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Reliability Evaluation of a Multicommodity Capacitated-Flow Network in Terms of Minimal Pathsets

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Abstract

Many real-world systems such as transportation systems, logistics/distribution systems, and manufacturing systems can be regarded as multicommodity flow networks whose arcs have independent, finite and multi-valued random capacities. Such a flow network is a multistate system with multistate components and its reliability for level $\mathbf{d} = (d_1, d_2, \ldots, d_k)$, i.e., the probability that k different types of commodity can be transmitted from the source node to the sink node in the way that the demand level $\mathbf{d} = (d_1, d_2, \ldots, d_k)$ is satisfied, can be computed in terms of minimal path vectors to level $\mathbf{d}$ (named $\mathbf{d}$-MPs here). The main objective of this paper is to present a simple algorithm to generate all $\mathbf{d}$-MPs of such a flow network for each level $\mathbf{d} = (d_1, d_2, \ldots, d_k)$ in terms of minimal pathsets. Three examples are given to illustrate how all $\mathbf{d}$-MPs are generated by our algorithm and then the reliability of one example is computed.

Keywords: Reliability, capacitated-flow network, $\mathbf{d}$-MP.

1. Introduction

Reliability is an important indicator in the planning, designing, and operation of a real-world system. Traditionally, it is assumed that the system under study is represented by a probabilistic graph in a binary state model, and the system operates successfully if there exists at least one path from the source node to the sink node. In such a case, reliability is considered as a matter of connectivity only and so it does not seem to be reasonable as a model for some real-world systems. Many physical systems such as transportation systems, logistics/distribution systems, and manufacturing systems that play important roles in our modem society can be regarded as flow networks in which arcs have independent, finite, and integer-valued random capacities. To evaluate the system reliability of such a flow network, several different approaches have been presented [6, 8], [12]-[21], [24, 25, 26]. However, these models have assumed that the flow along any arc consisted of a single commodity only. For such a flow network with multicommodity, it is very practical and desirable to compute its reliability for level $\mathbf{d} = (d_1, d_2, \ldots, d_k)$, i.e.,