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On efficient traffic engineering with DV-based routing protocols in DiffServ-aware IP networks

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Abstract

In this paper, an approach to efficient traffic engineering in the DiffServ-aware network environment is proposed. We focus to distance vector-based routing protocols, considering both modifications of routing protocols needed to support path differentiation and traffic engineering methods relied on adjusting multiple per-link costs to particular network conditions. Further, a method for determining link cost of particular traffic class, as a unique generic function of the single generalized performance metric has been proposed. In order to achieve efficient traffic engineering, possible approximations of generic cost function and mappings of generalized to particular metrics have been proposed. Finally, prerequisites for implementing proposed approach have been discussed in the context of different administrative policies and time scales of their application.

Keywords: Differentiated services; Distance vector routing; Internet protocol; Quality of service; Traffic engineering

1. Introduction

The Internet Protocol (IP) technology has been widely accepted as a basis for service integration in the next generation of multiservice telecommunication networks. One of the key issues in multiservice IP networks concerns resolving problems of providing different quality of service (QoS) levels, in accordance with specific requirements of different applications and users. Considering scalability requirements, the approach to QoS provisioning comprises standardized [1], or proprietary architectures with differentiated services, i.e. DiffServ-aware architectures. QoS-aware routing refers to traffic aggregates, instead of individual flows.

Traffic engineering (TE) involves adapting of routing to network conditions in order to improve the overall network performance in the sense of increasing availability and throughput, minimization of packet loss and optimization of resource utilization. In this paper, an approach to efficient TE in the DiffServ-aware network environment is proposed. We focus to distance vector (DV)-based routing and propose several approaches to perform efficient TE based on link costs, expressed as a function of the single generalized performance metric (PM). The main objective is to provide a trade-off between achieving the required network performance and the implementation complexity.

The rest of the paper is organized as follows: Section 2 contains an overview of related work. The network management architecture is described in Section 3. Section 4 comprises proposals for TE methods with DV-based routing protocols in the DiffServ environment. In Section 5, link cost has been considered as a function of the single generalized PM. Simulation experiments and the obtained results have been presented in Section 6. TE policies concerning

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implementation of proposed TE methods have been discussed in Section 7. Section 8 contains concluding remarks.

2. Motivation and related work

In the past few years, TE in IP-based networks has been widely addressed, including both intra-domain and inter-domain aspects. One approach concerns upgrading traditional IP routing protocols to support TE. A comprehensive research work is focussed to extensions of intra-domain link state routing protocols, like OSPF (Open Shortest Path First) and IS–IS (Intermediate System–Intermediate System). Recently proposed OSPF extension for intra-domain TE (OSPF-TE [2]) seems to provide more powerful and robust routing capabilities, on the count of acceptable additional protocol overhead [3].

Experimental studies have shown that traditional shortest path routing protocols such as OSPF and IS–IS can perform quite well, without any modifications, in combination with the TE [4]. This approach includes permanent monitoring of the traffic and topology, optimizing the set of the static link weights, and reconfiguring the routers statically, with new weight settings as needed.

Inter-domain TE has been explored more recently, in the context of BGP (Border Gateway Protocol) and its extensions to support TE, e.g. [5]. A heuristic algorithm for selection of the egress router that satisfies end-to-end bandwidth requirements, while optimizing the network resource utilization has been suggested in [6].

Alternative approach to TE is related with various propositions of QoS and constraint-based routing protocols [7,8]. In spite of significant advantages in terms of QoS provisioning and TE, the main drawbacks concern complex routing algorithms, and consequently implementation, as well as low scalability of the proposed protocols.

Another research topic is technology-specific and concerns networks based on the MPLS (Multi-Protocol Label Switching) and the emerging GMPLS (Generalized MPLS) [9,10]. They comprise explicit routing, based on pre-computed paths for specific types of traffic, with respect to their QoS requirements. In addition, proposals for TE in MPLS-based networks with DiffServ QoS architecture address an integrated QoS management based on both service demands and network conditions [11,12].

Following the basic idea presented in [4], which assumes Internet TE with link state protocols by adjusting link costs, our motivation for this work was to explore possibilities for TE based on similar principles, but in the DiffServ-aware environment. We suggest novel TE approaches that make a trade-off between fulfilling QoS requirements and the implementation complexity. We particularly focus to TE with DV-based routing protocols assuming calculating of DVs according to distributed Bellman–Ford's algorithm. This algorithm is applied in several well-known IP routing protocols including intra-domain protocols like RIP (Routing Information Protocol) as well as inter-domain protocols like BGP. BGP is frequently denoted as a path-vector protocol because its routing information includes the corresponding path. We will use the term "DV-based" protocols to denote a common class of protocols that rely on similar routing algorithms.

3. The network management architecture

Relationship of TE and network management process will be explained relying on the concept of QoS management suggested in [13] and extended in [14], where we have introduced a notion of the entity responsible for dynamic QoS management–QoS Manager (QM). TE methods proposed in this paper are also applicable to other similar architectures, e.g. [11,12]. QM entity encompasses the following functional components (see Fig. 1):

- *Service Level Agreement Manager* (*SLAM*): An entity that negotiates QoS with end users and other domains, by means of QoS signaling protocol, e.g. different variants of RSVP (Resource reSerVation Protocol) or some proprietary access signaling protocol.
- *Network Resource Manager* (*NRM*): An entity that decides about admission of new traffic flows to the network and resource allocation. NRM maintains a global view about the state of network resources, through the resource state table.
- *QoS Configuration Manager* (*QCM*): An entity that configures network elements for the new traffic flow and its associated traffic class.

Relationship of the TE process and QoS management is depicted in Fig. 1. TE performs adaptive management of traffic aggregates that are already present in the network, which involves short-term (seconds and minutes) controls

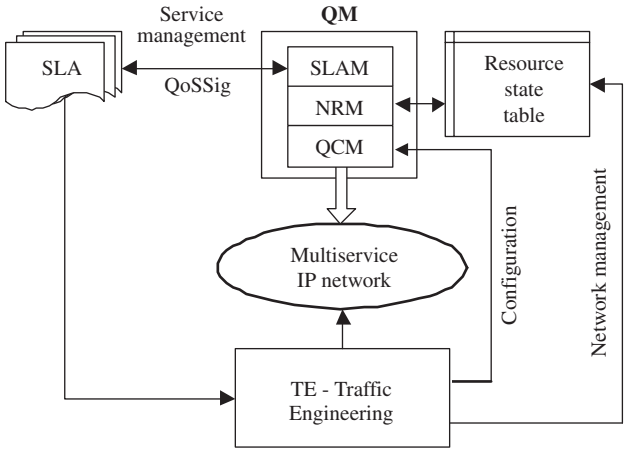

Fig. 1. Relationship of TE process and QoS management.