Routing in ATM networks

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Abstract

Asynchronous Transfer Mode (ATM) has been adopted by CCITT as the transport mode for B-ISDN. There are various performance issues that need to be resolved before B-ISDN networks can become a reality. In this paper, some of the performance issues in routing in ATM networks are addressed and the applicability of the routing concepts developed for today's low bandwidth public and commercial communication networks to B-ISDN networks is discussed.

1. Introduction

A communication network is a collection of devices that wish to communicate and a set of nodes that provide connections between such devices. Since, in general, there is no direct connection between devices, the network must route traffic from node to node throughout the network. A path in the network is then defined as a collection of sequential communications links ultimately connecting two devices to each other. Normally, there is more than one path connecting any two devices in the network. The process of selecting a path in the network is referred to as the routing function. There are a number of desirable attributes of routing functions [30]: correctness, simplicity, robustness, stability, fairness, and optimality. The first two attributes are self explanatory. Robustness is the ability of the technique to cope with changes in the topology of the network due to failures of network resources as well as congestion. Ideally, the network should react to such contingencies without affecting the service provided to current user traffic. Moreover, reaction to changing conditions should take place fast. Otherwise, network may experience unstable swing between extremes. For example, some traffic from one congested area may be shifted to another area. This may cause congestion in the second area while the first area may now be under utilized. Then, some traffic may be rerouted back to the first area trying to balance the load in the network. Swinging between different areas, the network may never reach steady state. Performance criteria to be

High-Speed Communication Networks, Edited by H. Perros
Plenum Press, New York, 1992

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optimized may depend on the type of traffic carried in the network. Usually, the criteria may be the minimization of the mean delay or maximization of the network throughput. Since these two objectives are conflicting, the goal may be to maximize the throughput while meeting end to end delay requirements of the traffic carried in the network. Furthermore, it may not be possible to achieve optimality and be fair to all users. Hence, some compromise between the global efficiency and fairness to individual connections is needed.

Various routing techniques have been implemented in current networks such as TYMNET, TRANSPAC, ARPANET, SNA and DNA. These networks are all examples of store and forward networks in which data packets moving from one device to another are buffered and processed at each node along their path. The link speeds of these networks are in the order of several Kbps. With these slow links, the main design criterion becomes the efficient use of network bandwidth. An interested reader may refer to [27] for a survey of routing techniques used in low bandwidth communications networks. In general, routing algorithms implemented in these networks are variants of shortest path algorithms that route packets from source to destination over a least cost path. They mainly differ in the cost criteria used. Some networks use fixed cost for each link in the network while others use some measured metrics such as congestion, mean packet delay, link utilizations, etc. Given the performance criterion, the routing technique used can further be classified according to the place and time of the decision [29]. In particular, the decision time is either at the packet or virtual circuit level. Routing decision for datagram networks is made individually at each node for all arriving packets. A virtual circuit is defined as a logical connection between two devices. It is set up and released per connection request basis. In virtual circuit networks, the routing decision is made at the circuit establishment phase and all packets belonging to a virtual circuit follow the same path in the network. The decision place also varies among different networks. In some networks, each node has the responsibility of selecting an output link for routing packets as they arrive, referred to as distributed routing. On the other hand, in centralized routing a central node is responsible for making all routing decisions. Another infrequently used alternative is the source routing, in which the originating node determines the complete path. The amount of information required on the topology of the network, i.e. traffic load at each link, accordingly depends on the performance criteria used and the time and place of the routing decision. Some techniques may use no information at all, some may use local information, i.e. queue size for each outgoing link, and some others may need global information about the network to make a decision.

Typically, the routing information in virtual circuit networks is given as a link-by-link logical channel number (LCN) defined uniquely for each virtual circuit in the network. In this scheme, the LCN is determined independently for each link. Accordingly, when LCN is employed as the path identifier, the node performs a table look up to determine the output port and updates the LCN of the cell label to the one used in the output link. Alternatively, the virtual circuit identifier may be unique from source to destination eliminating the need to update the LCN at every node. The main difference between the two are the size of the LCN required by each method and the processing times required at the intermediate nodes. LCNs can be made short with locally defined values for transmission efficiency. We note that this scheme requires the routing tables at each node to be set up at every connection establishment phase. A global VC identifier eliminates this problem. However, this scheme necessitates large routing tables at every node, and the table look up operation might be time consuming as the number of virtual circuits in the network increases.