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Method of controlling access to intellectual switching nodes of telecommunication networks and systems

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ABSTRACT:
The developed method of controlling access to intellectual switching nodes includes a mathematical model of intellectual switching nodes with service information packets of different priority and an improved algorithm to control access to the cloud "of telecommunications resources. Based on multi-channel model (CMO) $\overline{M}_r/M/V_r/K_r$ *as well as developed GERT model of intellectual switching nodes carried out the study of functioning information and telecommunication network. The Equivalent W-function, distribution function and density distribution of service time information packets of metadata in intelligent switching nodes when they are transferred to the cloud antivirus systems, it is determined that an additional criterion for attribution information packet "reference" priority can be the value of the probability of assigning priority.*

KEYWORDS: *Information and Telecommunications Network, GERT-model, access control, intellectual switching nodes.*

I. DEFINITION OF PROBLEM

In current conditions of dynamic development of various approaches of the analysis and synthesis of the telecommunication networks integrated into information and telecommunication technology [1-5] there are questions of elaboration and application of the general methods of ensuring service quality based on allocation of separate classes of quality and realization of managing algorithms, such as prioritization of information packages, reservation of telecommunication resources, organization of queuing in switching nodes etc.

The manifestation of new destabilizing factors associated with the influence of the malicious software on the process of the functioning of information and telecommunication networks obliges to revise the general capabilities of the existing mechanisms for managing the service quality and putting suggestions (algorithms) and adapting them with possible wrongful action of participants of telecommunications exchange.

Thus, there is a need to develop networking and communications technologies and to elaborate the methods of managing network resources that could provide:

- service quality and information security at the joint transfer of heterogeneous traffic, taking into account the constraint of network resources, the real reliability of telecommunications equipment and possible external influence malicious or other character ;
- Safety of functioning of individual nodes of information and telecommunication system from the effect of malicious software;

- Stability (reliability, survivability, functional safety) is functioning under the above conditions, etc.

One of effective mechanisms that face malicious software is the use of antivirus resources “cloud”.

Studies of main procedures of data exchange in information-telecommunication systems have shown that one of key roles at ensuring delivery timeliness of metadata (signatures) in "cloud" anti-virus systems plays a role of transmission control mechanism. Thus their basic algorithms are realized specifically in switching nodes. The given fact has allowed coming to the conclusion about the need to develop a method for managing network resources taking into account the advanced procedures of the organization and queue scheduling.

II. GENERAL DEFINITION OF PROBLEM AND DESCRIPTION OF SWITCHING NODES FUNCTIONING

According to data mentioned in [1-5], structural and functional structure ITS of next generation network (NGN) is heterogeneous. This factor is especially mentioned in the early stages of ITS structure.

It should be noted that only when combining low speed traffic, there are preconditions for the use of models of simplest packets [1]. This is because the large number of small independent ordinary stationary (non-stationary) streams with different aftereffect (Khinchin's theorem) [1.2], as well as the transformation of streams in network (summation, screening) [1.2] in limit gives the stream that is close to the simplest packet:

$$a_r = a_r(t) = 1 - e^{(-\lambda_r \cdot t)}, \quad \lambda_r \geq 0, t \geq 0, \quad (1)$$

-λ_r the parameter of stream, transferred to parameters of transmission by using this equation: $\lambda_r = \lambda_c(r) \cdot q(r) \cdot \eta_r$,

- $\lambda_c(r)$ intensity of received messages;
- $q(r) = (\mu_c(r) \cdot t_{сегм}(r))^{-1}$ the average number of packets in the message , r -го priority;
- $t_{сегм}(r) = \frac{L(r)}{\nu_{прд}(r)}$ the average time of packet segmentation , r -го priority;
- $L(r)$ the length of the information portion of packet , r -го priority;
- $\nu_{прд}(r)$ speed of sending(processing) information, r -го priority;
- $\eta_r = \frac{L_{пак}(r)}{L(r)}$ overhead on packet conversion ;
- $L_{пак}(r)$ the length of the packet , r -го priority;

