Method of Overloads' Elimination on Telecommunication Networks

Galyna Gayvoronska, Anna Kryzanovska

Abstract – **In this paper the decision of a problem of the overloaded switching node's unloading on telecommunication networks is given.**

Keywords – **Switching Node, Load, Overload, Unloading, Requirement.**

I. Introduction

At unexpected overloads' occurrence on telecommunication networks (TN), reallocation of streams of load can not provide the established quality of service. Often overloads cannot be foreseen, but sometimes though they are expected, the network is projected without their registration for the purpose of expenses' reduction for its creation. Thus already at network's designing reduction of the arriving in the network load is planned for the moment of overload, for example, at the expense of limitation of load from lowest categories' abonents or limitation of arriving load volume to provide fixed quality of service. For this problem's elimination there is a necessity of the decision of a problem of overloaded node's unloading to performance regulations of quality of infocommunication services for each and all categories of users.

II. The Decision of a Problem of the Overloaded Node's Unloading

The decision of a problem of the overloaded switching node's (SN) unloading is possible in two ways: introduction new basic SN and redistribution of a serviced load between existing SN. The fundamental distinction between these ways consists in single expenses for new SN's installation in the first case and long expenses for network reorganization in the second. For a choice of one of these ways the task in view to define time moment, into which it is necessary to enter a new node to receive the least expensive unloading plan for overloaded SN.

Let's consider the problem of search of optimal strategy of the overloaded node's unloading on the fragment of a network consisting of three nodes i, j and k. Here node i is supposed overloaded, and node j – possessing in free capacity which can be used for node's i time unloading. Node k is considered as a potential point of basic node's allocation for processing of node's i excessive requirements. The mathematical decision of the formulated problem demands the big number of simplifying assumptions which are in detail considered in the report. Let's designate as $s_i(t)$ and $s_j(t)$ requirements of connection to nodes i and j accordingly. Node k is entered only for service of the excessive requirements arriving on node i, therefore requirements of connection to node k will not be considered in the given problem. Thus value $s_j(t)$ is supposed determined, and $s_i(t)$ – stochastic, customized by distribution function $F_{s_i(t)}(s) = \mathbb{P}\left(s_i(t) \quad s\right) \quad \mathbb{P}^{s_i(t)}\left((- \quad , s]\right)$. Let's consider separately requirements which can be serviced by this SN, and excessive requirements because node i is overloaded.

Let $\bar{s}_i(t)$ – the requirements arriving on node i and serviced by it, and $\hat{s}_i(t)$ – the excessive requirements serviced by node j or k. Obviously these three values are coupled by a relation:

$$\hat{s}_i(t) = \max\{s_i(t) - \bar{s}_i(t),\ 0\} \qquad t = \overline{1,h} \tag{1}$$

Then distribution function $\hat{s}_i(t)$ can be set as follows

$$F_{\hat{s}_x(t)}(s) = \begin{cases} F_{s_i}(s), & \text{at } \hat{s}_i(t) > 0, \\ F_{s_i}\left(\bar{s}_i(t)\right), & \text{at } \hat{s}_i(t) = 0, \end{cases} .$$

Let $\breve{s}_x(t)$, $x = j,k$ – really established on node j or k number of ports for service of node's i excessive requirements at the moment of t, and $s_x^+(t)$, $x = j,k$ – number of scheduled connections or cutoffs on node j or k within a year t, assuming base of forecasting the beginning of the investigated period. Then it is possible to assert, that quantity of the ports added on port j or k in the beginning of year t for service of an additional load of node i, is the most from peak of an excessive load for a year ($t-1$) and quantities of the added ports, before planned for a year $t-1$:

$$\breve{s}_x(t) = \max\{\hat{s}_i(t-1),\ \breve{s}_x(t-1) + s_x^+(t-1)\} \qquad t = \overline{2,h}, x = j,k \tag{2}$$

Unique limiting for $s_x^+(t)$ is inequality performance

$$s_x^+(t) \quad -\breve{s}_x(t) \qquad t = \overline{1,h}, x = j,k \tag{3}$$

that is the number of cutoffs cannot exceed number of the established ports.

Concrete value x in expressions (3) and (4) depends on, whether already additional node k is entered. Let's enter variable-indicator $\iota(t)$ for a designation of this fact

$$\iota(t) = \begin{cases} 1, & \text{if node k in momet t is already established,} \\ 0, & \text{in other time.} \end{cases} \tag{4}$$

According to the assumption of evolution's irreversibility [1] as soon as on node k the equipment is established, this node continues to function till the end of the investigated period. That is

$$\iota(t-1) = 1 \quad \iota(t) = 1, \qquad t = \overline{2,h} \tag{5}$$

or, in other words, $$\iota(t) \quad \iota(t-1), \qquad t = \overline{2,h}\ . \tag{6}$$

