Development Of Test-Bed For Performance Evaluation Of Multiprotocol Label Switching

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ABSTRACT
Multiprotocol Label Switching is called multi protocol because its techniques are applicable to any network layer protocol. The need to converge voice, data, and multimedia networks over IP based protocols has lead to the development of label switching. In this paper we develop a test bed to evaluate the performance of MPLS protocol. Simulations of this MPLS protocol have been carried out with the simulator Omnet++4.0.MPLS improves packet-forwarding performance in the network, supports Qos for service differentiation, supports network scalability, Integrates IP and ATM in the network and builds interoperable networks.

General Terms
Multiprotocol Label Switching, Label switching router, Forwarding Equivalence Classes, Tag switching.

Keywords
IP routing, LDP, Label Switched Path (LSP), MPLS, Partial spatial-protection (PSP),

1. INTRODUCTION
Label switching was originally a concept to integrate ATM and IP. Over the last five years a few companies have developed label switching to integrate high speed ATM switching with the routing process of the Internet's IP network layer. Label switching is used in a variety of commercial and academic networks. Tag switching, developed by Cisco systems is a control driven technique that does not depend on the flow of data to stimulate setting up of label forwarding tables in the router. IBM's switching approach is similar to tag switching and is called Aggregate Route-based IP Switching. Cell Switching Router, developed by Toshiba, is designed to function as a router for connecting logical IP subnets over ATM. Labels are assigned on the basis of flows that are locally identified.

Multiprotocol Label Switching (MPLS) is a high-performance method for forwarding packets (frames) through a network. It enables routers at the edge of a network to apply simple labels to packets (frames). ATM switches or existing routers in the network core can switch packets according to the labels with minimal lookup overhead. MPLS integrates the performance and traffic management capabilities of Data Link Layer 2 with the scalability and flexibility of Network Layer 3 routing. It is applicable to networks using any Layer 2 switching, but has particular advantages when applied to ATM networks. In contrast to label switching, conventional Layer 3 IP routing is based on the exchange of network reach ability information. As a packet traverses the network, each router extracts all the information relevant to forwarding from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the packet's next hop. This is repeated at each router across a network. At each hop in the network, the optimal forwarding of a packet must be again determined.

Conventional IP packet forwarding has several limitations. It has limited capability to deal with addressing information beyond just the destination IP address carried on the packet. Because all traffic to the same IP destination-prefix is usually treated similarly, various difficulties arise. For example, it becomes difficult to perform traffic engineering on IP networks. Also, IP packet forwarding does not easily take into account extra addressing-related information such as Virtual Private Network membership.

The demand for improvements in performance, scalability, functionality, and quality of service ensures that Multiprotocol Label Switching will provide the technical foundation for the future networking solutions. MPLS provides significant improvements in the packet forwarding process by simplifying, processing, avoiding the need for duplicate header processing at each hop, and creating an environment that support Quality of Service. By adding fixed size labels to packets, similar to the way we add zip codes to mail, processing performance is greatly improved. MPLS is a new technology in its early stages of development. It is expected that MPLS will see deployment in both public and private IP networks, paving the way for true convergence of telephony, video, and computing services.

2. Related work
Imajuku W et.al [1] proposed the first multi-area multiprotocol label switching and generalized MPLS interoperability trial over a reconfigurable optical add/drop multiplexer and optical cross-connect

network. The interoperability trial demonstrated the routing of label switched paths over a multi-area GMPLS controlled ROADM/OXC network and the control of Ethernet over MPLS transport service on top of the GMPLS network. The trial was conducted using various network elements provided by 14 institutions and was carried out in Tokyo and Virginia. This provides the motivation for the trial, technical issues related to controlling multi area MPLS/GMPLS networks, test network topology, and experimental results. The results show that the interior gateway routing protocol based multi-area routing architecture is a promising solution for the nationwide deployment of GMPLS networks within a carrier domain. In addition, the author discussed the technical issues of routing constraints in ROADM/OXC networks and the limit of multi area routing without the Path Computation Element Protocol.

