

COMPREHENSIVE CONGESTION CONTROL IN IP NETWORKS

Honcharenko B.M., Partyka S.O.

Kharkiv National University of Radioelectronics, Kharkiv, Ukraine

In today's world, where digital services, cloud computing, and multimedia applications generate huge amounts of traffic, the efficient functioning of IP networks is critical for the stable operation of information systems. The constant growth in the number of users, devices, and the amount of data transferred increases the load on network resources [1,2].

The problem of congestion in IP networks affects the quality of service and the stability of network connections. It occurs when the volume of incoming traffic exceeds the bandwidth of communication channels or the computing capabilities of network nodes. In such cases, packets begin to accumulate in router buffers, which leads to increased latency and data loss. Over time, this can cause an avalanche-like deterioration in performance, when even a small increase in traffic causes a sharp drop in network throughput. Classical mechanisms, such as TCP window control, do not always have time to adapt to rapid changes in load, especially in environments with short flows or a large number of competitive connections. In addition, traditional router queues with fixed parameters do not take into account the nature of traffic, which leads to inefficient use of network resources [3].

The purpose of the report is compare modern approaches to comprehensive congestion control in IP networks, analyze their effectiveness in reducing delays, packet loss and increasing the stability of data transmission. Both classical methods of active queue management (AQM) and modern solutions based on adaptive control, software-defined networks (SDN) and machine learning are considered. Special attention is paid to their interaction and the possibility of integration into complex traffic management systems. It is shown that the combination of AQM mechanisms, intelligent routing and SDN-based control allows to significantly reduce the average queue length, reduce latency and improve bandwidth utilization compared to traditional methods.

A modified approach to congestion management is presented, which combines active queue management methods with adaptive machine learning models for dynamic parameter adjustment depending on the current network state. This approach allows to increase the efficiency of resource use and the stability of network connections in highly loaded environments.

References

1. Shahram Jamali, Mir Mahmoud Talebi, Reza Fotuhi. *Congestion control in high-speed networks using the probabilistic estimation approach*, 2021.
2. Sounak Kar, Bastian Alt, Heinz Koepl, Amr Rizk. *Optimal Decision Making in Active Queue Management*, 2022.
3. Cédric Join, Hugues Mounier, Emmanuel Delaleau, Michel Fliess. *Active queue management: First steps toward a new control-theoretic viewpoint*, 2022.