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DEPENDENCE OF VALUE OF PROBABILITY OF INFORMATION TRANSFER IN NETWORKS FROM AN AMOUNT OF PACKETS AT APPLICATION SRP AND GBN RECOVERY METHODS

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Abstract

The article discusses the issues of designing technical systems, when the designer having acquainted the known method of recovery confronts the following task: Which way to choose to obtain the best reliability indicators, to transmit data with the least number of packets or vice versa.

Keywords: *time-redundancy, computer network, SRP and GBN methods of recovery, Laplace-Stieltjes integral, Undetectable failures, conditional probability* .

1 INTRODUCTION

Redundancies of 5 types for increasing reliability in technical systems are known: load, equipment (structural), functional, informational and temporary. In computer networks it is often advisable to introduce time-redundancy, namely [1]: increase of incoming elements speed (functional modules) and increase of system efficiency, respectively; creation of a reserve of the processed information; functional time lag; increase of time limit allocated for execution of concrete problems of the system.

For error correction it is most effective to use such protocols that provide repeated transfer of packets. These protocols [2,3] may be grouped into three methods: 1) SWP (Stop and Wait Protocol) and ABP (Alternating Bit Protocol); 2) GBN (Go Back N protocol); 3) protocol of the third method SRP (Selective Repeat Protocol).

2 REAZERCH QWESTION

Some tens of kinds of failures are known on computation network level that belong to equipment and program kinds. The main load at failure correction comes on lower circuit levels from physical to transport. In electric channels, modems, units of these levels there happen failure detection and organization of through control for elimination of packet loss. But there are failures that are not detected at lower circuit levels at the used control means and, probably, it is not needed. Because, detection and neutralization of certain types of failures are better executed on the higher levels of a circuit. Such failures may be called as

“Not corrected refusal” “NCR”. Not corrected refusal in channel and transport levels are the following: indication of incorrect length of a package, addressing to the addressee that is out of a working condition, recovery and the assembly of the multipackage message , incorrect calling procedure, violation of the secrecy regime**.** For the session level, the failure of such type is a failure caused by absence of own resources, or by the needed record’s not having been available, or not reception of the answer to inquiry, or by the interruption of dialogue process. For the applying level, such failures can be detected in executing such specific actions as testing of the data for the given values, or check on the admission to the classified information**.** In order to create network models suppose that " Corrected refusal " "CR" and " Not corrected refusal " "NCR" failures are exponentially distributed with corresponding failure intensity coefficients $\boldsymbol{\alpha}$

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and ***β***. Sum coefficient of failure intensity is denoted as $\lambda = \alpha+\beta$. After refusal is detected in the circuit there begins "renewal". Denote : t_j is time, during which, in the ***j*** level, in case of the absence of refusal in the circuit, the accomplishment (execution) of the task takes place. Here $j \le n$, where $n=1\div7$; t_k and t_w are time of detection of " Corrected refusal " and " Not corrected refusal " failures, respectively.

j is network level factor , (j+m = n, n=1…7) .

$Y = \sum_{j=1}^{n} t_j$ is time of problem performance in the network

For computer network with time-redundancy Θ, we have T=Y+Θ, where T is the value of time allocated for the solution of the problem in the circuit.

3 METHODOLOGY

Concerning the characteristics of the system, on the basis of standard probability a reasoning , if we apply Laplace-Stieltjes integral ,we get the following integral equation:

$$\begin{aligned}\Phi_{ji}(t) = &\int_0^T e^{\lambda\cdot T} d\phi(u)\Phi_{j2}(t) + \int_0^T (1-e^{-aT})e^{-\beta\cdot T} d\phi(u)\int_0^{T-u} dK(\tau)\times \\ &\int_0^{T-u-\tau} dQ(\zeta)\Phi_{Jo}(T-u-\tau-\zeta) + \int_0^T (1-e^{-\beta\cdot T})e^{-\alpha\cdot T} d\phi(u)\int_0^{T-u} dK(\tau)\cdot\times \\ &\Psi_{j.2}(T-u-\tau-\zeta) + \int_0^T (1-e^{-aT})(1-e^{-\beta.T}) d\phi(u)\int_0^{T-u} dK(\tau)\times \\ &\int_0^{T-u-\tau} dQ(\zeta)\Phi_{Jo}(T-u-\tau-\zeta)\end{aligned} \tag{1}$$

Where $\Phi_{j.0}(t)$ is a conditional probability that ***j.0*** network level the system being in serviceable state and executing on ***j*** level the informational interchange will completely solve the problem for $t \le T$ time;

$\Phi_{ji}(t)$ is a conditional probability that ***j.0*** network level the system being in serviceable state, executed ***i*** under a stage of ***m*** network levels the rest are executed for $t \le T$ time;