Zheng et. al [2] considered Label Switched Path (LSP) protection for connections with various protection grade requirements in multi-protocol label switching (MPLS) over wavelength division multiplexing (WDM) optical networks. In full protection, bandwidth needs to be reserved for the backup LSP to protect the failure of any fiber along the primary LSP. The problem of partial spatial-protection (PSP) where bandwidth is reserved for the backup LSP to protect the failure of a subset of fibers traversed by the primary LSP to satisfy the specified protection grade. They formulated the optimal LSP PSP problem as an ILP and identified three suboptimal problems. For each suboptimal problem, an exhaustive search algorithm and a heuristic are developed. They analyzed the probability that a connection can be restored upon a fiber failure and find that it is higher than or equal to the protection grade specified. Huang Weili et. al [3] Multicast is an effective way for increasing the efficiency of network resources utilization. But when designed, MPLS did not consider the support of multicast. So multicast in MPLS has many problems. To solve this problem a new multicast strategy is proposed that combines ERM and AMFM. Compared with the previous multicast algorithms, it simplifies LSP setup and has less forwarding states. It is fault-tolerant can get a better performance in MPLS networks.

Toguyeni et.al [4] proposed a model to ensure for each application a better quality of service (QoS). Periodic Multi-Step Routing model(PEMS) built by integration of traffic engineering based on MPLS and differentiation of traffic depending on the class as proposed by Diffserv. Consequently, PEMS routing model treated each flow according to its needs. PEMS was compared with LBWDP through simulations based on the simulator MNS. If PEMS differentiates the flows, it does not have best performance than LBWDP in a network that is not overloaded.

Yong-liang Hu et.al [5] describe two kinds of layout designs in Multi-Protocol Label Switch network: on-line and off-line for traffic engineering based on a given topological structure and Qos requirement of the network. The layout design must be carried out to search an optimal link set to make the flow distribution. One advantage of off-line MPLS layout design is to allow a globally optimal network design. To obtain the optimal MPLS layout, namely, to minimize the link set of LSP and to allocate flow hereinafter is designated as MPSFAP (Minimum Path Set and Flow Allocation Problem). It is difficult to get an exact solution to MPSFAP because it is a mixed-integer nonlinear multi-depot problem. A heuristic algorithm based on tabu search is proposed. Rahimi et.al[6] addressed service quality issue in MPLS networks due to having to accommodate the higher bandwidth consumption by certain applications such as voice over IP (VoIP), client-server and peer-to-peer applications, java applications and customized applications. There are many types quality of service can be offered in MPLS network and one of them is Differentiated Services or Diffserv which is being used in this work. The author presented the QoS benefits of Diff-Serv aware MPLS networks when simulating the network using J-Sim. Cugin et.al[7] provided an iterative algorithm to achieve global load balancing of zero-bandwidth TE LSPs. Results show that the proposed algorithm closely approximates the ideal global load balancing result, without resorting to additional routing protocol extensions.

3. Multi Protocol Label Switching

Multiprotocol Label Switching (MPLS) is a high-performance method for forwarding packets (frames) through a network. It enables routers at the edge of a network to apply simple labels to packets (frames). ATM switches or existing routers in the network core can switch packets according to the labels with minimal lookup overhead.

The BPX® 8650 is an IP+ATM switch that provides ATM-based broadband services and integrates Cisco IOS® software via Cisco 7200 series routers to deliver Multiprotocol Label Switching (MPLS) services.

MPLS integrates the performance and traffic management capabilities of Data Link Layer 2 with the scalability and flexibility of Network Layer 3 routing. It is applicable to networks using any Layer 2 switching, but has particular advantages when applied to ATM networks.

