Sessions and Services Management Models in NGN/IMS and Post-NGN Networks

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***Abstract*—Today NGN/IMS and post-NGN networks are creating a new digital society, where everything is connected and is accessible from anywhere. Because of it these networks are complex and very hard to manage. It is both difficult to manage the networks according to new requirements, and to do it on control and data planes in real time. We present in this paper a new complete approach for these networks management models and methods. The exist telecommunications networks management methods are oriented on fixed network architecture, stable traffic structure, bounded list of telecommunication services. New NGN/IMS and post-NGN networks requirements need to extend that models and methods with ideas and results from cognitive multi-agent models. In this paper we present such type of new networks management models and methods.**

I. INTRODUCTION

Next Generation networks (NGN) in present days are used in greater degree of provision of mobile subscribers, communication in social networks, the exchange of text messages, positioning, listening to music, viewing video clips, network games and many other entertainment applications in real time, multimedia conference communication, transfer of banking information and telemetry, Internet, the interaction of computers M2M, management in on-line mode, i.e. than for traditional telecommunications services [1]. New services require fundamentally new and rapidly changing approaches to decision-making in the management of telecommunications Operator, a regular re-evaluation provided for the adoption of information from the OSS / BSS (Operation / Business Support systems- support systems of operations / business) [2].

II. TWO APPROACHES TO TELECOMMUNICATIONS NETWORKS MANAGEMENT

Aforementioned dynamics of the change presented in the Fig. 1. Here we speak about two methods to control info communications. We can definite them like centralized fixed designing, and, otherwise, decentralized dynamic self-organization. Both of these approaches were always presented in communicational and computer networks managing in some proportion. Correlation between these methods is achieved a new way every time at next stage of info communication development.

Modern stage of synergy of these both approaches to info communication management is represented in 3GPP documents, devoted to SON (Self-Organization network), and in TM Forum documents.

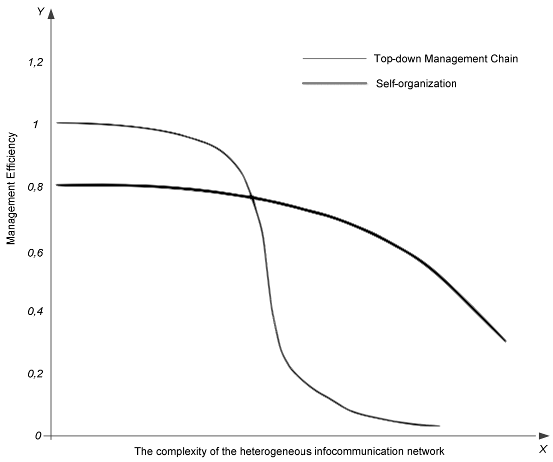

Fig.1. Dynamics of approach changing to info communication managing

The SON (Self-Organization network) become today the standardized approach de facto In connection with its inclusion in the standard of 3GPP beginning from releases 9 and 10 [3]. Development of Frameworx architecture includes the description of new requirements to managing and operational support due to the shift of info communicational operators business paradigm [2].

Exponential rising of number of info communication technologies using in modern telecommunication networks, and complication of logical interfaces between NCOSS and functional subsystems of business support BSS, subsystems of services and resources life cycle control system, subsystems of network services production, determination of basic business substances in info model NGOSS according to SID (Shared Information/Data) and dynamics of changing, complicated correlation between business substances and functional areas of Frameworx – all these require to attract models and methods of self-organization and multi-agent systems of cognitive info communication managing. Situation further develop trend is imaged in Fig. 1, according to authors opinion.

Concerning the first traditional approach (Fig.1), we note that it is still installed in model OSI, where the controlled objects are Identified by abstract expressions like MO (Managing Objects) .Recommendations for determination of controlled objects GDMO (Guide lines for Definition of

Managed Objects) expand the language of abstract notifications from recommendation ITU-TZ.105 specially to provide a method for controlled objects definition. We emphasize that control and controlled objects, called by mangers and agents, respectively, are considered as equal

code. Further, during the working-out the Internet Network Management Standards, the Working Group IETF received the development of the prototype of Count Simple Network Management Protocol (SNMP), which through the Intermediate versions has developed into version of 3 and defined the architecture for objects of the manager and the agent, the communication protocol, and also the well done Management Information Base (MIB) with definitions for most of the items in the IP network.

