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Minimizing preemption cost for path selection in Diffserv-ware MPLS networks

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Abstract

Preemption is becoming an attractive strategy for bandwidth reservation and management in DiffServ-aware Traffic Engineering. In this paper, we propose an improved heuristic algorithm for the well-known optimization formulation based on versatile preemption policy, which can minimize the preemption cost with high accuracy and less computational intractability. Simulation results show that the proposed algorithm significantly outperforms well-known algorithms recently proposed in the literature. Moreover, we present a new path selection scheme to minimize preemption. Due to preemption of those LSPs that share more links with the selected path, the proposed scheme obviously minimize rerouting in DS-TE environments.

Keywords: DiffServ-aware traffic engineering (DS-TE); Preemption; Algorithm; Path selection

1. Introduction

IP network is now evolving from a best-effort service network into an integrated network which supports multiple applications with different QoS requirements and different priorities. DiffServ-aware traffic engineering (DS-TE) proposed by IETF integrates the scalability of DiffServ architecture and the efficient routing policies of MPLS traffic engineering (MPLS-TE), and is known as a preferable solution for QoS guarantee as well as resource optimization in the multi-service network [1].

The DS-TE approach is based on the class-based bandwidth allocation in network routers and on routing an LSP through routers that have sufficient bandwidth for its QoS class. DS-TE introduces several new concepts including class types (CT), bandwidth constraints (BC), and traffic engineering classes (TE-Classes). Class types are defined as sets of traffic trunks that are governed by a specific set of bandwidth constraints. They roughly correspond to QoS classes defined in the DiffServ architecture. A DS-TE network can support up to eight CTs, where CT0 corresponds to the best effort traffic, and higher CT number correspond to traffic with more stringent QoS requirements. Bandwidth constraints are bandwidth allocations to individual CTs or groups of CTs depending on the BC model. CTs and BCs are the principal agents of transforming MPLS-TE into TS-TE. Instead of performing bandwidth accounting across the entire link bandwidth, DS-TE allows bandwidth calculations on the per-CT basis using the appropriate BC values.

TE-Classes were introduced as composite attributes that include both the traffic trunk's CT and the preemption priority of the LSP transporting it. DS-TE describes TE-Class mapping as:

$$\text{TE-Class}[i]\langle\text{--}\rangle\langle \text{CT}c, \text{preemption } p\rangle$$

Where $0 \leqslant i \leqslant 7$, $0 \leqslant c \leqslant 7$, $0 \leqslant p \leqslant 7$. Formation of TE-Classes follows several rules. The value of the preemption

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priority corresponds to the LSP's setup priority, holding priority or both. Each TE-Class represents a unique CT/P combination, but different TE-Classes may have the same CT with different values of *P* or different CTs with the same value of *P*. Once TE-Classes are formed, DS-TE compliant LSRs accept reservations only from LSPs whose attributes map into one of these TE-Classes.

TE-Classes are the primary LSP attributes in the DS-TE process. In order to support this advanced level of traffic engineering, IGP-TEs and RSVP-TE were extended beyond their MPLS-TE support, as described in [2]. Extended IGP-TEs still use the existing "Unreserved Bandwidth" sub-TLV for each of the TE-Classes instead of for each preemption priority. Extended RSVP-TE carries a new object with the LSP's CT value. Together with the existing fields for the setup and holding priorities, the RSVP-TE Path message contains complete information identifying the TE-Class.

Three BC models such as the Maximum Allocation Model (MAM) [3], the Russian Doll Model (RDM) [4] and the Maximum Allocation with Reservation (MAR) [5] have been proposed and their performance are evaluated and compared [5,6].

Preemption is an attractive strategy for bandwidth reservation and management in DS-TE. When there is a competition for available resources in a link, a new LSP with a certain priority can preempt the existing LSP with a lower priority. The preempted LSP may then be rerouted. Preemption can be used to provide available and reliable services to high priority LSPs within a DiffServ environment, especially when a network is heavily loaded and connection request arrival patterns are unknown, or when the network experiences link or node failures.

In this paper, we propose an improved algorithm which minimizes the preemption cost with high accuracy and less computational intractability. Furthermore, we also present a new path selection scheme for minimizing preemption in DS-TE. The rest of this paper is organized as follows. Section 2 reviews related work about preemption policy and path selection based on constrained shortest path first (CSPF) algorithm. Section 3 describes our improved preemption algorithm proposed and simulation results. In Section 4, our proposed path selection scheme for minimizing preemption cost is illustrated in detail. Finally, the paper is concluded in Section 5.

2. Related work

2.1. Preemption policy

In order to minimize wastage, the set of LSPs to be preempted can be selected by optimizing an objective function that represents three important parameters: bandwidth, preemption priority and the number of LSPs to be preempted. The objective function could also be any or a combination of the following [7,8]:

(1) Preempt the connections that have the least priority (preemption priority). The QoS of high priority traffic would be better satisfied.
(2) Preempt the least number of LSPs. The number of LSPs that need to be rerouted would be lower.
(3) Preempt the least amount of bandwidth that still satisfies the request. Resource utilization would be improved.

After the preemption selection phase is finished, the selected LSPs must be torn down (and possibly rerouted), releasing the reserved bandwidth. The new LSP is established, using the currently available bandwidth. The unreserved bandwidth (UB) information is then updated.

Peyravian and Kshemkalyani [8] proposed two connection preemption policies that optimize the discussed criteria in a given order of importance: number of connections, bandwidth, and priority, which has polynominal complexity; and bandwidth, priority, and number of connections, which has exponential complexity. The computation complexity of the two optimal algorithms makes them non-implemental in real networks.

de Oliveira et al. [9] proposed a versatile preemption policy named as V-PREPT that can balance the objective function to be optimized in order to stress the desired criteria. Their preemption policy is complemented by an adaptive rate scheme, which can minimize service disruption and rerouting by adjusting the rate of selected low-priority LSPs. Heuristics for both simple preemption policy and adaptive preemption scheme are derived. They still proposed the similar heuristic that concerns the fourth optimization objective (i.e., the minimum of the blocking probability) in [10]. Another optimization criterion termed as "revenue index" modeled after consumer satisfaction in addition to the other three previously optimization criteria is introduced in [11] and the corresponding heuristic similar to that in [9] is also derived.

2.2. Preemption-ware path selection

There are currently two approaches used for preemption-aware path selection, i.e., the decentralized and centralized. For the decentralized approach, every node on the path would be responsible to run the preemption algorithm and determine which LSPs would be preempted in order to fit the new request. Because current IGP extensions advertise only local summarized information, which means that per-LSP information on distant links is not available, this summarized information can only tell if a link has the required resources to accommodate a new LSP on a certain priority level or TE-Class, and it is insufficient for determining which LSPs will be preempted. As a result, a decentralized approach may sometimes not lead to an optimal solution. On the contrary, the centralized approach is aware of all LSPs of the whole network (e.g., the CT, priority level, bandwidth of each LSP, and path information of each LSP), a Network Management System