DIGITAL FLOWS ALLOCATION IN THE TRANSPORT NETWORK, BUILT WITH SDH.

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ABSTRACT

In this paper we consider the method of digital flows (DF) allocation in the transport network, built with Synchronous Digital Hierarchy system – SDH. DF allocation is carried out by means of linear programming. Thereat DF allocation is considered with different bitrates and with the same bitrates. Latter method guarantees maximization of low-bitrate flows in high-bitrate trunk line (TL). Considered methods may be used when designing the transport network and it's reconfiguration in case of variable gravitation between the nodes of network.

Such transport network may be used as a background for different switchable networks including telephone networks, packet networks, Integrated Services Digital Network – ISDN.

1. DF Allocation Method

At last time SDH [1] founds greater than greater application when designing digital networks. SDH includes different crossconnectors and multiplexers. Thus, the bachground crossconnection transport network arises.

Transport network must be transparent for transmission of different kindes of traffic, which demand different bitrates. In frames of SDH it is possible to organize DF 64 kbps, 2 Mbps, 155 Mbps, ... 10 Gbps, etc. Thus, the problem of DF allocation with different bitrates in the transport network comes up.

Let us remark that the problem of DF allocation is analogous to problem of channels allocation in channel-switching network [2], but differs essentially due to necessity of different-bitrate DF allocation.

Among well-known methods of channel allocation in channel-switching networks method by linear programming has been developed, and it solves this problem best of all.

In this paper the problem of different-bitrate DF allocation is also reduced to linear programming, but unlike well-known method of channel allocation [2], the coefficients, taking into consideration DF bitrates, are introduced to purpose function and inequalities system. Thus, the purpose function and inequalities system include the coefficients k_i, which take into consideration the bitrate, which exceeds in ki times the bitrate of the lowest-bitrate DF.

Let us simply assume, that the limit of bitrate in the TL corresponds to STM-4, and DF bitrate corresponds to STM-1, i.e. it is smaller then TL bitrate in 4 times.

Obviously, the high-bitrate DF with bitrate coefficient k_i is presented in linear program as a sum of k_i separated digital flows, which are peer to it as regards to optimization criteria.

Let us introduce these symbols:

ξ-number of different DF bitrates,

$M=\{\mu_i\}$ - a set of paths, which may be used for transmitting DF between two nodes of network,

f_i - bitrate in the path μ_i,

c_i - weight of the path μ_i. The choice of c_i depends on optimization criteria of DF allocation.

ϕ_{xy} - number of DFs, which must be transmitted between the two nodes k and l of network.

b_{xy} - bitrate in TL between the couple of nodes Nx u Ny.

Purpose function F and inequalities system:

$$F=\sum_{\mu_i=M} c_i p_i k_i f_i \quad (1)$$

$$\sum k_i f_i \le b_{xy} \quad (2)$$

$$\beta_{xy} \in \mu_{kl}$$

$$b_{xy}=\sum \phi_{xy} k_i$$

This problem is solved by symplex-method of linear programming.

Let us remark that the limitations of bitrate in TL amount to number of low-bitrate DF. It is connected with position that carrying a DF with bitrate coefficient ki into the allocation plan must lead to increasing the purpose function with amount, which bigger in ki times than one in case of carrying a lowest-bitrate DF.

Another version of purpose function and inequalities system is also possible. For instance, the bitrate coefficients are not included in purpose function and inequalities system.

Let us consider a case when the utilization of some TLs has become too low after the finish of allocation (e.g. 155 Mbps-TL has been utilized with amount of only 2 Mbps). In this case it is expedient to use iterating method with consequtive deleting of low-utilized TLs.

In process of recurring allocation the DF, which had been transmitted throw deleted TLs, was directed to other TLs.

Let us consider the following examples. In furst problem we should allocate DF in the 5-nodes network, thereat two kinds of DF are availiable. The bitrates in TLs are marked near TLs in fig. 1. The gravitations between nodes N_i and N_j are placed in tabl. 1. Preliminary allocation is carried out by means of occupation the shortest paths.

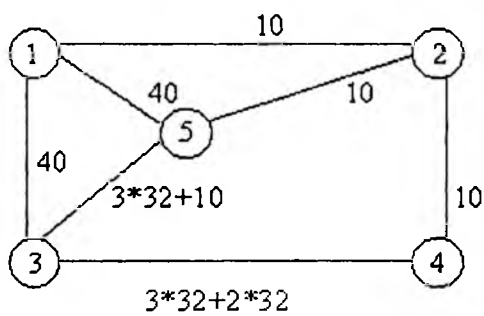

Figure 1. The bitrates in TLs are marked near TLs

Table 1. Dependence Bitrates of Couple of nodes and Number of DF

Couple of nodes i - j	Number of DF*	Bitrates
4-1	10	64 kbps
4-5	3	2,048 Mbps
3-2	10	64 kbps
3-4	2	2,048 Mbps

*DF bitrate coefficient equals

$$k = \frac{2048 Mb/s}{64 Kb/s} = 32$$

Problem is solved by means of program in C with IBM PC.