The same time when the ITF were elaborating the simplified technology of IP networks management, telecommunication companies were to control large, complex networks with special requirements of alacrity with five nines and ability to unite operators for providing new Info communication services. Therefore, ITU-T developed a set of standards Telecommunication Management Network that suit the specific requirements for networks of communication and formed the base for further development of the TMForum [2].

III. MULTI-AGENT MODEL FOR NETWORKS MANAGEMENT

Onwards this article author confirms that for the solution of info communication management tasks, in particular, to produce search and processing BI data in shared IT-landscape of Telecommunication Operator, it is most effective and expedient to use the multi-agent approach [4], in frame of which the system is constructed as a set of agents (Agents BI, Agents of Manager, agents of subsystems SSSS / BSS).

The choice of multi-agent technology makes it easy to combine in united system general purpose protocol of codes and each of the other tools for the work with specific data base types of managing subsystems and info communications.

But before discussing the formalized mathematical model and the research itself, we will consider the physical model of the telecommunications network management, which is presented in Fig.2.

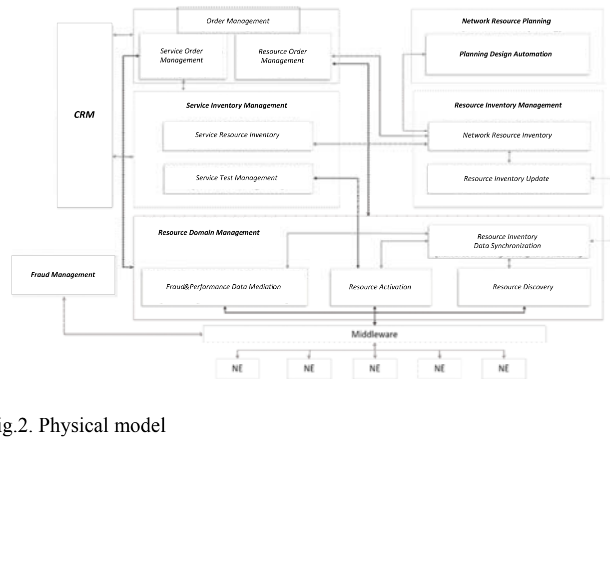

Fig.2. Physical model

As mentioned above and shown in Fig. 2, the basic BI operations (Business Intelligence) include the sending requests to various data of the technical accounting systems of NRI (Network Resources Inventory), billing, technical maintenance (Fulfillment), Performance Analysis Security, FM (Fraud Management), control quality of SQM (Service Quality Management), etc., as well as collection and Integral processing of the results of these interviews of sources, presented in Fig. 2.

Wherein the results obtained to the same request, but from other systems, as a rule, should supplement each other. It is also possible that obtained from different systems information will be duplicated or differentiated by the degree.

While the further evolution of the development of NSNN networks and, the creation of new services, the shift in the traffic to the side of M2M, development services related to the positioning of subscribers, diversity network elements and the introduction of the principles of self-organization in building communication networks evolve - these problems of BI information processing when managing super-complex post-NGN networks, become more significant. Therefore, multi-agent systems (MAS) are a suitable basis for resolving the problems with the construction of this formalized model, which enable us to evaluate the reliability, performance and efficiency of the control system. [5] The article also proposes a new multi-agent concession method for processing information in the BI, presented below.

Suppose that the information for decision-making by **D** telecommunications management system consists of N portions

$$\mathbf{D} = \{D_1, D_2, \dots, D_N\}, \quad (1)$$

located in N systems comprised to network manage complex (inventory, billing, fault management, quality control, performance analysis, fraud-management, etc.)

$$\varsigma = \{S_1, S_2, \dots, S_N\} \quad (2).$$

At the same time it has a place and is allowed, as it has been marked above, some overlapping of data,

$$Di \cap Dj \neq 0. \quad (3)$$

Fig. 3 shows the multi-agent system from N + 1 agents M = $\{M1, M2, \dots, MN+1\}$, corresponding to the physical model on Fig.2 .