Priority packets from different classes, as soon as they access to ITs, are divided into packets of different length, while limiting their maximum size. This assumption allows drawing a conclusion on the possibility of use while creating such networks, in the appropriate calculations, and a demonstration law of distribution of the random variable duration of their service in switching nodes [1-3]. In this case, the duration of service packet priorities $r = \overline{1, R}$ of the random variable with distribution function [1.2] is:

$$B(t) = 1 - e^{\left(-t/b\right)}, \; t \geq 0, \; b \geq 0 \quad (2)$$

And the end of the first two moments is:

$$b = \int_0^\infty t dB(t) = \frac{1}{\mu_{ср}}, \quad (3)$$

$$b^{(2)} = \int_0^\infty t^2 dB(t) = \frac{2}{\mu_{ср}^2}, \quad (4)$$

$$\mu = \sum_{r=1}^{R} \frac{\lambda_r}{\Lambda_r} \times \frac{\nu_{прд}(r)}{L_{пак}(r)}, \quad (5)$$

- $\mu_{ср}$ average intensity of service packets

In the example mentioned above, switching node is realized in the next service discipline.

If, at the time of access of packet with any priority $r = \overline{1, R}$ there are free channels (switching node status $0 \le i \le V - 1$), so it (packet) immediately access to the service.

b) in the case of occupancy of all channels (switching node status $V \le i \le V + K$) , the received packet λ -го priority is queued and it is accepted for service before the packet of j -го priority, if $\lambda < j$: If, at the time of access of the packet of priority in queues, there were K- packets (the buffer is filled completely), so the received packet is :

– Accepted in queue under conditions that there are packets with low-priority j-M, the latter packet with low priority is ousted from the system and, later does not have any impact on it (system);

– The packet Is Lost, given that in a queue there are only packets with higher or equal j -м priority.

b) For packets (equal) priorities that are in the queue, FIFO system is realized

As shown in the discipline of service in switching node when packets set in the queue and queue is managed, the absolute priority functions, while in the service the relative priority functions. The use of absolute priority queue management only provides service packets without interruption, but at the same time the losses and the average waiting time priority packet are minimized.

At the same time, this discipline mentioned above has a number of disadvantages associated with the lack of malicious factors or other external influences on ITS.

Therefore, in the conditions of destructive external influences and the frequent failure of telecommunications equipment using this model in the creation of ITS influence negatively on the process of ensuring the quality of service indicators such as information and functional security, reliability.

Studies have shown that in order to eliminate these disadvantages, it is advisable to use a mathematical model of switching node type" $\overrightarrow{M_r}/M/V_r/K_r$ "with relative priorities, resource reservation and taking into consideration the real reliability of serving devices.

Model of switching node and its relative priorities, reservations resources and real reliability of serving devices.

The assumptions listed above (concerning: approximation of packet stream , class : $r = \overline{1, R}$; with the characteristics of a Poisson distribution law; service with relative priorities $r = \overline{1, R}$ class of service quality, taking into account the categories of users and the subsystems; presence of V serving devices , with the ultimate reliability of the variable-length packets;, characterized by the exponential distribution function (2) with parameter defined by equation (5)), aim at managing traffic and ensuring the specified quality of service indicators (including informational and functional safety)under conditions of limited resources ITS, possible malicious or other effects, a discipline service and their relative priorities $r = \overline{1, R}$, of partial switching channel V_r and a joint (separate) use of drives K_r could be applied. This will ensure the backup of telecommunication resources for high-priority traffic (especially metadata in "cloud" antivirus systems) [3.5].

The analysis of basic algorithms management queue in ITS communications equipment showed that currently there are several types of disciplines (ways) of service queues that realize the reservation of resources:

– (Fair Queuing, FQ);

– (Priority Queuing (PQ));

– (Custom Queuing, CQ);

– (WFQ, Fair Queuing, Weighted);

– (Class Based Weighted Fair Queuing CBWFQ), etc. [3-5].

