

## SCALABILITY ANALYSIS OF MPLS LABEL DISTRIBUTION PROTOCOLS RSVP

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**ABSTRACT:** *MPLS has a choice of two signalling protocols CR-LDP and RSVP-TE. Both protocols have the ability to provide QoS, constraint based routing, explicit routing and traffic engineering in the core network. In this paper both signalling protocols performance is analyzed and its conclusion helps ISP and carrier providers to make a better choice of signalling protocol as per their needs. The paper reviews the advantages and disadvantages of both signalling protocols and then compares the CR-LDP and RVSP-TE in term of bandwidth and throughput of a link for a small and large scale network using video traffic.*

**Keywords:** *MPLS; RSVP-TE; CR-LDP; LSP; LSR.*

**1. Introduction.** Since the internet becomes widely available for public and commercial use, there has been a tremendous growth in the internet traffic. Many multimedia, real time applications and services have been developed in the internet market. These applications have created a significant demand for guaranteed bandwidth and Quality of Services (QoS) demand on from the internet core services [2]. Initially the Internet used relatively simple protocols for routing purposes. In this traditional layer – 3 IP routing method, packet forwarding decisions are made after looking up the destination IP address from the routing table maintained by each router [4][3]. This simple IP based network neither support Resource Reservation nor guarantees bandwidth to carry their customer’s heavy and delay sensitive traffic [9].

Multiprotocol Label Switching (MPLS) is intended for service provider core network or large enterprise networks. MPLS enabled network provide traffic engineering, bandwidth management, and quality of services to IP and other protocol traffic. MPLS has a choice of two signalling protocols CR-LDP and RSVP-TE. Both protocols have the ability to provide QoS, constraint based and explicit routing and traffic engineering in the core network. It is not an easy task to select a route that can offer the correct resources. These resources must be retained to guarantee that they are not stolen or shared by any other traffic [1].

This paper analyzes both protocols performance and its conclusion helps ISPs and carrier service providers to make better choice of signalling protocols as per their needs.

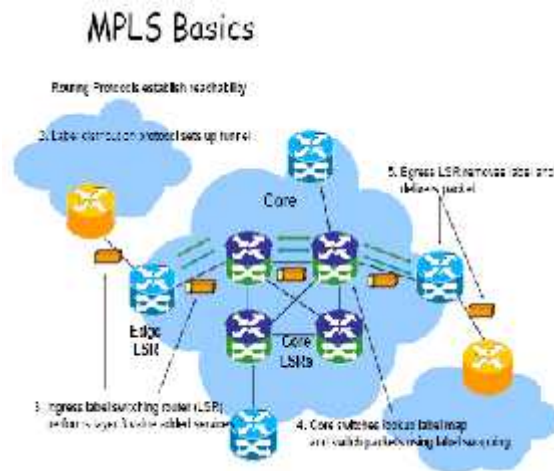
**1.1 Why MPLS:**For the past two decades, following are the carrier network technologies, which were used for the purpose of providing WAN connections.

1. Frame Relay
2. ATM

3. X.25
4. IP

In all these pre-MPLS technologies the same techniques were used to divide the network traffic into the discrete and manageable, smaller chunks and assigned them IDs to each of them to manage their flow separately. Then, these individual units were called Packets in IP network, Frames in Frame Relay network and Cells in ATM network [10]. In the start, the WAN links use to carry out their traffic of different protocols with the help of Frame Relay or ATM networks. But customer started to use these layer-2 links to build their layer-3 private networks over it, after the development of the widely spread of IP and Internet.

Now there was a desperate need to find out a mechanism to map layer-2 and layer-3 connection. The problem was that, that ATM had many service classes but it was not an easy task to translate them into an IP Classes [10]. What MPLS does here is, it merges both of the layer .i.e. layer-2 and layer-3 in way that it gets the properties of both techniques and illuminates the weaknesses of both. In detail, on one hand MPLS is making use of ATM switches to have a feature of faster layer-2 switching and on the other hand MPLS uses these switches to use IP control plane to have one IGP peer relationship only with its neighbouring nodes.



