MPLS Traffic Engineering
(An Implementation Framework)

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1 OVERVIEW

Multi-Protocol Label Switching

A technology that shims between Layer 2 and Layer 3, connecting connection-less IP technology with connection-oriented technologies like ATM, Frame Relay.

Traffic Engineering

The task of engineering the traffic flows in the backbone network, providing optimum network resource (bandwidth) utilization.

MPLS Traffic Engineering

MPLS Traffic Engineering encompasses the application of MPLS technology and scientific principles to the measurement, modeling, characterization, and control of Internet traffic and the application of such knowledge and techniques to achieve specific performance objectives.

2 DRIVING FORCE FOR THE DEVELOPMENT OF MPLS-TE

Providing Internet Communication services is a highly competitive business in which large investments are constantly needed in order to keep pace with increase in traffic. Consequently, performance optimization has become an important issue.

Over-dimension of network resources is not always a good solution for the above problem. Thus there is a need to increase the efficiency of resource utilization while minimizing the possibility of congestion.

Almost every busy network backbone has some congested links, while others remain under utilized. That’s because Shortest-Path First routing algorithm sends traffic down the path (which is the shortest distance between two end points), even though that path may be congested, without considering the other network attributes like bandwidth, etc. The figure below depicts this fact. (***Blue*** directed link from R4 to R7 is congested).

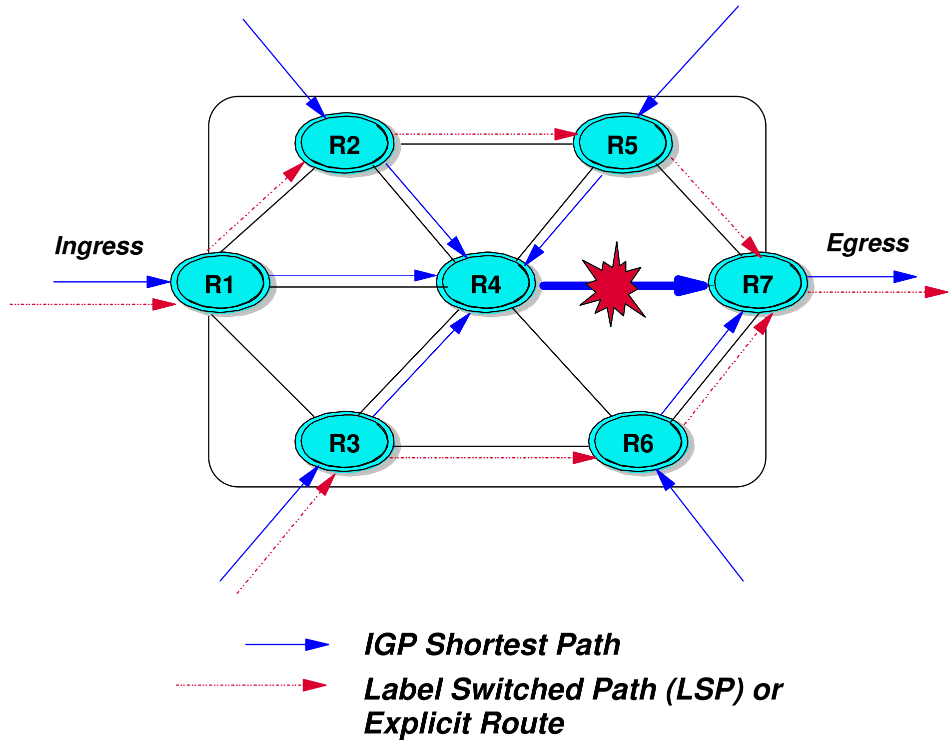

Figure 1. Backbone Network Topology

The primary goal of Traffic Engineering is to control traffic flow, providing Class of Service and Quality of Service to the end user, while still utilizing the network resources in an optimum way.

The key characteristics of Traffic Engineering are:

- Redirect the traffic flows to avoid congestion, and to increase the efficiency of network resource utilization.
- Apply "Constraint Based Shortest Path First", for the traffic flows. Force the traffic on to Label Switched Path (LSP) established, though not the shortest distance between two end points.
- Privilege to the Internet Service Provider(s), for a better control and management of the traffic flow, delivering QoS and CoS to the end user.

3 ENHANCEMENTS TO THE ROUTER ARCHITECTURE TO SUPPORT MPLS-TE

The figure below represents the possible extensions to the Router Architecture to support MPLS Traffic Engineering.

