CALCULATION IN THE NGN NETWORKS OF INDEXES OF RELIABILITY OF TRACTS OF TRANSMISSION OF PACKET INFORMATION

A. Muradova

Tashkent University of Information Technologies,
108, Amir Temur Ave., Tashkent 100200 Uzbekistan
1982alya@rambler.ru

Abstract: The article describes the main elements that make up the transport network NGN. Shows the relevance of research of reliability of the NGN network, as well as the need of numerical calculation of complex indexes of reliability of tracts of transmission of packet information is given. On the developed imitating model of the NGN network indexes of reliability of tracts of transmission of packet information are calculated when using mechanisms of reservation, and also at their absence. Numerical calculation of the main indexes of reliability (failure rate $\lambda$, average time of restoration of communications of $T_r$, average time of a time between failures $T_o$, $K_g$ the coefficient of availability, probability $P(t)$ of no-failure operation in the range of $t$, coefficient of operational readiness $R_r$) the NGN network equipment (router, switch) for the main period of operation is given. By the received results conclusions are makes.

Keywords: network of the following generations, transport network, public communication network, softswitch, reliability of the NGN network, complex indexes of reliability, the reservation mechanism, tract of transmission of packet information, fault in the equipment of NGN network.

Introduction

The basis of NGN (Next Generation Network) is made by a universal transport network with switching of the packets, realizing functions of transport level and level of management of switching and transmission.

A part of the transport NGN network can be: the transit nodes which are carrying out functions of transmission and switching; the terminal (boundary) nodes providing access of subscribers to a multiservice network; the controllers of the alarm system which are carrying out functions of information processing of the alarm system, management of calls and connections; the locks, allowing to carry out connection of traditional communication networks (PSTN – public switching telecommunication network, NDT – network of data transmission, CNMS-communication network of mobile stations). Controllers of the alarm system can be taken out in the separate devices intended for service of several nodes of switching. Terminal and transit nodes of a transport network can carry out functions of nodes of services, i.e. the structure of functions of boundary nodes can be expanded thanks to addition of functions of service. For building of such nodes is used the technology of flexible switching (Softswitch). (Goldshteyn et al., 2011).

Interaction of existing networks with NGN

At the initial stage of PSTN became part of a convergent network, and on joints between PSTN and the transport IP/MPLS network locks of VoIP (Voice over IP) – device which are intended for the transformation of a flow of information arriving from a communication network of general use (switching of channels), to the look suitable for transfer on IP networks (switching of packets) are established.

For management of interaction of the networks entering a convergent network, the multipurpose Softswitch hub is used. This node operated connections at gateway communication, locks and network traffic. In management of connections of Softswitch solves problems of support of systems of the alarm system of interacting networks. It should be noted that Softswitch operates service of calls and isn't responsible for connection through IP network (Netes, 2006b, p. 2) routers.

The RSVP protocol is a protocol of the alarm system which provides reservation of resources for granting in IP networks of services of emulation of the allocated channels. The protocol allows requesting, for example, the guaranteed capacity of such channel, a predictable delay, a maximum level of losses. But reservation is carried out only in case there are demanded resources. To provide demanded level of efficiency of service of a traffic speech and video-applications, the mechanism allowing sources to inform service about
the requirements is necessary. On the basis of this information the network can reserve resources to guarantee implementation of requirements to quality of delivery. In the absence of resources the service refuses to the appendix, compelling it either to revise requirements, or to postpone a communication session. The sender of data using the RSVP protocol, transmission the message of tract in which desirable characteristics of quality of delivery of data are specified to the individual or group address of the recipient: top and bottom borders of a pass-band; average duration of a delay; admissible variation of duration of a delay. In the V.A. Netes’s work of «Reliability of communication networks during transition to NGN» the question of the solution of problems in the field of reliability of NGN networks (Netes, 2007, p. 8) is very sharply raised.

