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# Optimal Selection of Routs in Data Transmission Networks. Energy Approach

**V. I. Parfyonov and S. V. Zolotarev**
*Voronezh State University, Voronezh, Russia*
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**Abstract**—A new algorithm has been proposed for solving the problem of optimal alternative routing based on the energy approach to the network analysis with generalization of Kirchhoff's laws. This algorithm is the fastest among a wide class of optimization methods based on finding an admissible direction of decreasing the target function. By the example of network analysis it was shown in the case of a quadrature target function this algorithm requires only one iteration for finding an optimal solution that favorably distinguishes it from the gradient projection and other possible methods. Optimization of the same network was conducted by the criterion of average delay minimum that is one of the main criteria used in optimizing networks of queues with representative time of message servicing.

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The routing problems are present in networks of any types: in packet- and message-switched networks and in digital channel-switched networks. A particular solution of the routing algorithm significantly depends on specific features of the network, but quite a similar body of mathematics is generally used for different networks including the shortest path algorithms and search algorithms applied to the flow models of networks based on intensities of the traffic entering the communications line. Flow models make use of an implicit assumption that the statistics of traffic entering the network is time invariable. Such assumption is reasonable, when this statistics changes very slowly as compared with the average time needed for reducing queues in network and when flows in lines are measured by time averaging.

Under the routing algorithm one can understand the rule in accordance with which a communications line is selected for data block (message or packet) transmission at each node of the data transmission network. Under the fixed (unbranched) routing we shall understand such procedure of route selection where a single route is used for data transmission from the source node to destination node (source-destination pair, SD-pair). If the route selection procedure allows us to choose more than one path, it is called branched or multipath. It is obvious that in the general case the alternative routing is preferable as compared with the fixed one, since it ensures a better use of the network resources.

Let us consider the following flow model of data transmission network (DTN) with alternative routing of messages. Let DTN consist of $N$ switching nodes and $M$ communications lines. The total traffic entering the network consists of messages with the same priority and forms a stochastic flow with mean value $\gamma$ [messages/s]. Each communications line having number $i \in [1, M]$ consists of single unidirectional communications channel with capacity equal to $d_i$ [byte/s]. The average length of message [byte] is equal to $1/\mu$. The total flow passing through line $i$ [messages/s] will be designated as $f_i$.

If the vector of flows in communications lines of the network is designated as $\mathbf{f} = (f_1, \ldots, f_M)$, an expression having the form

$$D(\mathbf{f}) = \sum_{i=1}^{M} D_i(f_i), \tag{1}$$

where each function $D_i(f_i)$ is steadily increasing, is often selected as a target (cost) function during optimization. Let us define the optimal routing problem as follows:

$$\text{minimize } D(\mathbf{f}),$$