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Advanced solution of the Fast ReRoute based on principles of Traffic Engineering and Traffic Policing

The paper proposes a mathematical model of Fast ReRoute based on principles of Traffic Engineering and Traffic Policing in communication networks. The advantage of the proposed solution is the formulation of the problem as an optimization one with the optimality criterion, which focuses on minimizing the dynamically controlled upper bound of communication links and the intensity of flows that receive denial of service at the edge of the network weighted in relation to the priority of serving.

Introduction.

One of the important trends in the development of telecommunications is the design of fault-tolerant networks capable of maintaining their high efficiency in the face of various failures of switching equipment. The solution of this scientific and applied task requires the coordinated work of all available functional technological and protocol means of Open Systems Interconnection (OSI) models. Thus, at the network level, the key role is given to protocols and Fast ReRoute (FRR) methods, when not only the main route, but also a number of backup routes are calculated for transmission of packet flows [1-4]. However, during a fast rerouting, network resiliency is enhanced by supporting basic elements of protection for its elements due to resource redundancy, which negatively affects network performance and the quality of service (QoS) level as a whole. To minimize this impact on the network, it is necessary to use the balancing of the available network resource using the Traffic Engineering (TE) concept [5-8], and in case of a possible network overload, use the Traffic Policing (TP) function [9].

Therefore, this paper solves the scientific and practical problem associated with the development of an appropriate mathematical model while ensuring coordinated solutions to such complex network problems as FRR, TE and TP.

Flow-based Model of Traffic Engineering Fast ReRoute with Support of Policing.

Within the flow model of fast rerouting, the structure of a telecommunications network is described using a graph, which is represented by multiple routers and communication channels in a network. It was also determined such functional parameters as: source router, destination router, average flow intensity in packets per second and a set of flows transmitted over the network.

The implementation of fast rerouting with policy support is ensured by the introduction of route variables, each of which characterizes the fraction of the flow intensity that is sent from a node to a node through a communication link that enters the main or backup multipath. Also, to ensure the connectivity of the

routes, in the proposed model of fast rerouting, the conditions of stream conservation are introduced on the nodes are provided under the limiting condition (TP implementation) of incoming flows at the network boundary, which are part of the main or backup multipath.

To protect network elements during fast rerouting with support TP in a telecommunications network, the proposed model introduced conditions describing the implementation of protection schemes (reservation) of the communication link, node and bandwidth.

1. The conditions of link protection, which implies the introduction of additional restrictions on the desired route variables and ensures that the channel that is protected is not used by the backup route.

2. The conditions of node protection, which are generalized in case of protection of multiple communication links incident to the protected node.

3. Conditions for implementing a bandwidth protection scheme, when implementing fast rerouting to prevent overloading of communication links. To ensure load balancing, these conditions were modified by introducing an additional control variable that numerically determines the upper bound of the network links utilization and on which restrictions are also imposed depending on the threshold value (upper limit) of threshold of the upper bound of the network links utilization, the value of which is determined based on the requirements for the level of quality of service in the network. Introduction of the given conditions by the novelty of the proposed approach in comparison with the models proposed in [10-12].

The optimality criterion in this model is an expression characterizing the minimization of conditional costs associated with a coordinated solution of the FRR, TE and TP problems, namely:

- the conditional cost of denials to maintain flows that transmitted through the primary paths;
- the conditional cost of denials in servicing the flows transmitting in the backup paths;
- the weighted upper bound of the network links utilization.

Conclusions.

When conducting numerical studies of the proposed model of fast rerouting with load balancing with support of policing. the initial data were a variety of network structures for different numbers of traffic flows and their characteristics. The results of the researches confirmed the adequacy of the proposed solution and the possibility of obtaining optimal solutions to the problem of fast re-routing with load balancing with support traffic policing in telecommunication networks when implementing various protection schemes for network elements (link, node) and bandwidth, both in terms of ensuring their resiliency and load balancing, and for policing traffic.

At the same time, in the course of traffic policing, two important principles were realized: firstly, the limitations, first of all, concerned the flow that was the source of overload; and secondly, if overloading created several flows, the limitations, above all, concerned a flow with the lower priority.

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