ISSN 0735-2727, Radioelectronics and Communications Systems, 2008, Vol. 51, No. 5, pp. 239–246. © Allerton Press, Inc., 2008.
Original Russian Text © V.I. Parfenov, S.V. Zolotarev, 2008, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2008, Vol. 51, No. 5, pp. 12–22.

Algorithm of Conditional Minimization of the Goal Function for Optimal Routing in Information Networks

V. I. Parfenov and S. V. Zolotarev
Voronezh University, Voronezh, Russia
Received in final form August 9, 2007

Abstract—A new algorithm has been proposed for solving the optimal routing problem. This algorithm is based on applying the Kirchhoff laws to information networks and does not require the mandatory use of derivatives of the goal function making it quite convenient for distributed realizations. The algorithm convergence is substantiated by drawing an analogy between information and electric networks. On the basis of a case study of the network it was shown that its speed is tens of times as high as that of the flow deviation algorithm. It was shown that theoretical labor intensity of implementing this method is substantially less than that of the algorithms based on finding the shortest routes, since the cyclic part of this algorithm does not contain laborious logical operations.

DOI: 10.3103/S0735272708050026

The routing problems exist in all kinds of networks: packet and message switching networks and digital circuit switching networks. Actual realization of the routing algorithm tangibly depends on special features of the network, but generally, a fairly similar mathematical apparatus is applied for different networks. This apparatus consists of the shortest route algorithms and the flow algorithms applied to flow models of networks based on intensities of the traffic entering communication lines. In flow models a tacit assumption is made to the effect that traffic statistics varies with time very slowly. Such assumption is valid when the specified statistics varies very slowly as compared with the average time required for reducing queues in the network and when flows in the lines are measured by temporal averaging.

Under routing algorithm we understand the rule which determines the choice of communication line for transmitting a data block (message or packet) in each node of the data network. Under fixed (unramified) routing we shall understand such routing procedure, where a single route is used to transmit data from the source node to the destination node (sender-receiver pair, SR-pair). If the routing procedure allows more than one route to be used, it is called alternative ramified or multipath. It is obvious that generally the alternative routing is preferable as compared with the fixed one, because it ensures a better use of network resources.

Let us consider the following flow model of information network (IN) with alternative routing of messages. IN consists of N switching nodes and M communication lines. The traffic entering the network consists of messages having the equal priority; it generates a stochastic flow with average value γ_p [messages/sec] for messages following path p. Let us designate the total external traffic by the formula

$$\gamma = \sum_{w \in W} \sum_{p \in P_w} \gamma_p,$$

where P_w is the set of oriented paths for SR-pair $w = (i, j)$, where node i is sender, while node j is receiver of messages and W is the number of SR-pairs in the network. Each communications circuit consists of a single unidirectional communications channel with capacity d_{kl} [byte/sec], where (k, l) is communication line between nodes k and l. The average length of message [bytes] is equal to $1/\mu$. The total flow passing through the line (i, j) [messages/sec] will be equal to

$$f_{ij} = \sum_{\substack{\text{over all paths } p, \\ \text{containing } (i,j)}} \gamma_p.$$