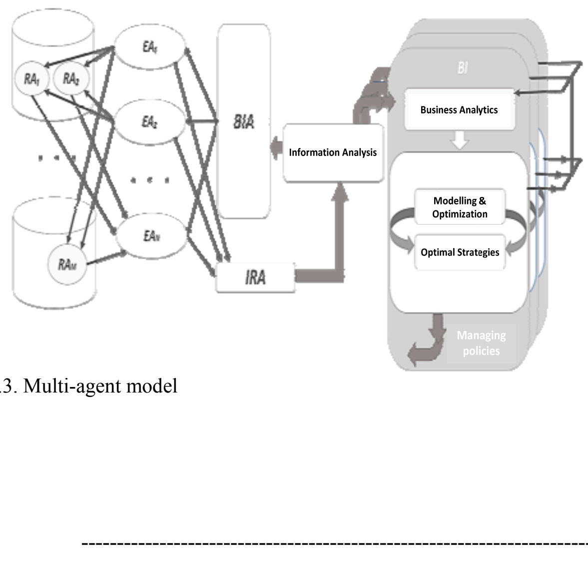

Fig.3. Multi-agent model

Here, each agent implements his own strategy Ω. Agents have access to various control systems and return information on the topic of the request from BI. For the request with index J the agent Mi sends data $D_i^{j(+)}$ from the collection of data D_i.

Further, the data sent by the agents is combined (Integrate) in two ways: data are combined obtained from one system i, and then the data from all systems i=1,2…

$$\Phi^{D_L}\left(\Omega_{N_i}(q_i, D_L), \dots \Omega_{N_L}(q_L, D_L)\right) = \bigcup_{j=1}^{k} \left(\bigcap_{i=1}^{L} D_j^{i(+)} \right) = D^+ \quad (4)$$

To assess the quality of the information D^+ collected by multi-agent system in Fig.3 and thus combined we use the criteria known from the theory of searching..

Actually for the aims of this study only two parameters are important: the fullness (nothing Is forgotten needing for BI) and the accuracy (nothing unnecessary to be send).

These parameters often refer to a one-word relevance (that means suitable, relating to matter). Here Relevance is the accordance between the answer and the request, accounting such concepts as fullness and accuracy.

Fullness is the ratio of the number of received results to the total number of data existing in the operate info communication system relevant to this request (λ-queries for the intensity λ).

$$P = \frac{|D^{\lambda_3} \cap D^+|}{D^+} \quad (5)$$

Accuracy is the ratio of the number of relevant results to the total number of results in response to this request .

$$R = \frac{|D^{\lambda_3} \cap D^+|}{D^{\lambda_3}} \quad (6)$$

For estimating the effectiveness of the information searching other criteria is often used: the coefficient of loss information and the coefficient of searching noise. In our study, for obvious reasons, it is assumed that the coefficient of loss of information = 0, the coefficient search noise = 1. The query / response loss rate between the OSS subsystems is 0, which is quite natural for any industrial OSS/BSS system.

The accuracy can fluctuate in the range 0.1- 1.0, the fullness is usually close to the values of 0.8-0.9. It is much more important that for the tasks of this study these criteria of completeness and accuracy are necessary apply a slightly complicated version. The fact is that for multi-agent system effective decision making to operate info communicate network, as noted above, we need integrated processing of data requested from vary systems OSS/BSS.

At that to ensure the effectiveness of these operate decisions, there are required not only accuracy and fullness of data response from vary systems OSS / BSS, but also, first of all, the accuracy and completeness of the corresponding values of the integral function FDi.

To achieve that we need a simultaneous, cooperative processing of data produced by agents in different systems, with appropriate "equalization" of time delays, for it is proposed to fill out the source-agents representing the corresponding from operational management subsystems, periodically with the selected in a probabilistic definite manner by a constant survey period T.

The model of probability-time characteristics is presented in next section.

IV. Calculation of the Number of BI Information Sources

Proposed in this section the algorithm for determining the allowable number of OSS / BSS systems involved in this or that business process with a certain intensity of the input stream of answers to information requests is useful for designing IT- landscape of the operator. Simplified block diagram of survey in the multi-agent control system is shown in Fig.4.