$\Psi_{ji}(t)$ is a conditional probability that ***j.0*** network level the system being in serviceable state, executed ***i*** under a stage of ***m*** network levels having an " Not corrected refusal " with intensity coefficient ***β*** solves the problem on that level for $t \le T$ time. This function is determined from the following integral equation:

$$\begin{aligned}\Psi_{j.t}(t) = &\int_0^T e^{-\lambda\cdot T} d\phi(u)\Psi_{j.i+1}(u) + \int_0^T e^{-\beta.T}(1-e^{-aT})d\phi(u)\int_0^{T-u} dK(\tau)\times \\ &\int_0^{T-u-\tau} dQ(\zeta)\Phi_{Jo}(T-u-\tau-\zeta) + \int_0^T e^{-\alpha.T}(1-e^{-\beta\cdot T}).d\phi(u)\int_0^{T-u} dK(\tau)\times \\ &\Psi_{j.i+1}(T-u-\tau) + \int_0^T (1-e^{-aT})(1-e^{-\beta.t})d\phi(u)\int_0^{T-u} dK(\tau)\times \\ &\int_0^{T-u-\tau} dQ(\zeta)\Phi_{Jo}(t-u-\tau-\zeta)\end{aligned} \tag{2}$$

Boundary conditions:

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$$\Phi_{no}(t) = 1 \quad , \qquad \Psi_{jm}(t) = \int_0^T d\Omega(u) \int_0^{T-u} dQ(\tau)\Phi_{J0}(T-u-\tau) \tag{3}$$

While $\phi(t) = \int_0^T e^{-\lambda T} dt$ is the probability of problem solution

As an example, let us explain the idea of the integral equation of conditional probability of solving $\Phi_{j_1}(t)$ task on ***j*** level. The idea is the following: On ***j*** level, at performance of the first under a stage the failure doesn't happen and the system proceeds to effecting the second under a stage with probability $\Phi_{j_2}(T-u)$, or there is the "CR" refusal present with the coefficient $\boldsymbol{\alpha}$ of intensity of refusal, which is detected through doubtful control K (τ) on under a stage. After the corresponding restoration Q(ξ) the system returns to the initial condition with probability $\Phi_{jo}(T-u-\tau-\xi)$, or " CR" failure with **α** intensity coefficient of failure doesn't happen on the stage, but rather there takes place "UD" failure with $\boldsymbol{\beta}$ intensity coefficient of refusal, which is not detected on the under a stage through the doubtful control K(τ). system proceeds to effecting the next under a stage with probability $\Psi_{j_2}(T-u-\tau-\xi)$, or there are present the both types of failures on the under a stage, and after the corresponding control and restoration the system will execute the task in the initial stage with probability $\Phi_{jo}(T-u-\tau-\xi)$. The condition $\Phi_{jo}(t)$, for which the efficiency of the system was known , is called the return condition. K(t), Q(t) and Ώ(t) are distribution functions: K(t) is the function of doubtful control exposing the failures of " detectable " type with intensity coefficient α; Q(t) is the function of restoration; Ώ(f) is the function of authentic control exposing the undetectable failures with intensity coefficient $\boldsymbol{\beta}$. Generalizing (1) and (2) we get:

$$\Phi_{j0}(t) = \frac{A^m}{1-[CE\sum_{\tau=0}^{m} A^{m-1-\tau}(A+C)^{\tau} + (B+D)\sum_{\tau=0}^{m}(A+C)^{\tau}]} \tag{4}$$

here

$$\begin{aligned}
A &= \int_0^T e^{-\lambda T} d\phi(u) \\
B &= \int_0^T e^{-\beta \cdot T}\left(1-e^{-\alpha \cdot T}\right) \cdot d\phi(u) \int_0^{T-u} dK(\tau) \int_0^{T-u-\tau} dQ(\zeta); \\
C &= \int_0^T e^{-\beta \cdot T}\left(1-e^{-\beta \cdot T}\right) \cdot d\phi(u) \int_0^{T-u} dK(\tau); \\
D &= \int_0^T \left(1-e^{-\alpha \cdot T}\right) \cdot \left(1-e^{-\beta \cdot T}\right) \cdot d\phi(u) \int_0^{T-u} dK(\tau) \int_0^{T-u-\tau} dQ(\zeta); \\
E &= \int_0^T d\Omega(u) \int^{T-u} dQ(\tau)
\end{aligned} \tag{5}$$

Then the corresponding integral equation in case of SRP protocols of renewal will have the form:

