

# Restoration Routing Using MPLS-TE

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The increasing demand for multimedia applications such as VoIP and video streaming has created new challenges for network service providers. The requirements of delay, throughput and packet loss for such applications are inherently different from those of data traffic. The IP service, which is characterized as best effort and performs satisfactorily with data traffic, fails to provide the desired Quality of Service (QoS). There is a need for providing such guarantees by differential treatment of the traffics for these multimedia applications.

Differentiated Services (DiffServ) architecture allows traffic differentiation on the basis of traffic class [2]. Packets are marked onto predetermined DiffServ classes at the edges. This marking determines the Per Hop Behavior (PHB) received by the packet at all the subsequent hops. The PHB is achieved through a combination of scheduling and queue management schemes and ensures that varying requirements of different traffics are considered. While DiffServ specifies traffic differentiation to achieve higher service quality, the efficacy of DiffServ architecture is limited by the traditional shortest path routing employed by IP. This shortcoming can be overcome through the traffic engineering (TE) capabilities offered by Multi-protocol Label Switching (MPLS) which enables constraint based routing of bandwidth guaranteed label switched paths (LSP) [3]. Therefore, significant research effort has been directed towards integrating DiffServ and MPLS [4][5].

Bandwidth guarantees provided in MPLS are affected by failures of nodes and links in the network. Therefore, *restoration routing* mechanisms have been proposed which enhance the QoS guarantees provided to an LSP [6][7][8]. Restoration routing requires establishing backup paths which are node and link disjoint from the primary path. When a network element fails, traffic is redirected onto these backup paths until re-optimization of the primary path takes place. The re-optimization process requires few seconds and it is assumed that further failures would not occur in the network during this short period. This assumption allows bandwidth sharing along those backup paths which would not be activated simultaneously to share bandwidth, resulting in improved network utilization. Therefore, bandwidth sharing is used as the single most important criterion in evaluating a restoration routing scheme.

To achieve the goal of efficient bandwidth sharing, we presented NPP—a new framework for online routing of bandwidth guaranteed paths with local restoration [15]. NPP relies on the propagation of only aggregate link usage information [6] through routing protocols. The key advantage of NPP is that it delivers the bandwidth sharing performance achieved by propagating complete per path link usage information [6], while incurring significantly reduced routing protocol overhead. We also specified precise implementation models for the restoration routing frameworks presented in [1] and [9] and compared their traffic placement characteristics with those of NPP. Simulation results show that NPP performs significantly better in terms of number of LSPs accepted and total bandwidth placed on the network. For 1000 randomly selected LSP requests on a 20-node homogenous ISP network [8], NPP accepts 775 requests on average compared to 573 requests accepted by the framework of [9] and 693 requests accepted by the framework of [1]. Experiments with different sets of LSP requests and on other networks indicate that NPP results in similar performance gains.

We are currently enhancing our work on MPLS restoration routing by extending it into a DiffServ environment. We have proposed a restoration routing architecture for DiffServ aware MPLS traffic engineering [16]. Our architecture, namely CAIP, relies on propagating per-class aggregate link usage information. We have showed that propagating per-class aggregate link usage information results in improved bandwidth sharing compared to the case where aggregate link usage information is propagated. Moreover, CAIP allows precise calculation of preemptable bandwidth (while computing backup paths) based on the requirements of the network service provider. We presented the calculation of the preemptable bandwidth for predetermined rules as a case study. The case study included various simulation scenarios that compared preemption of backup bandwidth with other similar non-preemptable scenarios. CAIP can also be integrated with existing restoration routing schemes which are based on propagating aggregate link usage information. Furthermore, existing preemption schemes [10][11] can be used with CAIP in order to decide the actual LSPs which are to be preempted. In future, we intend to incorporate our own preemption scheme that takes into account the bandwidth sharing possibilities, while deciding upon the LSPs that are to be preempted, into CAIP.

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