Comparative studies of these algorithms have shown that the most effective in terms of ensuring quality of service, is the algorithms of WFQ, CBWFQ, derived algorithms CQ. Therefore further research is based on the management of WFQ and CBWFQ queue.

Let's present a telecommunication system, in which the services are divided into several classes, quality of service (QoS) with appropriate priorities for latency and packet loss (for example, transfer of information and measurement of monitoring data, telephony, postal information transfer, video conferencing, etc.). The total number of priorities for the types of services, users and subsystems is R

Let's consider that at the entrance, intellectual switching node receives the simplest packets stream r -s priority classes { $a_1,..., a_r,..., a_R$ }, which are numbered in order of priority. Each priority class is characterized by the intensity of packets $\lambda_r : \lambda_r > 0$

In the particular case, priorities are grouped in three groups $r_1 = 1$, $r_2 = \overline{2, J}$, $r_3 = \overline{J+1, R}$, corresponding to the services:

– $r_1 = 1$ - traffic of metadata for transmission in" the cloud" antivirus system;

– $r_2 = \overline{2, J}$ -traffic of real time, critical to network delays (telephony, videoconferencing, data objective control, etc.);

– $r_3 = \overline{J+1, R}$ Traffic of data, critical to losses and not critical to network delays, including stream of traffic (audio, video on demand, etc..) and elastic traffic (email, web-applications, etc..).

In this case the highest priority is using metadata for transmission to the cloud antivirus system.

Therefore In the switching nodes of information and telecommunication systems, presented different smart devices (controllers, gateways, switches, routers, gateways, etc.), transport network users of different categories and subsystems stream received message of different classes. The intensity of received and service messages is characterized by parameters $\lambda_c(r)$ и $\mu_c(r)$, $r = \overline{1, R}$ and, in accordance with, the speed of received message (transfer $v_{прд}(r)$). The received messages in the switching nodes are converted into a packet form and form R an independent packet stream $a_1,..., a_r,..., a_R$ with intensities $\{\lambda_1,..., \lambda_r,..., \lambda_R\}$.

The intellectual switching nodes ITS consists of $0 < V < \infty$ serving devices with identical tactical-technical characteristics, depending on capabilities of manufacturers of telecommunication equipment, and the buffer memory capacity $0 < K < \infty$.

In switching nodes, restrictions are imposed on serving devices resources $V_r \leq V$ and memory buffer size $K_r \leq K$ packet of different priority classes. In this case the packet with priority accesses to all serving devices and allocates a portion of buffer of the total volume of the buffer, determines in accordance with the advanced algorithm to control access to "cloud" telecommunications resources described below.

For packet of priorities $r_2 = \overline{2, J}$ the available part $V_r \leq V$ of the device service is not in use at the moment of metadata packet priority, determines the improved algorithm to control access to cloud telecommunications resources, and allocates a part of buffer $K_r \leq K$ from total capacity of the buffer K

For packets of remaining priorities $r_3 = \overline{J+1, R}$,there are a restrictive threshold- only one part of the overall service devices $V_r < V$ is available and a part of the total capacity of the buffer is allocated $K_r < K$, so $\sum_{r=1}^{R} K_r = K$. Within each priority class r_1, $r_2 = \overline{2, J}$, $r_3 = \overline{J+1, R}$, allocated buffer shared data packets priority classes.

It should be noted that the organization of distribution of resources of switching nodes in a memory buffer information packet priority class r_1 practically is zero ($P_{r_1} = 0$)). Similarly there is probability of losing P_{r_2} information packet priority class r_2 $P_{r_2} \approx 0$.