**Figure 1: MPLS Basic Network [8]**

**2. MPLS.** It was designed by Internet Engineering Task Force (IETF) for the purpose of traffic forwarding. The MPLS provides an efficient and effective traffic flow through the network. In MPLS network for the flow of packet this mechanism is followed. Information is contained in a fixed-length Label, which routes the packet through the MPLS network. With each IP packet this Label is attached between the layers 2 and 3 headers, by Ingress Label Edge Router (LER). The Ingress Label Edge Router (LER) Receives the packet form the IP network via incoming connected interface and performs the lookup in the Forwarding Information Base (FIB) for the purpose of finding corresponding label to this destination address. If it finds the label inserts a label with this packet, if it does not than the packet is forwarded through the normal IP routing protocol. For incoming packets the complex process of filtering, analysing and classification are performed and then the packet is assigned to Forward Equivalence Class (FEC). Now it's the responsibility of Forward Equivalence Class (FEC) to determine the requirements for this packet like bandwidth, QoS and than deciding which Label Switch Path (LSP) should be used for this packet. Than the next step is the forwarding of this FEC assigned and label attached packet to its neighbour downstream Label Switch Router (LSR). The packet through the MPLS network arrives at the Label Edge Router (LER), it receives this labelled packet through the incoming interface and perform the same steps of reading its label value and then performing the label look-up from Forwarding Information Base (FIB) to find out the outgoing label for this packet. The process of swapping and mapping of the label takes place for the incoming packet with outgoing label if it finds any. The process of swapping and mapping is also known as Label Push and Label Pop. The packet finally arrives at the egress Label Switch Router (LSR) through this repeated process of Label Push and Label Pop. Now finally, the

removal / Push last Label from the packet takes place at the egress Label Switch Router (LSR) and then the packet is forward through layer-3 routing to its outgoing interface.

**2.1 MPLS Signalling Protocols.** The LSP setup and the Label assignment processes should be completed in an MPLS network before the traffic forwarding process takes place.

LSP can be setup using two major methods:

- Control Driven LSP
- Explicitly routed LSP also referred as CR-LSP

The main difference among these techniques is, in control-driven LSP method path definition is decided by the routing protocol and on the other hand in explicit routing method this path is decided by the network engineers and management. The IP protocol determines the outgoing interface for each LSR, through which a label request is send to its next hope node. This process takes place in control-driven LSP method.

In case of CR-LSP LSP method, setup message contains and specifies the route information, then this message travels via all the LSRs and finally to the egress LSR. Each node on the way sends a label request to its neighbour or next-hope LSR, which is already defined in the setup message.

The MPLS network requires a mechanism to send control signals to and from LSRs to establish and manage LSP operation.

There are two different types of protocol proposed by the Internet Engineering Task Force (IETF) for each method of LSP setup and maintenance.

1. Label Distribution Protocol (LDP) for control-driven LSP
2. RSVP-TE and CR-LDP for CR- LSP

Both CR-LDP and LDP are similar, with extra capabilities like setting up CR-LSP, and support of QoS and Traffic Engineering features. Similar type of case is with RSVP-TE, which inheriting all the features from generic RSVP with plus like traffic engineering and ER-LSP capabilities [11].

**2.2 Requirements for MPLS signalling protocol.** For smooth MPLS operations and efficient signalling mechanism the signalling protocol should have the following features.

**Robustness-** In this feature of signalling protocol the signalling system should ensure in time message delivery and reliability in terms of a prompt.

**Scalability-** In order to provide a large scale carrier services, the signalling protocol should support huge number of sessions, LSPs and LSRs and should provide the desired level of performance. Each and every signalling protocol requires more or less computing and memory overhead form LSRs and Bandwidth form link, in order to perform their operations.

**QoS Specification-** To ensure the requirements of QoS for sensitive traffic and for multi-media traffic, the signalling system should be able to able to encounter the delay, bandwidth and losses associated with LSPs.