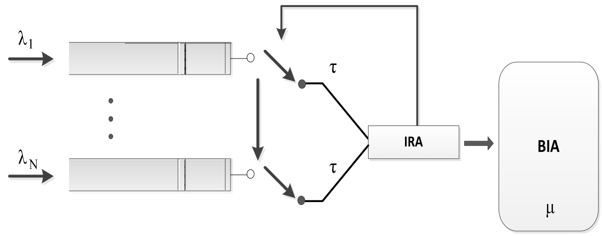

Fig.4. Mathematical model

The function of collecting the requested information in BI is performed by a recurrent (with period T) survey of all the agents of the system integrated to processing of the data. Duration of data processing is a random variable with a function distribution B (t) and mathematical expectation 1 / μ; the Laplace transform of this function is denoted by β (s). The flow of data arriving at the system, create N agents.

Intervals between the initiation of information in each agent has an exponential distribution with mathematical expectation 1 / λ, i.e., it has a Poisson place load of the second kind [6]. Intensity of arrival information in BI in this case depends on the current state of the system - the number of previously received data from agents:

$$\Lambda = \begin{Bmatrix} \lambda(N-i), i = 0,1,2,\dots,N; \\ 0, \quad i > N \end{Bmatrix} \quad (7)$$

For this model, differential-difference equations for multiplication of a general type, describing the dynamics of the probabilistic process have a solution in the binominal distribution of the requested data received in interval [τ), with form

$$P_k = \binom{N}{N-k} e^{-N\lambda\tau}(e^{\lambda\tau} - 1)^k \quad (8)$$

The main characteristic of this procedure is the distribution function (t) of the processing time of data coming in the interval [τ) for which in the assumption that the time of fulfillment programs of processing this data has an exponential distribution, the following expression is obtained

$$\Psi(t) = e^{-N\lambda\tau}\left\{1 + \sum_{k=1}^{N}\binom{N}{N-k} \times (e^{\lambda\tau} - 1)^k \left[1 - e^{-\mu t}\sum_{j=0}^{k-1}\frac{(\mu t)^j}{j!}\right]\right\} \quad (9)$$

Fig. 5 shows the distribution functions (t), calculated at constant total intensity incoming data Nλ = 2 request / s, τ = 10 s, μ = 5 requests / s different values of the number of agents N = 4 (curve 1), N = 8 (curve 2), N= 16 (curve 3), N = 32 (curve 4), N = 64 (curve 5). The dashed curve 6 is constructed according to the formula published in [7] and corresponds to Poisson load of the first kind from an infinite number of sources of common-intensity, and curve 7, where ς is the whole set of OSS / BSS, and S1, S2,. . . , SN are their subsystems, for example, those shown in Fig. 2.

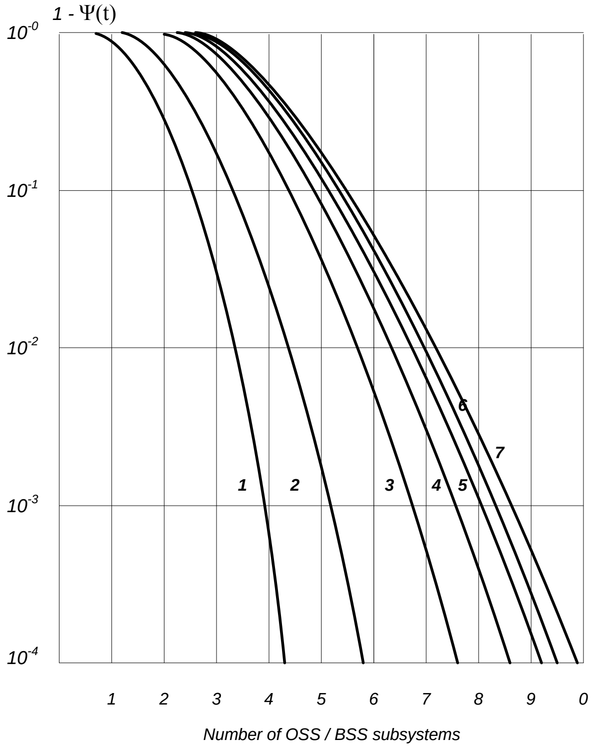

Fig.5. Distribution function 1-Ψ(t).

The received expressions allow define admissible the number of agents with a given decision quality, satisfying the condition Ψ (tc)> 1-ξ, where the probability values of data losses are given by the usual limits: 0.02-0.06.