In intellectual switching nodes ITS, service packet, is subject to the following discipline [3-5].

a) If, at the time of access of the information packets with priority r_1 , $r_2 = \overline{2, J}$, $r_3 = \overline{J+1, R}$, they are free from the priority class for the devices so it's in accordance with an algorithm to control the access to cloud telecommunications resources enters at the service.

b) in case of occupancy of all available services devices (intellectual switching nodes status $V_r \le i \le V_r + K_r$) separate queues are organized for packets with the priorities r_1 $r_2 = \overline{2, J}$ and $r_3 = \overline{J+1, R}$. In this case in each one, the following discipline is realized: when setting the packet in the queue ,the absolute priorities are acting, and when selecting packets for service relative priorities are acting in accordance with advanced algorithms to control access to "cloud" telecommunications resources.

The use of the absolute priorities for queued reduces the average waiting time of priority packets from the groups r_1 and $r_2 = \overline{2, J}$, allows to improve security information ITS (improving antivirus) and ensures the quality of data service

As a result in each queue, packet λ -го priority is accepted for service before the packet j -го priority if $\lambda < j$. Furthermore, if, at the time of packet arrival λ -го priority in queues r_1 , $r_2 = \overline{2, J}$ or $r_3 = \overline{J+1, R}$ there was K_r packets, so the arrival packet is processed as follows:

- Either Accepted in queue under conditions that there are packets with low-priority j-M, the latter packet with low priority is ousted from the system and, later does not have any impact on it (system);
- Or Is Lost, given that in a queue there is only packets with higher or equal j -м priority.
- b) For packets r -го (equal) priorities that are in the queue r_1 , $r_2 = \overline{2, J}$ or $r_3 = \overline{J+1, R}$,or serviced in accordance with an advanced algorithm to control access to the "cloud" telecommunication resources. The service discipline of information packets in intellectual switching node implements redundancy of network resources that is based on the strategy of moving boundary.

III. AN IMPROVED ALGORITHM TO CONTROL ACCESS TO CLOUD TELECOMMUNICATIONS RESOURCES

To study the functional indicators of intellectual switching nodes quality of type $\overline{M}_r / M / V_r / K_r$, we use the method of the structural-logical GERT-model. Let's take a look at its distinctive features.
According to switching nodes ITS model with relative priorities and resource reservation changes in the states of the node let's present GERT-network. Each branch r_1 , $r_2 = \overline{2, J}$, $r_3 = \overline{J+1, R}$, of communication network conditionally describes a separate multi-threaded service system (V_r, K_r) with dedicated and shared resources (V_R).

It should be noted that presenting the structural-logic model GERT takes into consideration the factors of external influences (loss of information packet) and the real reliability (possible equipment failures) through introducing branches of inverse connection with appropriate characteristics (example W_{42} , W_{52} , , W_{74} , etc.).
The presentation of GERT-structural-logic model, as well as an analysis of several studies [1, 3, 5], devoted to the study of processes of preventive and final management of information stream to intellectual switching nodes service allows forming branches characteristics and distribution parameter.

It should be noted that the studies allow finding a number of regularities in the process of intellectual switching nodes functioning related to practical identical indicators, accordingly producing function moment at separate stages and in series mode of operation. Final result is the reduction of producing functions moment.

To solve the above optimization problem of accelerating the process of information packet in intellectual switching nodes when it is transferred to the cloud antivirus system, is proposed to optimize the algorithm control access to the cloud "telecommunications resources. The basis of the algorithm is put procedure for calculating the virtual time processing of information packet, which differs from the known factor providing an additional level of prioritization for information packet metadata [1-5]., these information packets receive highest priority processing in intellectual switching nodes class r_1 .

Table 1 shows the valid values of average time and Jitter of processing time and information packet for different level of priority in intellectual switching nodes

The valid values for the average time jitter of processing time of information packets from different levels of priority

Let's look at the structural scheme of algorithm of controlling access to cloud telecommunication resources.

