability of error occurrence can be presented at the consideration of the network processes coupled to session layer of OSI model, carrying out functions of establishment, maintenance, termination of session, and also to definite technologies of the information transportation.

The important characteristic of messages stream is value of the information - generally it's its consumer cost defined by that material effect which gives use of each message, for example, at management of object *A* during the moment *t*. In that case it can be both material prize and material losses in case if as a result of the received message it was necessary to make the expenses which have not given a positive effect. And also the ratio of the expenses received at realization of object management to achieve a goal depending on the received information. Besides it function of information value $Q(t)$ is characterized by an information priority, as its personal importance for the user, timeliness of delivery, the validity of the received information, and also function of emotional adequacy of information transfer $Sm(t)$. The problem of functions $Q(t)$ determination even for concrete systems, not speaking about the big system which is CTN, has no decision now.

CTN user as the information consumer isn't interested in technical tools providing realization of the pointed requirements at all. However their realization, especially taking into account economics and requirements on increasing of labour productivity of engineering-technical stuff, puts a number of complex technical-economical problems.

The messages streams circulating in CTN can be classified in the form of the N-dimensional matrix. Its dimension is defined by quantity of stream characteristics which are to be reflected. Matrix elements represent, accordingly, their coded designations for which it's possible to fix requirements to messages.

For example, as it's shown in [14] according to the information transfer mode, priorities and content types variety of CTN messages streams can be classified in the form of a three-dimensional matrix. Matrix elements a_{ij}^k are symbolic designations of messages, i.e. a_{ij}^k – code of the message of i^{th} content type, j^{th} priority on k^{th} switching mode. Each message, except the code, has characteristics p_0^A, T^A, D^A which can be fixed for each separate message where p_0^A – the maximum admissible probability of symbol distortion, T^A – the maximum admissible mean delay of UIM or SIU, D^A – the admissible dispersion of delay time.

By means of a message priority it is possible to point obviously, besides objective, subjective value of information message. It's necessary to note that the formal sign of the priority far is not always adequate from the point of

view of the user. For example, the long-distance incoming call (high priority: high cost of the call, the big connection path length) from the point of view of the called user at the certain moment of time can be much less important of the local call (low priority: one servicing SN, calls within a service area are free) «extremely important for me now».

One more possible variant of CTN messages streams classification is determination of the stream and its characteristics within the limits of spatio-temporal representation of internodes interaction in the CTN. For example, according to [15] it's possible to designate the messages stream as *Fm* and to consider requirements to messages delivery as the value depending on definite pair of CTN nodes, between which the messages stream circulates, and on time moment

$$Fm : I^2 \times T \to I\!R .$$

Values of this function, illustrated in fig. 1, can correspond both to values of real measurements between nodes at the definite time and to predicted parameters.

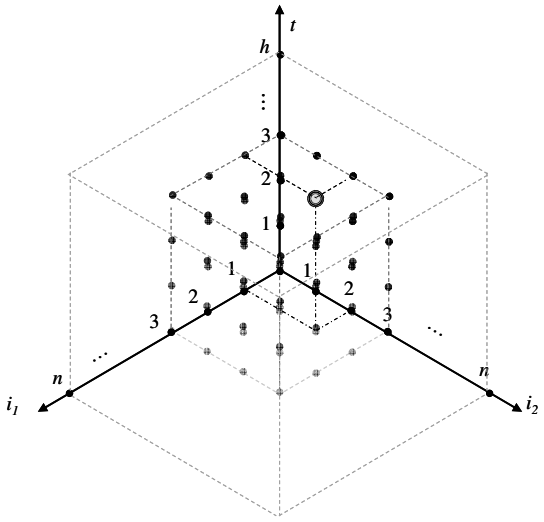

Fig. 1 Spatio-temporal representation of internodes interaction

At the spatial section of internodes interaction it's possible to fix the pair of nodes $< i, j >$ and to define its spatial section ς_{ij} as

$$\varsigma_{ij} : T \to I\!R , \ \varsigma_{ij}(t) = Fm(i, j, t) .$$

Thus, for each pair of nodes it's possible to define the function of one argument defining the messages stream, circulating between this pair of nodes during each moment of time. From this system it's simple enough to receive also the time cut. For these purpose we build square matrix of n^{th} order $Fm(t)$ at some fixed moment of time t so that

$$Fm(t) = \left\| \varsigma_{ij}(t) \right\| \in M_n(I\!R) ,$$

at the same time, considering discreteness and limitation of T, it's possible to speak about Fm as about final system of streams matrixes.

