

Method of Hierarchical QoS-Routing in Software-Defined Networks

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Abstract. In the paper, the method of hierarchical QoS based inert-domain routing in Software-Defined Networks has been presented. The novelty of the method is that the obtained routing solutions have to ensure the normalized Quality of Service under indicators of average transmission rate and end-to-end average packet delay. Numerical research has been conducted with the aim of confirming the workability and effectiveness of the method by providing a normalized QoS under the finite number of iterations that help to decrease the amount of overall service traffic.

Keywords: inter-domain routing; hierarchical coordination; Quality of Service; end-to-end delay; SDN.

I. INTRODUCTION AND PROBLEM STATEMENT

Providing a demanded Quality of Service (QoS) for user requests is the primary purpose of modern networks, including Software-Defined Networks, SD-WAN, and Hybrid SD-WAN [1-5]. At the same time, when solving the tasks of routing and traffic management, there is a problem of increasing the scalability of the obtained solutions [1, 4]. Therefore, the paper proposes a method of hierarchical coordination of inter-domain routing in a software-defined infocommunication network. The novelty of the method is that the routing solutions obtained through it are aimed not only at increasing the network scalability, but also at ensuring the normalized QoS under such indicators as average transmission rate and end-to-end average packet delay.

II. PROBLEM SOLUTION AND RESULTS

The proposed method is based on the use of decomposition of the flow-based inter-domain routing model under the following conditions and constraints:

- implementation of a single path and multipath routing;
- conditions of flow conservation;
- conditions of the overload prevention of network links;
- conditions of inter-domain interaction, which guarantee the connectivity inter-domain routes.

Additionally, the flow-based model of inter-domain routing has been supplemented by the provision of normalized QoS. In order to formulate in an analytical form the conditions for ensuring the normalized QoS, the means of tensor modeling of networks were used with the geometric space, which were respectively created by coordinate paths – edges (links), interpolator paths and internal node pairs.

Therefore, the problem of inter-domain QoS routing under the proposed method was presented as an optimization using the quadratic optimality criterion, which was solved using the principle of goal coordination [6, 7]. Accordingly, two hierarchical levels solved the tasks that were assigned to them:

- the lower level (the level of SDN domain controllers) was responsible for the calculation of intra-domain routes;
- the upper level (the SDN level of the network controller) was responsible for coordinating the lower level solutions by performing inter-domain interaction conditions to ensure inter-domain connectivity within the gradient procedure.

The coordination of routing solutions was completed when the gradient approached zero.

III. CONCLUSIONS

The study of the proposed method of inter-domain QoS routing on a number of numerical examples confirmed its workability and effectiveness in terms of providing a normalized QoS. On the ground that, it was found experimentally that the method converged to the optimal solution for the finite number of iterations. Moreover, for network structure under investigation, the number of iterations of the coordination procedure, with the appropriate gradient search, was not more than three iterations. All the things considered, reducing the number of such iterations will decrease the amount of service traffic in the network between routers and SDN controllers at different levels, as well as minimize the overall time of solving the inter-domain QoS routing task.

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