Reliability of the NGN network directly depends on how processes of reservation of tracts of information transmission between network devices (routers, switchboards and others) are carried out and what protocols are used for this purpose. The complex of the technical equipment and the communication lines, intended for formation of specialized channels of information transmission is called as a tract of information transmission. Numerical calculation of complex indexes of reliability of linear tracts of information transmission is necessary for further research of reliability of the NGN (Netes, 2006a, p. 19) network. The imitating model of the NGN network developed in the program Cisco Packet Tracer environment. For this model key parameters and characteristics of devices of the NGN network (routers, switchboards and locks) are set. Two scenarios of network functioning of NGN are used: with use of protocols of reservation of tracts of transmission of packet information between devices and without use of these protocols (Cisco, 2013).

We will calculate complex indexes of reliability of tracts of transmission of packet information on the NGN network in case of use of protocols of reservation, and also in the absence of special mechanisms of reservation (Polovko and Gorov, 2006).

Calculation in the NGN networks of indexes of reliability of tracts of transmission of packet information

We will calculate value of coefficient of availability (Netes, 2004, pp. 37-39) separate sites of the NGN network with use of reservation of tracts of transmission of packet information and it is comparable they received results.

Example 1. Value of a time between failures not redundant m of working linear tracts of one direction of transmission \(T_o = 1500\) h, and average time of restoration of communication of \(T_B = 5.5\) h. Working tracts are redundant the M number of tracts so that reliability of each tract of \(P_i = 1\) where i from 1 to m, thus reservation is absolutely reliable also time of switching for a reserve of \(t_{пр}<< T_B\).

To define the \(K_g\) coefficient of availability at reservation of tracts if it is given: number of highways \(M=3; m=3\).

Decision:
1) We will define a coefficient of availability of three working tracts without reservation:
\[
K_g = \frac{T_o}{T_o + T_B}
\]
\[
K_g = \frac{1500}{1500 + 5.5} = 1500 / 1505.5 = 0.9963
\]

2) We will define a coefficient of availability at reservation of three working tracts by one:
\[
K_{г(р)} = 1 - \left(\frac{(m+M)!}{(M+1)! \times m!}\right) \times (1-K_g)^{M=1}
\]
where \(m\) – quantity of the main directions; \(M\) – quantity of the reserve directions.
\[
K_{г(р)} = 1 - \left(\frac{(3+3)!}{(3+1)! \times 3!}\right) \times (1-0.9963)^{3+1} = 1 - (6! / 4! \times 3!) \times 0.0037^3 =
\]
\[
= 1 - 180 \times 0.0037^3 = 0.999999967
\]
Answer: \(K_{г(р)} = 0.999999967, K_g = 0.9963\).

Conclusion: The coefficient of availability at reservation of tracts is higher, than without reservation. From this we draw a conclusion that application of reservation increases reliability of linear tracts of transmission.

Example 2. Around service of the equipment of the NGN network (a router, the switchboard) for time interval \(\Delta t\) there was \(N = 1527\) refusals. In 55 identical cases communication reestablished for \(8.0\) hour, in \(92\) – for \(5.0\) hour, in \(153\) – for \(3.0\) hour, in \(202\) – for \(2.0\) hour, in \(262\) – for \(0.8\) hour, in \(397\) – for \(0.5\) hour. To calculate the main indexes of reliability (failure rate \(\lambda\), average time of restoration of communications of \(T_B\), average time of a time between failures \(T_o\), the \(K_g\) coefficient of availability, probability of \(P(t)\) of no-failure operation in the range of \(t\), coefficient of operational readiness of \(R_e\) for the main period of operation in time intervals:

– The set interval of time of \(t\), hour = 2;
Decision: 1. We will calculate failure rate $\lambda$ on a formula:

$$\lambda = \frac{N(\Delta t)}{\Delta t \cdot T_r},$$

Where: $N(\Delta t)$ – number of refusals of elements on time interval $\Delta t$; $T_r$ – number of hours within a year, 8760, $\lambda = \frac{1527}{1 \times 8760} = 0.174$ (refusals at an o’clock).

