Performance Optimization Methods for Flow Control Problems in Multi-Traffic and Multi-Hop Communication Networks

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Performance optimization and performance evaluation are key tools in reliable communication networks operation, and for managing network services. Communications networks have become ubiquitous in public and private organizations all over the world. Organizations are comprised of entities that need to communicate with each other. These entities (or stations) can be computer workstations, databases, facsimile machines, local area networks, wireless networks or other entities. Stations communicate over links, which can be various types of suspended or underground cables, as well as microwave or satellite transmission.

Communication networks to support several different traffic types and several different hopes to retransmit have become so complex that intuition alone is not sufficient to predict their performance and optimization. Mathematical modeling and performance optimization have come to play an important role in the workings of communication networks. Queuing models are defined algorithmically rather than by an explicit formula. Even so, system parameters such as the mean service time, arrival rates, and number of servers can be chosen so that the predefined design objective are met.

Flow control algorithm in high speed communication networks is a resource-sharing policy. Flow control of large-scale communications networks involves making decisions on the type of network: centralized or distributed; type of communication network architecture; type of switching: circuit switching or packet switching; type of routing: static or dynamic; and type of network control and monitoring: centralized or distributed. Given node locations and peak traffic demand, variables such as topology, link capacities, routing policy must be considered. Each constraint of link capacity, node capacity and delay, then must also be considered to minimize total network cost or maximize the network utilization.

Still another problem is the routing of traffic on the network. In a resource-sharing communication environment, transmission route choice models or transmission assignment models aim to describe traffic flows on communication networks, which operate at known switches. The route choice models or traffic assignment models are also flow control problems with a waiting phenomenon: traffic experiences a waiting time for the switch of the line on which traffic is chosen.

The modeling of such communication networks is taken to be the minimization of expected waiting and transmission time, or the expected total generalized cost if waiting times and transmission times may have different weights.

Given potential sites for network node location, traffic data, and available link types and their cost, the lowest-cost local access network configuration must be obtained considering optimum variables. That being a network with an optimum number of network nodes and their locations, optimum set of links interconnecting the network nodes, their capacities, routing paths, subject to constraints on delay, throughput, reliability and link capacity.

In this paper, the author introduces three research results related to performance optimization methods for the above flow control problems in multi-traffic and multi-hop communication networks. The first research introduces a novel concept of backlog balancing and demonstrates its application to network flow control and congestion control by presenting a rate-based flow control algorithm for the communication networks. The aim of such flow control models is to maximize the network utilization for achieving high throughput with tolerable delay for each access point.

The second research results provide a performance optimization analysis of virtual route networks using queuing theory for which a pacing window flow control mechanism is employed with an input queue included. Messages prevented from entering the network are stored in the input queue in a first-come first-serve manner. Both cases of finite and infinite capacity of buffer are considered. The results show that although the average number of messages in the network is higher, when the input queue delay is taken into consideration. The overall performance of the system is better than that of the other systems.

The third research proposes a flow control scheme for data packet traffic to avoid network congestion and to obtain the maximum throughput. The flow control algorithm of transmission control protocol determines the packet transmission rate using the congestion window size, which is adjusted to obtain a large throughput without network congestion and buffer overflow of the receiver. The flow control algorithm decreases the window size when network congestion is detected. Fairness, stability, and optimality of the proposed method are discussed with respect to the performance of the system.