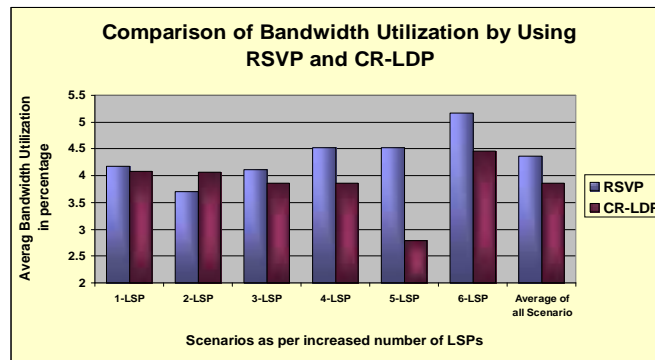
**LSP Setup/Teardown/Maintenance-** In the signalling protocol the basic and most important functionality of the signalling system is to make setup, maintain it and then drop LSPs when not required. LSP Priority/Pre-emption- In the signalling protocol this is the feature of QoS. Using this feature to prioritise LSPs the particular LSP can maintain the required bandwidth associated with it. With the help of this feature of LSP prioritising, LSPs having a higher priority can pre-empt lower priority LSPs and they can occupy the lower priority LSPs resources, if there is not enough bandwidth available for the higher priority LSP. This feature of LSP priority ensures smooth and permanent flow of traffic through an LSP which has highest priority.

**Route flexibility-** This feature of route flexibility offers great flexibility especially in the absence of the information about the specification of a complete network. This feature gives great ease and configuration flexibility to the network operator when he is defining the LSP path. Operator has the choice of defining a loose or strict CR-LSP and plus can define a pin loose LSP to make sure it existence when it is setup.

**Re-routing and convergence-** In MPLS networks this is one of the most important feature, this feature of MPLS network makes sure that the customer get the non-stop flow of his traffic through the core network. This will also include completing setup an optimized backup link ready to use before the failure of the primary link. Further more in case if the link fails the signalling system should be capable of sending a small message even through a busy link and should identify the failure and replace it with the new one [11].

**3. Comparison of Signalling Protocol Topologies.** In this section we will compare the capabilities of signalling protocols CR-LDP and RSVP-TE, with respect to related key issues, problems and network requirements. Which have the ability to impact the network performance?

**3.1 Scalability.** If we define the term Scalability in signalling protocol, the scalability is measured in terms of traffic flow of the control signals. I.e. resource requirements (computational and memory overhead of LSRs), bandwidth utilization. As we know that CR-LDP makes use of hard state algorithms, so it creates, maintains and releases LSPs using these algorithms. Another advantage of CR-LDP is that it sends minimum number of messages for the status of each session.



**Figure 2: link utilization as number of LSPs increase [11]**

To maintain TCP session the CR-LDP will only send the Hello and KEEPALIVE signals to peer LSR. Due to this end-to-end connection oriented approach there is no increase in the overhead and effects on network performance when the number of LSPs increases. On the other hand in RSVP, it sends large amount of refreshing traffic over the network after a specific amount of time or interval for each session this is because of using IP datagram which is connection less approach. In this approach there is a risk of signal lost while on their way to destination.

These overheads consume significant amount of network resources, although there has been massive increase in the hardware specification and network bandwidth. RSVP has undergone through many extension in order to reduce these refreshing message overhead, so that we can make use of the bandwidth effectively for the transmission of data not for signalling traffic itself. Changes include suppression of refresh messages, message aggregation and extensions to hello protocol for the purpose of peer loss detection. With the addition of these changes the RSVP is being mould from soft-state model i.e. by adding hard-state properties. Instead of sending individual refresh message it send group/aggregate refresh message. Moreover it makes a good use of message ID to know the status of the session, which reduces the cost of computing on the node to check each refresh message. In this process, only ID of the message is checked by the node if the id is different from the previous message this will depict the change