It should be noted, however, that the value of tc is the largest possible scope of the data provided for the collection of data from agents, - in turn, depends on the number of the agents. We will return to this later.

The algorithm for determining the admissible value of N with the following received formulas has following view.

Step 1. Assign N = 2.

Step 2 . Calculate Ψ (t) by the formula (4). Check the completion inequalities 1-Ψ (t) <ξ. If the inequality is satisfied, go to step 3, in the opposite case, go to step 4.

Step 3. Assign N = 2N. Repeat step2.

Step 4. (dichotomous search). Assign an auxiliary variable NA = NB = N / 2.

Step 5. Assign NB = NB / 2; N = NA + NB. Calculate Ψ (tc) by formula (4). Check the fulfillment of the inequality 1-(t) <ξ. If the inequality is satisfied, put NA = N, otherwise, N = NA.

Step 6. Check the condition NB = 1. If the condition is not fulfilled, go back to step 5. When the condition is met, read the current value is selected and complete the algorithm.

It should be noted that, despite the assumption of exponential distribution of gaps between points signal arrival, giving a somewhat pessimistic estimate admissible contribution of the Erlang distribution, adequacy of the proposed model is confirmed by a number of experimental data.

In the final section of the article, let us consider the development of formulated the multi-agent approach to the investigation process management of communications on a real scale time.

In other words, here the strategy of the reflective agent is mapping from the current network states to appropriate action because in many situations it is permissible consider that the state of the data at the time indicates a complete description history to the time t. For such a managed object state, which provides all the important information about the past, they say that it is Markovian or possesses the property of Markov.

From the above, we can draw a conclusion that in Markov world agent can safely use a strategy without memory for decision making instead of a theoretically optimal strategy, which may require a greater memory size.

Hitherto, we have considered how an agent strategy can depend on the last event and individual characteristics of environment. However, as we discussed at the beginning, the adoption of optimal solution can be deduced from the assessment of the future.

To complete this section it is important to emphasize that proposed in this chapter mathematical methods of organization operational management of the Communications Operator facilitates the transition of a promising client-centric model (hereof in more details in Chapter 5), because besides all about these methods provides increase in demand for info communication services on the simple reason that a client-centric model is a huge amount of information about each subscriber and devices connected to the Operators network, therewith information in real-time mode.

V. MANAGING ASSETS FOR NGN/IMS

As noted at the section 1, conception of the self-organizing networks (SON) was created by a non-profit foundation 3rd Generation Partnership Project (3GPP) with purpose to increase efficiency and flexibility of telecommunication networks management, reducing the cost and increasing profit of the Operator, and was originally oriented to the application the mobile communication networks of generations 3G /4G/5G.

There is defined the key position in recommendations 3GPP at conception SON: concerning its implementation, there is said that SON and associated with its applying the benefits are extremely important and extremely demanded by the telecommunicate Operators. Consequently, a modern and forward-looking network management system should fully support the functionality of the SON, as defined in 3GPP standards [8].

In parallel, the conception was developing and is developing in the working drafts of the TM Forum non-commercial organization that is de facto leader in management and automation communication enterprises. The ideas developed by TM Forum connect IT developers, vendors of telecommunication equipment, communication Operators and are fair in relation to management any mobile network, such as a fixed connection. These ideas have determined the modern approach to automation of network processes, assuming the presence of an IT landscape Operator for OSS-complex.

In department of the network operation the complex should include a system of technical accounting (Network Resource Inventory System (NRI), which is the foundation for work with physical and logical resources, and is a base for interacting equipment system, that is to manage network objects, including the possibility of automatic provision of data to the NRI system, testing equipment, survey network, the activation of equipment (services).

Such data exchange is organized using intermediate software (PSP), or Middleware, by the way of applying standard interfaces for protocols, MTNM, SNMP, MTOSI etc., and / or specially developed command codes.

Today, speaking about solving operational tasks on mobile networks, we mean, first of all, the network manage systems of NMS (Network Management System) type, i.e. program-hardware tools that help the IT specialist of the Operator to realize:

- Network research (Network device discovery) with purpose of detection of new network elements;
- Monitoring network devices (Network device monitoring) on matter of devices good condition and compliance with the SLA;
- Network performance analysis, monitoring key indicators such as uptime of equipment, delay and loss of the package;
- Set up smart notifications-customizable alerts that will respond to specific network scenarios by an electronic mail or telephone.

