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Approximation algorithm for estimating failure probability of multipath transmission☆

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Abstract

In a computer network where nodes can fail, multipath transmission can be used to increase the probability of successful transmission. However, even multipath transmission has a probability of failure, which depends on the selected paths. Hence, estimating this probability of failure is of great importance for designing good multipath routing algorithms. In this paper, we show that it is NP-hard to compute the failure probability of multipath transmission. Therefore, we design a polynomial-time approximation algorithm for estimating this failure probability and give analysis of its error bounds. We also compare the results of our approximation algorithm with the results of Matlab simulations.

Keywords: Computer network; Multipath transmission; Approximation; Polynomial complexity; Error bound

1. Introduction

Multipath transmission [2,4,1] is an important technique in computer networks. Unlike traditional single-path transmission, multipath transmission uses multiple paths in a session for sending data from the source to the destination. An advantage of multipath transmission is that it can tolerate node failure, because even if some of the paths were blocked due to node failure, other paths may still be able to carry the traffic.

However, even multipath transmission has a probability of failure, because the set of paths used for transmission may become blocked simultaneously. When one designs a routing algorithm for multipath routing, it is important to make this failure probability as small as possible. Consequently, it is crucial to have an algorithm for computing this failure probability.

Formally, we can describe the above problem as follows. Suppose that $G = (V, E)$ is a simple graph. Let $P = \{P_1, P_2, \ldots, P_n\}$ be a set of paths. Suppose that each node $v \in V$ fails with a probability p. Compute the probability p_f that for all P_i $(i = 1, \ldots, n)$, at least one node in P_i fails.

The problem of computing p_f seems simple, but it turns out to be NP-hard.

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