2. We will define average time of restoration:

$$T_B = \sum_{i} \frac{T_{ri}}{N_o}$$

where: $T_{ri}$ – restoration time at i refusal; $N_o$ – number of refusals for $\Delta t$;

$$T_B = \frac{8.55 + 5.92 + 3.153 + 2.202 + 0.8262 + 0.5397}{1527} = 1.422$$

3. We will define average time of a time between failures:

$$T_0 = \frac{1}{\lambda}, T_0 = \frac{1}{0.174} = 5.75 \text{ h}$$

4. We will calculate a coefficient of availability:

$$K_r = \frac{T_0}{(T_0 + T_B)}, K_r = \frac{5.75}{(5.75 + 1.422)} = 0.8017289$$

5. We will calculate probability of no-failure operation in the range of time of $t=2$ of hour:

$$P(t) = e^{-\lambda t}, P(t) = e^{-0.174 \times 2} = 0.706$$

6. We will define coefficient of operational readiness:

$$R_r = K_r \times P(t), R_r = 0.097 \times 0.706 = 0.068$$

Conclusion: According to calculation it is possible to draw a conclusion that the equipment of the NGN network is efficient and rather reliable, so failure rate is insignificant (0.174), quite good probability of no-failure operation in a certain interval of time (0.706), rather small average time of restoration of the equipment after malfunction (0.2 hour).

Example 3. The NGN network consists of ten consistently connected devices (routers, switchboards) which reliability is known (tab. 1).

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>0.27</td>
</tr>
<tr>
<td>Q2</td>
<td>0.003</td>
</tr>
<tr>
<td>Q3</td>
<td>0.005</td>
</tr>
<tr>
<td>Q4</td>
<td>0.05</td>
</tr>
<tr>
<td>Q5</td>
<td>0.089</td>
</tr>
<tr>
<td>Q6</td>
<td>0.076</td>
</tr>
<tr>
<td>Q7</td>
<td>0.089</td>
</tr>
<tr>
<td>Q8</td>
<td>0.2</td>
</tr>
<tr>
<td>Q9</td>
<td>0.01</td>
</tr>
<tr>
<td>Q10</td>
<td>0.21</td>
</tr>
</tbody>
</table>

To find malfunction a method of half splitting and to represent graphically search procedure, thus to state a method essence.

Will describe the procedure of search of fault graphically.

Decision:

![Fig. 1. Consecutive connection of devices in the NGN network](image-url)

We will propose that transmission of packets goes from the device 1 to the device 10. If in the 10th device there are no arriving packets, it is necessary to define the faulty device. For this purpose we arrive as follows:
1. We will make measurement in a point of I if packets aren't present then fault in the device 1 or 2, but proceeding from reliability, it is more probable that fault in the device 2, if the packets are there, we move to the right on the line. 2. We make measurement in a point of II if packets aren't present, we arrive similarly (1) with blocks 3 and 4. 3. We make measurement in a point of III. We will make measurement if packets are there, we move to the right. 4. We make measurement in a point of IV. If packets are there, there are two elements 9 and 10 in which fault is possible. Preceding from reliability it is possible to assume that the device 9 is faulty, but we will make measurement for accuracy. 5. We will make measurement in a point of V if packets aren't present, the device 9 is faulty.

When determining the faulty device it is possible to use a method of splitting at which the number of measurements and consequently it is possible to define the faulty device quicker is reduced. Originally we break a chain into two equal parts, i.e. we make measurement of I between devices 5 and 6. If there are packets, we measure in a point of II, if packets are there, we move ahead further to the right and we do measurement in a point of III. We will allow packets in this point are absent, therefore fault in devices 8 or 9. On reliability of work (Q9=0.01) it is more probable in 9, but nevertheless it is necessary to execute measurement of IV for more exact result. If in a point the IV packets are there, the device 9 is faulty.