Then, thanks to the entered indicator, expressions (3) and (4) can be copied in the following, more strict kind

$$\breve{s}_j(t) = \max\{\hat{s}_i(t-1),\ \breve{s}_j(t-1) + s_j^+(t-1)\} \qquad t = \overline{2,h} : \iota(t) = 0,$$
$$\breve{s}_j(t) = \max\{\hat{s}_i(t-1),\ \breve{s}_k(t-1) + s_k^+(t-1)\} \qquad t = \overline{2,h} : \iota(t) = 1,$$

Galyna Gayvoronska – Odessa state academy of refrigeration, Dvoryanskaya str., 1/3, Odessa, 65082, UKRAINE, e-mail: gsgayvoronska@gmail.com

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$$s_j^+(t) \quad -\breve{s}_j(t) \qquad t=\overline{1,h} : \iota(t)=0,$$
$$s_k^+(t) \quad -\breve{s}_k(t) \qquad t=\overline{1,h} : \iota(t)=1.$$

Taking into account the entered denotations, the problem can be formulated so: to find such sequences of values of indicator of installation of additional node $\iota(t)$ and such values of capacity of ports $s_x^+(t)$ which are necessary for adding or deleting on an node x and which satisfy to conditions (3), (4) and (5) and provide the minimum cost of network's development.

On the basis of results presented in [2], function of capital expenses for the transmission equipment $\varsigma_x^K(t)$, $x=j,k$ represents annual increase in expenses at installation of the equipment and increase in number of channels between node i and node j or k, and is defined as follows

$$\varsigma_x^K(t)=\ell_x(t)s_x^+(t),$$

where $\ell_x(t)=\ell(X(x,t))$ – increase's cost at unit of capacity of the equipment installed on node x at moment t.

The right part of expression can accept and negative values that corresponds to possibility of the income of the dismantled equipment's dismantle and reuse [3]. Except the considered expenses, it is necessary to consider also the expenditures connected with a possibility of service requirements' redistribution. First of all it concerns expenses for network's reorganisation $\varsigma_x^R(t)$, $x=j,k$, which including expenses for a payment and is defined by additional cost parameter

$$\varsigma_x^R(t)=c_x(t)\left|s_x^+(t)\right|,$$

where $c_x(t)$ – expenditures on equipment unit's connection or disconnecting, installed on node x at moment t.

Actual expenditures at the expense of calls' losses are defined as

$$\varsigma_x^U(t)=\begin{cases}\tilde{\ell}_x\left(\breve{s}_x(t) \quad \left(\breve{s}_x(t)+s_x^+(t)\right)\right), & \text{at } \breve{s}_x(t)>\left(\breve{s}_x(t)+s_x^+(t)\right),\\ 0, & \text{otherwise.}\end{cases}$$

where $\tilde{\ell}_x(t)$ – the losses connected with the failures in service of one user connected to node x at moment t.

Service of calls demands except the planned quantity of channels, commutative capacity and expenses for reorganisation, additional expenditures connected with operations not considered in preliminary developed schedule. Quantitatively it can be expressed as follows

$$\varsigma_x^U(t)>\varsigma_x^K(t)+\varsigma_x^E(t)+\varsigma_x^R(t) \qquad t=\overline{1,h}, x=i,j,k.$$

Here expenses for calls' losses $\varsigma_x^U(t)$ are a casual variable, and it is necessary to select $s_x^+(t)$ so that the population mean of expenses for calls' losses $\underset{\breve{s}_x(t)+s_x^+(t)}{\mathbb{E}}\left(\varsigma_x^U(t)\right)$ was as less as possible.

The formulated problem can be solved in the various ways, in particular, it possesses essential similarity to a storekeeping problem. Moreover, it is possible to assert, that after installation of a new node and switching of a part of users on a new node, up to the end of the period of planning, the decision of a problem of capacity's management is optimum and for a problem considered in our case. Besides, it is possible to prove, that the decision of storekeeping problem is applicable also by the years previous installation of a new node when expenses depend on two nodes and the unloading capacity is limited.

III. CONCLUSION

The offered model of SN's unloading can be used for creation of computing procedure of determination of optimum year of new nodes' introduction. The minimum expected expenses easily settle up with its help for each scenario of development. Thanks to model's stability to forecasting errors, minor parameters' or network growth factor's variation will not affect a choice of optimum year.

The optimality of usage of the threshold levels strategy at SN's capacity handle is shown. By means of the offered model of SN unloading the minimum expected expenses for each scenario of development can be easily settled up. Thanks to stability of model to forecasting errors, change of minor parameters or coefficient of network's growth will not affect choice of optimal year. On the basis of the offered approach it is developed the algorithm, allowing to select the optimal introduction moment of new node for user's switching from the overloaded node. The same algorithm can be used for observation of the unloading schedule's implementation after it has been accepted to fulfillment and adjustment of the accepted solutions.

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