Process of the information messages stream delivery from its source is being splitted into stages:

– information delivery in CTN inlet point,

- forming of the message and its input in CTN,
- message transfer from inlet point to CTN outlet point,
- output from the CTN in kind convenient for further use,
- delivery to place of use.

Besides it justification of requirements to information delivery and handling is being essentially influenced by information transformation in the terminal equipment. However, considering assumptions of the given statement of the problem, this aspect hasn't been reflected meaningly.

At the researching of the messages streams circulating in CTN, in the course of network service process it's important to accurately define boundary of interaction between the network and information metastructure. Taking into consideration complexity and heterogeneity of CTN as big system, it seems expedient to authors at the development of CTN messages streams model to summarize these streams to definite streams modes, which are being defined by means of information content ratio in UIM and SIU. The question of development of appropriate apparatus of the formal description of messages streams and its modes is one of subtasks of the given research. At the same time for each special case of CTN service system it's necessary to specify characteristics of circulating messages stream and information metastructure, considering at that length of service path, possible recalls, etc.

Development of one unified model of CTN messages stream seems not possible in view of practical accounting impossibility of features of all number of the network service moment in CTN spatio-temporal cuts. If at the approximation of real statistics of messages streams it won't be possible to bring them directly to the modes of the messages streams apparatus, that is quite possible at research of CTN in real conditions, or it'll be necessity of development of messages streams model for big section of CTN it's possible to use superposition of the streams.

The messages stream model allows to define quantitative and qualitative characteristics of the streams circulating in CTN at: interaction between the CTN and information metastructure within the limits of processes of network service, transmission of messages streams through bypaths instead of the basic one, etc.

Thus, it's possible to determinate characteristics of mainly stochastic processes in CTN during the different moments and time intervals at different sections of the network. That is especially important, for example, at realization of interoperators interaction within the limits of sharing of common physical network's resource. Such special case can be result not only of market relations in infocommunication sphere, but also of pressing need of providers in the conditions of monopoly.

The question of CTN messages streams model's development, as a whole, and decisions of subtasks arising at that, in particular, is open and represents not trivial scientific problem.

Conclusions

1. Calls stream – the stream of requirements for messages transfer service. Messages stream – the stream of information transformed into electromagnetic signals. The calls stream is defined by sequence of the calling moments, sequence of time intervals between the calling moments and sequence of the numbers defining quantity of calls, arriving during definite intervals of time. The messages stream, besides the mentioned time characteristics, is defined by information content – volume of separate messages. According to this it's necessary to develop the apparatus of the formal description of information content in messages stream. It's necessary to determine distribution function of messages stream in time and distribution function of information content in messages stream.

2. The messages stream consist of both useful, from the point of view of the user-information consumer, and control, necessary for technical realization of transfer, information. According to this it's necessary to develop the apparatus of the formal description of control information in CTN messages streams.

3. The information unit with finished semantic value, depending on its dimension and technology of transportation, can be presented either as the messages stream, or the separate message. According to this it's necessary to develop the formalized apparatus for determination whether is the separate message the finished semantic unit or represents a part of the whole.

4. The information containing in the messages stream, has various value for the information consumer. Value of the information is defined by set of mainly badly formalized factors. According to this it's necessary to develop a formalistic approach for determination of the information value and to define function and/or set of functions of the information value.

5. Characteristics of intensity and stream parameter are sufficient for the determination of the calls stream. Much more characteristics are necessary for determination of the messages stream. According to this it's necessary to develop the formal description and the mechanism of determination of messages stream characteristics.

