M_CSPF: A Scalable CSPF Routing Scheme with Multiple QoS Constraints for MPLS Traffic Engineering

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In the context of multi-protocol label switching (MPLS) traffic engineering, this paper proposes a scalable constraint-based shortest path first (CSPF) routing algorithm with multiple QoS metrics. This algorithm, called the multiple constraint-based shortest path first (M_CSPF) algorithm, provides an optimal route for setting up a label switched path (LSP) that meets bandwidth and end-to-end delay constraints. In order to maximize the LSP accommodation probability, we propose a link weight computation algorithm to assign the link weight while taking into account the future traffic load and link interference and adopting the concept of a critical link from the minimum interference routing algorithm. In addition, we propose a bounded order assignment algorithm (BOAA) that assigns the appropriate order to the node and link, taking into account the delay constraint and hop count. In particular, BOAA is designed to achieve fast LSP route computation by pruning any portion of the network topology that exceeds the end-to-end delay constraint in the process of traversing the network topology. To clarify the M_CSPF and the existing CSPF routing algorithms, this paper evaluates them from the perspectives of network resource utilization efficiency, end-to-end quality, LSP rejection probability, and LSP route computation performance under various network topologies and conditions.

Keywords: Packet scheduler, flow aggregation, rate control, IntServ, DiffServ, QoS.

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I. Introduction

Multi-protocol label switching (MPLS) is an Internet Engineering Task Force (IETF)-defined protocol that overcomes some of the shortcomings of IP-based networks. MPLS is meant for service provider core networks or large enterprise networks. There are two major benefits of MPLS traffic engineering: better total network use efficiency and better end-to-end quality for each traffic flow. To achieve these objectives, MPLS supports two traffic-engineering protocols: resource reservation protocol-traffic engineering (RSVP-TE) [1]-[4] and constraint-based label distribution protocol (CR-LDP) [1], [3], [5]-[7]. However, these protocols can manage only the bandwidth resource, the routing protocol is not defined in these protocols. In designing a network where traffic engineering is performed, the selection of routing algorithms and network topologies is believed to exert a great influence on the end-to-end quality and overall network resource utilization.

In the case of constant bit rate (CBR), traffic demands are placed dynamically, often on a first-come-first-serve basis. Routes are calculated one by one using the appropriate algorithm; for example, constraint-based shortest path first (CSPF) [8], shortest-distance path (SDP) [3], widest-shortest path (WSP) [3], or shortest-widest path (SWP) [9] algorithms as individual routes are computed meeting the quality-of-service (QoS) constraints.

On the other hand, fine-grained traffic engineering is also important. In order to achieve this, we generally consider multiple QoS metrics such as bandwidth, delay, jitter, administrative weight, and others, although this traffic engineering causes the NP-complete problem.

In addition, the minimum interference routing algorithm