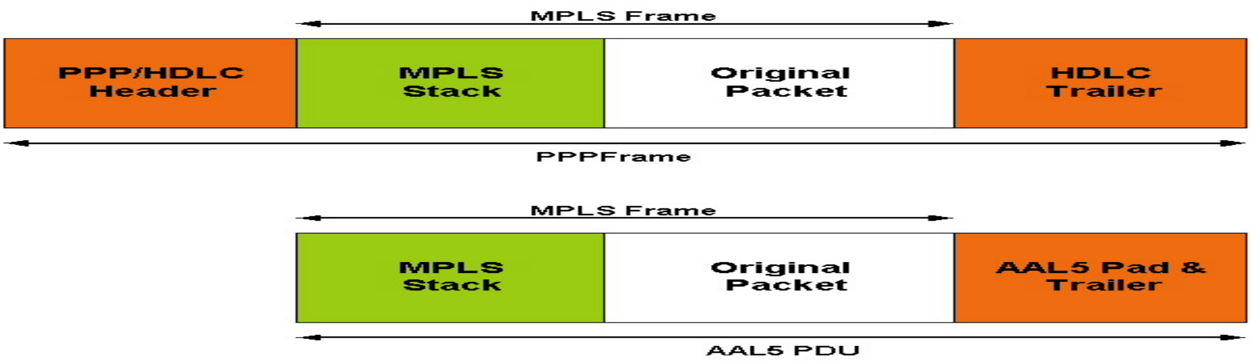

Fig1. MPLS encoding for PPP over SONET/SDH and ATM links.

MPLS forwarding is defined for a range of link-layer technologies, some of which are inherently label switching (ATM, FR) and others not (packet over SONET/ SDH (POS) and Ethernet). Although switching logically occurs on the label in the top stack entry, ATM and FR switch their native data units (cells and frames, respectively) based on a link layer copy of the top stack entry. For packet-based layers, the MPLS frame is simply placed within the link´s native frame format. The stacking scheme allows for LSPs to be tunneled through other LSPs. The action of putting a packet onto a LSP constitutes a "push" of a MPLS Label Stack entry. The action of reaching the end of a LSP results in the top stack entry being removed ("popped").

3.1 Concept of MPLS

The main concept of MPLS is to include a label on each packet. Packets or cells are assigned short, fixed-length labels. Switching entities perform table lookups based on these simple labels to determine where data should be forwarded.

The label summarizes essential information about routing the packet:

Destination

Precedence

Virtual Private Network membership

Quality of Service (QoS) information from RSVP.

With Label Switching the complete analysis of the Layer 3 header is performed only once: at the edge label switch router (LSR), which is located at each edge of the network. At this location, the Layer 3 header is mapped into a fixed-length label, called a label. At each router across the network, only the label need be examined in the incoming cell or packet in order to send the cell or packet on its way across the network. At the other end of the network, an Edge LSR swaps the label out for the appropriate header data linked to that label.

A key result of this arrangement is that forwarding decisions based on some or all of these different sources of information can be achieved by means of a single table lookup from a fixed-length label. For this reason, label switching makes it feasible for routers and switches to make forwarding decisions based upon multiple destination addresses.

Edge behaviors

At the edge of a MPLS network sits the label edge router (LER). A LER terminates or originates LSPs and performs both label-based forwarding and conventional IP Routing functions. On ingress to a MPLS domain, a LER accepts unlabeled packets and creates an initial MPLS frame by pushing one or more MPLS label entries. On egress the LER terminates a LPS by popping the top MPLS stack entry and forwarding the remaining packet based on rules indicated by the popped label. Figure 5 shows a LER labeling an IP packet for transmission out of a MPLS interface. Conventional IP packet processing determines the FEC and, hence, the contents of a new packet´s initial MPLS Label Stack and its outbound queuing and scheduling service. Once labeled, packets are transmitted into the core along the chosen LSP.

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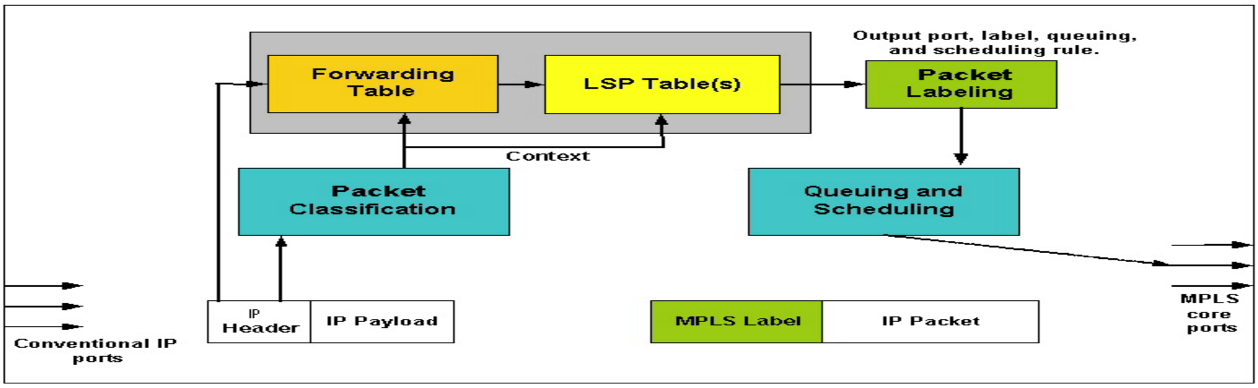