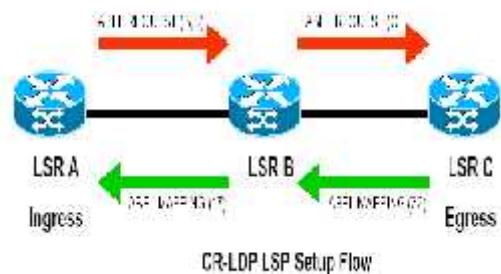
in state from last. If the message ID is same the time and resources are not wasted reading it. These changes are effective but on the other hand these changes also again introduce some additional processing overheads. These changes introduce the following overheads like detect changes, manage message ID, duplication ID, loops and avoid errors etc. These overheads results in reducing the capability of a node to support number of LSPs, so extra computing and memory load on nodes. In the new versions of RSVP, it hasn't got prompt refresh message, which effects RSVP badly on some features such as rerouting, recovering notification and failure. These changes have entirely modified the nature of RSVP and it has lost feature like reusability.

**3.2 Interoperability:** The manifestation of CR-LDP multi-vendor Interoperability trail proves the interoperability of CR-LDP. It is an open standard protocol which is fully capable to work with other vendor protocols. Moreover the CR-LDP signalling protocol is backward compatible with the legacy protocols. On the other hand, there have been no compatibility test manifestation for RSVP so far and it is going through transition phase.

**3.3 Reliability:** In order to ensure a reliable transfer of the customer data, reliability has become the core issue for the core network. CR-LDP makes use of TCP as a transport protocol which is connection oriented for the LSP setup/maintenance, peer discovery, failure recovery and label creation/ distribution etc. Especially in the case of node or link failure prompt indication message is sent, which goes through the transport layer reliably to end-point node to let him know about the failure. Using same architecture a response is sent to that end point which sends recovery or route signals to other node [6]. On the other hand, RSVP is making use of connection less UDP as a transport protocol which is unreliable. There is an absence of notification message in case a failure occurs. As an alternative the RSVP sends periodic refresh messages using the same unreliable process to verify the session status. The RSVP has the explicit tear down message but the edge LSR will not start rerouting until the expiry of cleanup timeout interval. This is because of unreliable transport. The recommended cleanup timeout interval is 90 seconds and refresh interval is 30 seconds according to RFC 2205. The recommended time to start rerouting is too long for fast, reliable and efficient carrier generally. But on the other hand if we reduce this time interval it will cause update traffic load on the network and gives birth to scalability problem.

The same unreliable protocol is used for the purpose of sending recovery and rerouting message. The RSVP protocol is unable to guarantee QoS and traffic engineering to the customer traffic, due to these unreliability and latency issues.

**3.4 Simplicity:** The RSVP signalling protocol makes use of 'downstream-on-demand' as a distribution, label allocation and binding mode. The RSVP hasn't got the ability of supporting any other mode. In case if want to use other mode like 'downstream unsolicited' mode, both the signalling protocols RSVP and CR-LDP have to be running on the same network at the same time. This will make the network very complex and very difficult to manage and configure, which will result in increasing the cost. Plus in order to define network policy and provision of QoS and service class, network operator will have to configure the sender and receiver end individually.



**Figure 3: CR-LDP LSP Setup Mechanism [1]**

In contrast to RSVP, In CR-LDP configuration for all these settings are needed only on sender side, end-node is configured. Plus using the features of CR-LDP like multi-modes support makes it easier and simpler to manage and setup [7, 5].

**4. Conclusions:** Both RSVP and CR-LDP are equally capable to provide MPLS network QoS and traffic engineering features. Mainly, they use different transmission protocol for signalling which makes big difference in their performances. CR-LDP is originally designed for signalling and solves many issues except security and multicasting. Main advantages of CR-LDP are its scalability and reliability due to its connection oriented TCP based operation. CR-LDP creates session with its peering node and sends hello packets only to its neighbouring node through TCP to update the path and node status.

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