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$$\Phi(t)_{j0} = \int_0^T d\phi(u)e^{-\lambda u} \int_0^{T-u} dK(\tau)\Phi_{j1}(t-u-\tau) + \int_0^T d\phi(u)(1-e^{-\beta u}) \int_0^{T-u} dK(\tau)\Psi_{j1}(t-u-\tau) + \int_0^T d\phi(u)(1-e^{-\alpha u}) \int_0^{T-u} dK(\tau) \int_0^{t-u-\tau} dQ(\xi)\Phi_{j0}(T-u-\tau-\xi) \quad (6)$$

here

$$\Psi(t)_{j,k-1} = \int_0^T d\phi(u)e^{-\lambda T} \int_0^{T\text{-}u} dK(\tau)\Psi_{jk}(u) + \int_0^T d\phi(u)(1-e^{-\alpha T}) \int_0^{T\text{-}u} dK(\tau) \int_0^{T\text{-}u-\tau} dQ(\xi).\Phi_{jo}(T-u-\tau-\xi) \quad (7)$$

4 REZULTS

With elementary transformations (6),(7) and with consideration of limiting condition (3), we receive dependence for calculation of probability for method SRP taking into account quantity of the transferred packages **:**

$$\Phi_{n-k}(t) = \frac{A^k}{1-\left[(k\times A^k\times C\times D)+\left[B\times D\times\sum_{\rho=0}^{K}(\rho+1)\times A^P\right]+B\times\sum_{\rho=0}^{K}A^\rho\right]} \quad (8)$$

Here n - total of transferred packages at this level of a network , ***i*** quantity of already transferred packages . Let us solve the following problem: Determine the dependence of packages transmitted on the probability of faultless transmission of information through using SRP protocol. There is a problem of frequent presence, for which it's better to transmit the same information with the minimal number of packets or vice versa. Here are the obtained results of calculations (see Table 1 and picture 1) of using SPR Restoration Method by transmission of packets 800, 600 and 400 in the circuit. For calculation we get [1] the following data : α = $7.657 \cdot 10^{-3}$ 1/h, $\beta = 1.933 \cdot 10^{-9}$ 1/h, restoration time tg=0.6 h, Θ =0.333 h, duration of true control (TC) tw = 0033 h, duration of untrue control (UC) tk = 0.0028 sec , m=800.600.400 packets, ym = 1.333 h, ti = ym /m h.

Table 1 Results of calculations at application SRP of a method at transmission of packets 800, 600 and 400.

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$\mathrm{srp}\Phi4_{\mu} =$

$3.126 \cdot 10^{-3}$
0.013
0.056
0.239
1

$\mathrm{srp}\Phi6_{\xi} =$

$1.735 \cdot 10^{-4}$
$7.363 \cdot 10^{-4}$
$3.126 \cdot 10^{-3}$
0.013
0.056
0.239
1

$\mathrm{srp}\Phi8_{\eta} =$

$9.625486 \cdot 10^{-6}$
0.000041
0.000173
0.000736
0.003126
0.013268
0.056313
0.238899
1

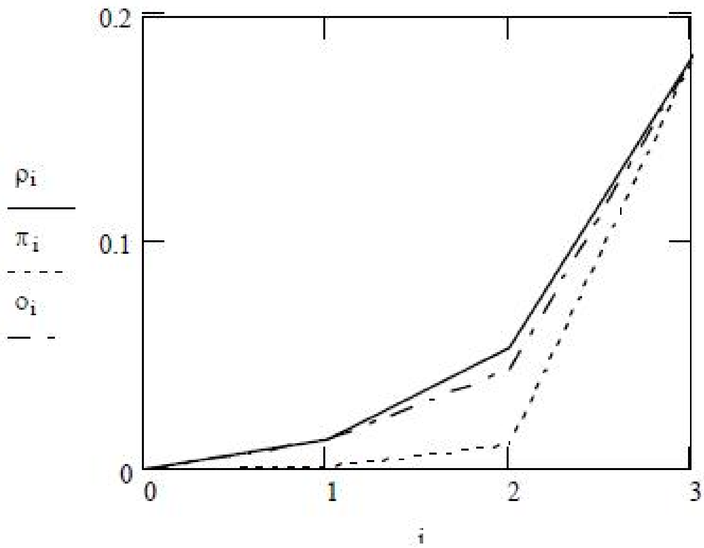
Comparisons are made by symmetric numbers of frames:

$$\rho_1 := \mathrm{srp}\Phi4_1 - \mathrm{srp}\Phi8_2 \qquad \pi_1 := \mathrm{srp}\Phi6_1 - \mathrm{srp}\Phi8_2 \qquad o_1 := \mathrm{srp}\Phi4_1 - \mathrm{srp}\Phi6_1 \tag{9}$$

$$\rho_2 := \mathrm{srp}\Phi4_2 - \mathrm{srp}\Phi8_4 \qquad \pi_2 := \mathrm{srp}\Phi6_3 - \mathrm{srp}\Phi8_4 \qquad o_2 := \mathrm{srp}\Phi4_2 - \mathrm{srp}\Phi6_3$$

$$\rho_3 := \mathrm{srp}\Phi4_3 - \mathrm{srp}\Phi8_6 \qquad \pi_3 := \mathrm{srp}\Phi6_5 - \mathrm{srp}\Phi8_6 \qquad o_3 := \mathrm{srp}\Phi4_3 - \mathrm{srp}\Phi6_4$$