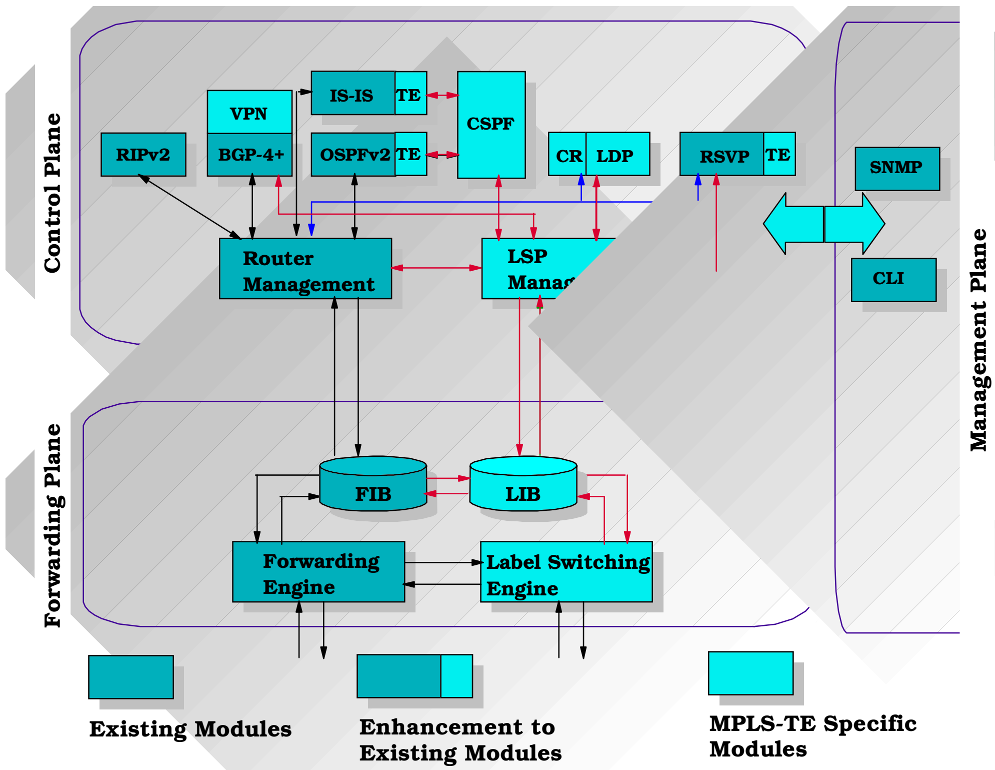

Figure 1. MPLS-TE Router Architecture

This section covers the technical specifications for implementing MPLS Traffic Engineering. Two levels of classification of modules are derived in this Router architecture.

1. **MPLS-TE Specific Modules**

   Modules representing MPLS-TE specific functionality.

2. **Enhancement to existing modules**

   Module enhancements to support MPLS-TE functionality.

Please attribute the description of the following sections with the Figure 2.

3.1 MPLS-TE SPECIFIC MODULES

3.1.1 LSP Management Module

- Centralised controller, responsible for the management of complete explicit route (alias Label Switched Path [LSP]).
- Interface with CSPF for computing Constraint-based Shortest Path between two end points. These end points are normally termed as Ingress and the Egress.
- Interface with MPLS signaling modules like CR-LDP, RSVP, BGP Piggy back, etc for establishment of complete explicit route (LSP).
- Updates the Label Information Database (LIB) with the established LSPs.
- Interface with Router Management module to map the traffic on to the LSPs established.

3.1.2 Constraint-based Shortest Path First (CSPF) Module

- Responsible for calculating constraint-based shortest path between two end points.
- Interface with IGPs like IS-IS, OSPF, to use the adjacency database, Link state database and the Traffic Engineering database which are part of IGPs, for computing the constraint-based shortest path between two end points.

3.1.3 Constraint-based Routing - Label Distribution Protocol (CR-LDP) Module

- Responsible for establishment of complete explicit route (LSP) computed by CSPF between two end points.

3.1.4 Label Switching Engine Module

- Interfaces with Label Information Database (LIB) to switch the labeled packets.

3.2 ENHANCEMENT TO EXISTING MODULES

3.2.1 Extension to IGPs like IS-IS, OSPF

Traffic Attributes to be flooded	The following attributes to be flooded in both Periodic and Triggered flooding: Router ID Administrative group (color) Maximum Link Bandwidth Reservable Bandwidth Unreserved Bandwidth TE Default Metric
Enhancements to SPF	Determine the next hop (first-hop) using SPF enhancements. RFC 2702 gives an insight to the SPF enhancements.

3.2.2 Extension to RSVP

Establishment of complete explicit route (LSP). The extensions are to the message formats, for carrying the traffic attributes during the signalling process.

4 MPLS TRAFFIC ENGINEERING OPERATION :

Step 1. Upgrade

MPLS-TE enabled feature on all the routers in the backbone network.

Step 2. Flood

The Link-state Traffic attributes across the topology. RFC 2702, describes the transitioning to the new technology.

Step 3. Identify

The traffic flows that are to be redistributed due to congestion in the network backbone. The network administrator does the job of identifying the congested links.

In the Figure1, Link R4 to R7 is congested because of “Shortest Path First Algorithm”. Hence the traffic flow from R1 to R7 and R3 to R7 are identified to be redistributed. R1, R3 forms the Ingress and R7 is the egress.

Step 4. Employ

“Constraint-based Shortest Path algorithm” at the ingress routers, i.e., R1 and R3

At Router R1

The resource requirements for establishing an LSP from R1 to R7 is passed to the “LSP Management Module” by means of CLI/SNMP.

- LSP Management Module, requests CSPF module for ***computing*** the complete explicit route (LSP) from R1 to R7 that satisfy the resource requirements along the path.
- LSP Management Module then triggers the Signaling protocol (CR-LDP or RSVP) for ***establishment*** of the complete explicit route (LSP) from R1 to R7, which is computed by the CSPF Module.
- On successful establishment of an LSP from R1 to R7, the “LSP Management Module” updates the Label Information Database (LIB) with the Label bindings.
- “LSP Management Module” then interfaces with “Router Management Module” to map the traffic flow, either destined to egress (R7) or destination(s) reachable through R7.

At Router R3

Repeat the above steps to compute and establish a complete explicit route (LSP) from R3 to R7.

The “***Red***“dotted line in the Figure1 represents the complete explicit route (LSP).

5 BENEFITS

Path calculation, considering the traffic attributes flooded by every router in the topology. The path calculated is always constraint-based shortest path.

Utilizing the existing network backbone infrastructure efficiently, thereby reducing the operation cost.

Load balancing the traffic flows on to multiple LSPs established.

Re-optimization of path(s) at will, to reduce the bottlenecks of congestion.

Backup or alternative path when the primary path fails.

Fast reroute support to recover from single failures of primary path.

6 CONCLUSION

This document mainly focuses on the Implementation framework only and does not give an insight on the functional specifications to the modules.

7 REFERENCES

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