![Fig. 2. Search of disrepair by a method of half splitting](image)

**Example 4.** It is necessary to find fault of the equipment of the NGN network, consisting of seven parallel devices and average time for trouble in the considered equipment if one of parameters of reliability of each device \( \lambda_i \) and time of check of each device \( \tau_i \) is known: \( \lambda_1=0.5, \tau_1=6 \text{ minute}; \lambda_2=0.15, \tau_2=11 \text{ minute}; \lambda_3=0.8, \tau_3=8 \text{ minute}; \lambda_4=0.28, \tau_4=13 \text{ minute}; \lambda_5=0.4, \tau_5=10 \text{ minute}; \lambda_6=0.7, \tau_6=9 \text{ minute}; \lambda_7=0.3, \tau_7=18 \text{ minute}.\)

To describe procedure search of disrepair graphically.

Decision: Procedure search of disrepair at parallel connection of devices is made according to the scheme: \( (\tau_i/\tau_{i+1}) \leq p_i \).

We will define reliability coefficient for each device.

![Fig. 3. Parallel connection of devices in the NGN network](image)

1) \( \tau_1/\tau_6=6/0.5=12; \) 2) \( \tau_2/\tau_7=11/0.15=73; \) 3) \( \tau_3/\tau_4=8/0.8=10; \) 4) \( \tau_4/\tau_5=13/0.28=46; \) 5) \( \tau_5/\tau_6=10/0.4=25; \) 6) \( \tau_6/\tau_7=9/0.7=13; \) 7) \( \tau_7/\tau_8=18/0.3=60\)

\[
\frac{\tau_3}{\tau_1} < \frac{\tau_1}{p_1} < \frac{\tau_6}{p_6} < \frac{\tau_5}{p_5} < \frac{\tau_4}{p_4} < \frac{\tau_7}{p_7} < \frac{\tau_2}{p_2}
\]

\[
p_1(\tau_1 + \tau_3), \ p_2(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6 + \tau_7), \ p_3(\tau_3), \ p_4(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6), \ p_5(\tau_1 + \tau_3 + \tau_5 + \tau_6), \ p_6(\tau_1 + \tau_3 + \tau_6), \ p_7(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6 + \tau_7).
\]

We will define average time for search of disrepair:

\[
T_n = \sum_{i=1}^{n} p_i \times \sum_{j=1}^{n-1} \tau_j
\]
\[ T_n = p_1(\tau_1 + \tau_3) + p_2(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6 + \tau_7) + p_3(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6 + \tau_7) + p_4(\tau_1 + \tau_3 + \tau_4 + \tau_5 + \tau_6 + \tau_7) + p_5(\tau_1 + \tau_3 + \tau_5 + \tau_6 + \tau_7) + p_6(\tau_1 + \tau_3 + \tau_6 + \tau_7) + p_7(\tau_1 + \tau_3 + \tau_5 + \tau_6 + \tau_7) \]

\[ T_n = 0.5(6+8) + 0.15(6+8+13+10+9+18) + 0.28(8+6+9+10+13) + 0.4(8+6+9+10) + 0.7(8+6+9) + 0.3(8+6+9+10+13+18) = 81.38 \text{ min}. \]

**Answer:** The device 3 is in disrepair, time for search of disrepair – is faulty 81.38 min.

**Conclusions**

Results of calculations of value of a coefficient of availability of separate sites of the NGN network with use of reservation of tracts of transmission of packet information showed that reservation allows increasing reliability of tracts of information transmission. Calculations of the main indexes of reliability of the equipment of the NGN network show average time of restoration of the equipment after fault which is necessary at development and construction network. The received results will be used for further calculations of complex indexes of reliability of the NGN network for the developed imitating model with use of various scenarios of connection of the equipment of a network.

**References**


