EVALUATION OF NETWORK RELIABILITY FOR A COMPUTER NETWORK SUBJECT TO A BUDGET CONSTRAINT

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ABSTRACT. This paper constructs a multistate flow network composed of multistate edges to model a computer network. Each edge has lead time, capacity, and cost parameters. Therefore, the minimum transmission time through a single path is not a fixed number. Under the transmission protocol that the data are sent through \( p \) \((p \geq 2)\) minimal paths simultaneously, the minimum transmission time is also stochastic. This paper is mainly to evaluate the probability that a given amount of data can be sent through \( p \) minimal paths simultaneously subject to both time and budget constraints. Such a probability is named network reliability herein, which can be treated as a performance indicator to measure the transmission capability of a computer network. Without knowing all minimal paths, a solution procedure is first proposed to calculate network reliability. Furthermore, the network administrator decides the routing rule indicating the first and the second priority \( p \) minimal paths in order to enhance the network reliability. Subsequently, network reliability according to the routing rule is also computed. At last, the expected demand, expected budget, expected time, and the criterion to find an ideal routing rule are presented as well.

Keywords: Transmission protocol, Network reliability, Multistate flow network, Routing rule, Multiple minimal paths, Budget

1. Introduction. The shortest path problem to determine a path with minimum length is one of the well-known and practical problems in computer science, operations research, networking and other areas. This problem focuses on a network in which each edge has a fixed length parameter. When data/commodities are transmitted through a flow network, it is desirable to adopt the shortest path, least cost path, largest capacity path, shortest delay path, or some combination of multiple criteria [1-4], which are all variants of the shortest path problem. From the viewpoints of QoS (quality of service) [5-8] and business competing, it is an essential issue to shorten the transmission time through a computer network with the time parameter. Hence, a version of the shortest path problem called the quickest path problem proposed by Chen and Chin [9] arises to derive a single path with minimum transmission time for sending a given amount of data. Such a path is named the quickest path. In this problem, each edge has both capacity and lead time parameters [9-12]. The lead time is the time needed to travel through the edge. Several variants of the quickest path problems are thereafter proposed: constrained quickest path problem [13,14], the first \( k \) quickest paths problem [15-18], and all-pairs quickest path problem [19,20].

In the above problems, both the capacity and lead time parameters are assumed to be deterministic. However, due to failure, partial failure, maintenance, etc., each edge has multiple capacities/states in many real-life flow networks such as computer, pipelines...