Sometimes, speaking about managing of the 4G/5G networks, they have in a view, by tradition, the mobile part of the network only, as it was while 2.5G/3G existed, when a fixed part of the network was living its own life and was operated apart. However in today's reality of the generation of 4G/5G, as point of view at services, and review of the operational control tasks, it is not the best strategy to separate the tasks of managing transport networks and equipment.

Today, the main reasons for the introduction of SON architecture Is the natural desire of the Operators to abridge (at least not increase) operating expenses by the reduction of the human intervention degree in the implementation planning, implementation and operation of their networks, reduce capital costs by optimize the use of their network resources, save and to increase profits, reducing the errors from the human factor.

In the age of high-growth urban mobility broadband internet access, have a place at regional Russian market in the present time is rapidly increasing demand for exchanging data service, provoking the development of technologies radio department of chain. The independent analysts point out that volumes of operational tasks, their quality and speed Implementation will be different in the near future from present.

Consequently it concerns planning and deployment processes of the operator's network while it is expanding, to ensure the required quality of service and uninterrupted work of the whole network infrastructure.

Operational management of OAM & P are playing an important role in achieving these three goals, uniting resource management (Operations), administration management (Administration), technical maintenance (Maintenance) and new resources input (Provisioning). If these tasks are directly are controlled by personnel, even with automation tools, still this manual labor requires a lot of time, significant financial costs, highly qualified specialists, and the human errors are equally possible. Therefore, the principles embodied in the concept of self-organizing networks, begin to be reflected and applied in reality existing in operators networks.

The mathematical models presented above in Fig. 3 and Fig. 4 allows to assess in practical plan the opportunities and boundaries of SON functionality in terms of interaction with OSS/BSS systems and technologies in the structure of automation systems, and answer the question, how the described technology can approximate operators to cherished goals.

To ensure end-to-end business processes of the operator need the interaction of the OSS/BSS systems with network elements and a network management system. MW systems are intermediate software between equipment (and their systems management) and high-level applications of class OSS/BSS. Consequently, middleware systems will be a level - intermediary between SON functions, that is, the network level, and high-level BSS/OSS applications, such as Inventory, CRM, billing frame, as represented in this Fig. 6.

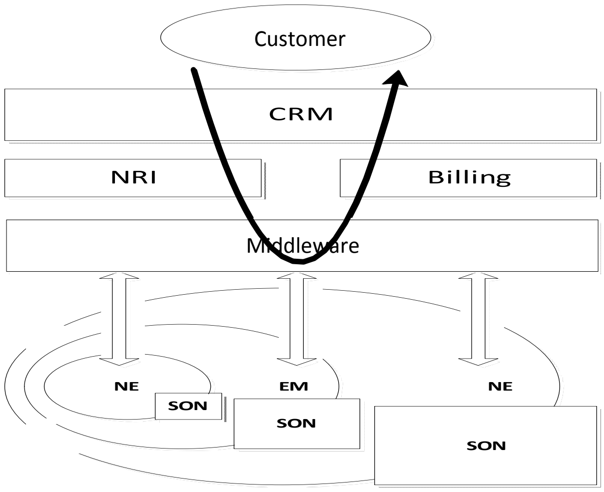

Fig.6. Shock "passing" of the business process through the system operator (NE Network Element, EM-Element Manager, NM-Network Manager)

Consider the map of ETOM and define the groups of processes, which can be attributed to the functions of middleware. The groups of processes "Provision and support of the resource level processes" and "Collecting and spreading the resource data" are determined by one middleware function. The processes of the remaining four groups sufficiently tightly use the functions of middleware; especially it concerns the processes of the group "Provision of services resources." From position of inventory and technical accounting the operational processes implemented by mechanisms and algorithms of SON in the part of self-configuring and optimizing network elements infrastructure Operator are important for automation.

VI. Conclusions and future work

The work reported in this paper is a part of the research for perspective networks management modeling, formally specifying and developing post-NGN management methods. The model described above allows post-NGN operators to abstract physical network resources, to add in/replace them with software-defined and virtualized network functions, to orchestrate resource provisioning in an automated way with multiagent system on Fig.2 and 3.

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