6. The priority of messages stream is defined both by formal sign - stream priority from the CTN technological point of view, and by subjective sign - private priority from the point of view of the user-information consumer. According to this it's necessary to develop the mechanism of formal determination of messages stream priority, including also conditions of fuzzy statement.

Thus, it's necessary to develop mathematical model of the messages stream circulating in the CTN. Such model should consist of: distribution functions of messages in time; distribution function of information content in messages; function of the messages information value; mechanism for determination of messages priorities; mechanism for determination of messages information integrity. Model's features are defined by parameters of processes of interaction between the CTN and information metastructure and network service in CTN.

On the basis of such mathematical model of the messages streams circulating in CTN, it's necessary to develop imitating model of CTN messages streams. Its check of adequacy can be carried out by means of comparison of modeling results with the real statistical data of existing telecommunication networks.

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Bibliography

1. Гайворонская Г.С. Анализ возможности использования математического аппарата теории телетрафика для описания взаимодействия конвергентной телекоммуникационной сети с внешней средой / Соломицкий М.Ю., Гайворонская Г.С. // Холодильна техніка і технологія. – Одеса: ОДАХ, 2011. – № 2 (103) – С. 61-67
2. Соломицкий М.Ю. Возможный подход к разработке модели трафика конвергентной телекоммуникационной сети / М.Ю. Соломицкий // Applicable Information Models. – Sofia: ITHEA, 2011. – № 22. – P. 189-198.
3. On the Self-Similar Nature of Ethernet Traffic (Extended version)/Will E. Leland, Murad S. Taqqu, Walter Willinger, Daniel V. Wilson// IEEE/ACM Transactions on Networking – 1994, February.
4. Statistical Analysis of CCSN/SS7 Traffic Data from Working CCS Subnetworks / Diane E. Duffy, Allen A. McIntosh, Mark Rosenstein, Walter Willinger // IEEE Journal on Selected Areas in Communications – 1994, April.

5. Crovella M. Self-Similarity in World-Wide Web Traffic: Evidence and Possible Causes / Crovella M., Bestravros A. // Proceedings, ACM Sigmetrics Conference on Measurements and Modeling of Computer Systems – 1996, May.
6. Long-Range Dependence in IEEE 802.11b Wireless LAN Traffic: An Empirical Study / Carlos Oliveira, Jaime Bae Kim, Tatsuya Suda // CCW 2003. Proceedings. 2003 IEEE 18th Annual Workshop on – Computer Communications, 2003.
7. Sergejs Ilnickis M/M/1 And G/M/1 Systems with a Self-Similar Input Traffic / Sergejs Ilnickis – 2004.
8. Geyong Min A Performance Model for Wormhole-Switched Interconnection Networks under Self-Similar Traffic / Geyong Min, Mohamed Ould-Khaoua // IEEE Tansactions on Computers – Glasgow, 2004.
9. В. Столлингс. Современные компьютерные сети / В. Столлингс. – [2-е изд.] – СПб.: Питер, 2003. – 783 с.
10. Давыдов Г.Б. Сети электросвязи / Г.Б. Давыдов, В.Н. Рогинский, А.Я. Толчан. – М.: Связь, 1977. – 360 с.
11. Гайворонская Г.С. Объединение потоков нагрузки на сетях связи с обходными направлениями / Г.С. Гайворонская // Труды УГАС «Информатика и связь». – 1998. – С. 128 -136.
12. Гайворонская Г.С. Служба пакетной передачи данных общего пользования сети стандарта GSM / Г.С. Гайворонская, А.Н. Кальнев //Труды УНИИРТ. – 2001. – № 2 (26). – С.57-61.
13. Гайворонская Г.С. Проблема синтеза пространственно-временной структуры телекоммуникационной сети / Г.С. Гайворонская // Вісник ДУІКТ. – 2007. – №1. – С. 117-122.
14. Советов Б.Я. Построение сетей интегрального обслуживания / Советов Б.Я., Яковлев С.А.– Л.: Машиностроение, 1990. – 332 с.
15. Гайворонская Г. С. Метод представления пространственно-временной структуры модернизируемой телекоммуникационной сети / Г.С. Гайворонская // Зв'язок. – 2006. – №8 (68). –С. 57-60.

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