The results are placed in fig. 2. The bitrates in TLs are marked near TLs and amount to the number of low-bitrate DF.

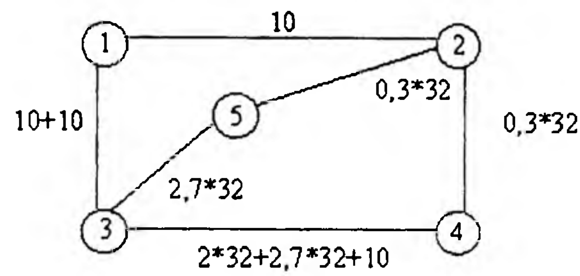

Figure 2. Solving the problem

Thus, TLs, which has not been carried into the optimal plan, was deleted out of consideration. Thereat 3 high-bitrate DFs between the nodes 4 and 5 was divided: 2.7 standart bitrate was directed throw the path 4-3-5, and 0.3 standart bitrate was directed throw the path 4-2-5.

The division of DFs between different paths may be desired because of increasing of reliability of connections between appropriate nodes.

In case of necessity of avoiding the DF dividing we should discriminate the inequalities for different types of DF.

The result is placed in fig. 3.

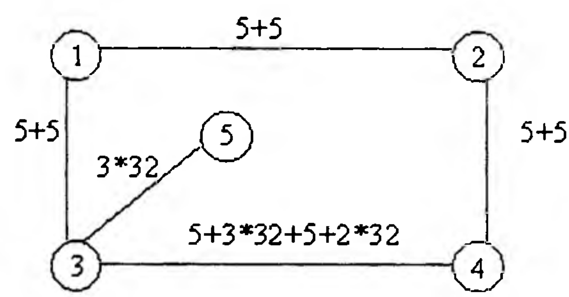

Figure 3. Discrimination the inequalities

Thus, there is no dividing of DFs between different paths.

When allocating DFs with the same bitrate in the networks with high-capacity TLs, the problem of optimizing the filling of TLs with low-bitrate DFs comes up.

We expound the method to solve this problem by means of also linear programming below.

Let us consider an example. The network is placed in fig. 4.

This network uses TLs with bitrate, increasing the DFs in 4 times, i.e. $C2=4C1$.

Demands for DFs level $C1$:

$\varphi 25=\varphi 14==\varphi 13=15$.

TL capacities ($C2$):

$b'12=4$, $b'15=4$, $b'23=5$, $b'24=3$,

$b'34=3$, $b'35=4$, $b'45=4$.

Number of DFs level C1:

$b12=16$, $b15=16$, $b23=20$, $b24=12$, $b34=12$, $b35=16$, $b45=16$.

The result of allocation is placed in tabl. 2:

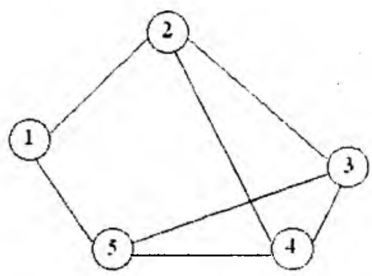

Figure 4. An example of network

Table 2. Before modifying the allocation plan

TL utilization			Unused DF
TL i, j	C1	C4	Q
1, 2	16	4	0
1, 5	14	4	1
2, 3	18	5	2
2, 4	10	3	2
3, 4			
3, 5	12	3	0
4, 5	15	4	1
Sum total unused DF			6

Thus, 6 DFs have not been allocated, including 1 DF in TL 1,5; 2 DF in TL 3; 2 DF in TL 2, 4; and 1 DF in TL 4, 5.

After modifying the allocation plan we have got a result, placed in tabl. 3.

Thus, the method by linear programming allows us to solve the problem of DF allocation rather effectively both when designing the transport network with SDH and when executive managing in case of variable gravitation between the nodes of network. When solving the problem of executive managing (reconfiguration) the transport network approximate methods, which have been developed earlier for channel allocation in non-switching networks [2, 4], may be used.

Table 3. After modifying the allocation plan

TL utilisation			Unused DF
TL i, j	C1	C4	Q
1, 2	12	4	0
1, 5	16	4	0
2, 3	20	5	0
2, 4	7	2	1
3, 4			
3, 5	15	4	1
4, 5	16	4	0
Sum total unused DF:			2

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