Level priority	$r_3 = \overline{J+1, R}$	$r_2 = \overline{2, J}$	$r_1 = 1$
$T_{доп}^{[i]}$, мс	100-800	50-150	1-10
$J_{доп}^{[i]}$, мс	47-53	10-30	1-5

The first step: structural scheme is checking the access of packet to intellectual switching nodes if there is no packet; the algorithm goes into waiting mode of received packets. In case When at the entrance of the intellectual switching node information packet is received (all levels prioritization or only selected), it is necessarily to select of each queue buffer memory of each intellectual switching node according to the first packet, and the level of priority to determine the "reference"of information packet with the appropriate level of priority. This will reduce the processing time of the metadata packet of information while ensuring indicators of efficiency of processing information packets of other priority levels.

The fourth step of the algorithm is determined by the value of the VST and VFT. Next we start with the accomplishment of procedures to identify the information packet for processing in operating unit of intellectual switching nodes. This includes the following: while receiving buffer device N packets could enter (N is the number of queues in the system), and priority levels may enter.

If the value of the VST is entered, then in step 6 of the stream of information, the first ("reference"), packet is selected, as well as the value of virtual service time in queues.

Next, in step 9 of structural scheme there is a comparison between "standard of information packet with other entering at the same moment.

The decision about "reference "of priority of the information packet was adopted by the following criteria:

1) The minimum value of virtual service time in the queue (($VFT = \min$) ;

2) Belonging of information packet to the queue with the highest priority ($r_1 > r_2 > r_3$).

It should be noted that the condition of assignment "reference" priority setting in step 14 is not complete , and with some exceptions, determined by the previous indicator, for example an indicator-the probability of assigning priority [3]. This indicator can be determined experimentally in this case, the control procedure using this indicator, is a distinctive feature of the algorithm to control access to the "cloud" telecommunication resources. These exclusions are necessary to ensure the quality of service information packet of other (lower) priorities.

The Information packets can be compared in pairs, at the initial time; the first selected information packet conditionally has the highest level of priority.

If the condition mentioned in step 5, then in step 7 ,the algorithm updates information about VST and VFT.

In step 10 a transition happens directly to the packet information processing procedures. In step 12 information packets assigned the values of the VST and VFT in order to accompany the information packet to the destination.

Next, in step 13 information packet is added to the output queue and ends its process of its processing in intellectual switching node.

Thus, algorithm is developed to control the access to cloud telecommunications resources whose distinctive feature is the introduction of non-standard conditions, decide on the attribution of the "reference" priority information packet based on the additional indicator-the probability of assigning priority. This allows solving the problem of minimizing the processing time of the metadata packet of information during the transmission to the cloud antivirus systems while ensuring quality of service information and other telecommunication services.

IV. CONCLUSION

Thus, the access control method in intellectual switching nodes includes a mathematical model of intellectual switching with information packet of different priority and improved algorithm to control access to cloud telecommunication resources. A distinctive feature of the method is the integrated use of standard criteria for information management in intellectual switching nodes with additional possibility of service packet metadata information as it transfers to the cloud antivirus systems.

The main results are:

Based on GERT-mathematical model of network intellectual switching node with information packet of different priorities, differs from the known, taking into consideration the maximum prioritizing information metadata packets during their transmission to the cloud antivirus systems. This helps to determine the equivalent W-function, distribution function and density distribution of service time information packet of metadata in intellectual switching nodes when they are transferred in the cloud antivirus systems. The result of studies indicates that maximum distribution density of the processing time information in metadata packets in intellectual switching nodes represent an interval from 1 to 2 Ms.

The developed algorithm of control access to cloud telecommunication resources, distinguished from the known introduction of non-standard conditions a decision on assigning the "standard" priority information packets based on the additional indicator-the probability of assigning priority. This makes it possible to solve the problem of minimizing the processing time of the metadata packet of information transmission to the cloud antivirus systems while ensuring quality of service information and other telecommunication services.

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