Here (see picture 1) Φ8 , Φ6 and Φ4 are the corresponding values of probabilities of calculations according to (9).



Picture 1. Comparison value of probabilities under symmetric numbers of the under a stage for SRP method Let us examine another example, the time of excess computer network, where, for increasing of reliability (e.g. for the transport level) the method of restoration realized by the GBN protocol.

According to the protocol functioning algorithms [2] and (2), we obtain analytical interrelation of the probabilities of faultless passage of information in channels through application of GNB Protocol.

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$$\Phi(u)_{n-1} = \int_0^T e^{-\lambda u} d\phi(u) \int_0^{T-u} dK(\tau)_{\Phi_n}(T-u-\tau) + \\ + \int_0^T \left(1-e^{-au}\right) d\phi(u) \int_0^{T-u} dK(\tau) \int_0^{T-u-\tau} Q(\xi) \cdot {}_{\Phi_j}(T-u-\tau-\zeta) \qquad (10)$$

Generalizing (10) and (3) and using β=0 for one network level (e.g. for the transport level), the time of excess computer network, we will have:

$$\Phi_{n-k}(t) = [A + A^k (1 - B \times \sum_{\rho=0}^{k} A^\rho)^{-1}] \qquad (11$$

As stated above, the problem set is to determine the dependence of the number of packages to be transmitted on the value of probability of faultless transmission of information when using GNB Protocol. Calculations are done according to the above stated values of the parameters and to (11) and (9), on which basis have received (see Table 2 and picture 2).

Table 2 Results of calculations at application GBN of a method by transmission of packets 800, 600 and 400 .

$gbn\Phi8_\eta$ =

0.24813015
0.24813042
0.24813149
0.24813579
0.24815311
0.24822294
0.24850433
0.24963784
1

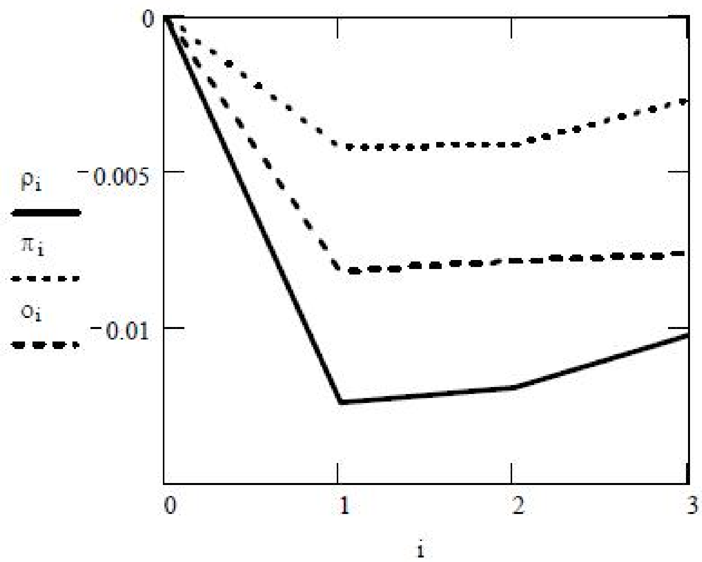
$gbn\Phi6_\xi$ =

0.24393334
0.24393854
0.24395984
0.24404717
0.24440512
0.24587168
1

$gbn\Phi4_\mu$ =

0.23560585
0.23572021
0.23620559
0.23826438
1

It shows (see picture 2) how, when using the GNB Restoration method, the probability of information transmission depends on the number of packages (the more the better).



Picture 2. Comparison value of probabilities under symmetric numbers of the under a stage for GBN method

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If dependences (Fig2) are crossed, then for comparison it is possible to use a technique of "Total Efficiency" offered in [4].

5 CONCLUSION

After generalization of results (the picture 1 see), we decide that the probability of information transmission depends on number of packets (the less, the better), applying a method of recovery SRP and on the contrary (than it is better than subjects more), applying a method of recovery GNB(the picture 2 see).

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