Fig 2: Simplified Ingress Label Edge Router**.**

3.2 Label Distribution

Label Distribution can be performed in two different modes

- Unsolicited Downstream

The MPLS architecture also allows a LSR to distribute FEC-label binding information to LSRs that have not explicitly requested for the information. This is known as "Unsolicited downstream" distribution.

- Downstream-on-Demand

When a LSR explicitly requests from its next hop (LSR) for a particular FEC and label binding for that FEC, it is called "downstream-on-demand" label distribution. The "ingress" LER requests a label from its downstream neighbor so that it can bind to a specific FEC. The same mechanism is employed down the chain of LSRs up until the "egress" LER. In response to "label request" a downstream LST sends a label to the upstream initiator using the "label mapping".

Any MPLS node may provide one or both the modes but the peer LSRs should agree for a common technique.

MPLS provides a third mechanism (different from IP and ATM) for control and path calculation. MPLS nodes (called Label Switched Routers – LSRs) use a routing protocol such as OSPF to calculate network paths and establish connection-oriented path. The paths are called Label Switched Paths (LSPs) and these paths are built using CR-LDP (Label Distribution Protocol) or RSVP-TE (Resource Reservation Protocol- Traffic Engineering). These LSPs are connection-oriented rather than connectionless and they can be provisioned manually analogous to PVCs that have been set up for traffic engineering. LSPs are independent of underlying link-layer (Layer-2) protocols. The initial goal of MPLS was to bring the speed of layer-2 switching at layer-3. Label based switching methods allows routers to make forwarding decision based on the content of label rather than by performing a complex route lookup based on destination IP address. MPLS brings many other benefits to IP based network like Traffic Engineering and support for VPN.

3.3 Requirements

The MPLS technology addresses following requirements

- It integrates the label-swapping paradigm (switching cells when ATM is used as the underlying link layer) with network layer routing.
- It improves the price-per-performance of network layer routing.
- It facilitates scalability through traffic aggregation
- It provides greater flexibility in the delivery of new routing services, thereby improving the potential of traffic engineering
- It supports the delivery of services with guaranteed Qos.

The MPLS-LDP has four categories of messages.

- Discovery Messages – used to announce and maintain the presence of a LSR in the network.
- Session – used to establish, maintain and terminate the sessions between LDP peers.
- Advertisement – used to create, change, and delete label mappings for FECs.
- Notification – used to provide advisory information and signal error information.

Each LSR maintains "Incoming Label Map (ILM)" to store routing information for labeled packets. The ILM maps each incoming label to a set of "Next Hop Label Forwarding Entry (NHLFE)".

NHLFE contains following info

- Next hop
- Operation to be performed on the packet's label stack

Following are the possible operations that a LSR can perform on the label stack

- Replace the label the TOS with a specified new label
- Pop the label stack
- Replace the label at TOS with a specified new label and then push one or more specified new labels

If the packets next hop is the current LSR itself then the label stack operation must be to “pop the stack”. In order to forward a labeled packet a LSR examines the label at the top of the label-stack and then uses ILM to get corresponding NHLFE.

Using the information given in the NHLFE it determined where to forward the packet and performs appropriate operation on the label-stack.

4. Network Setup

Simulations of this MPLS protocol is carried out using Omnet++ 4.0 In these Network five Loose Source routers are connected with the different hosts and there is one scenario manager which manages all the scenarios generated by the different running configurations .This scenario manager noted down the changes occurred during the simulation of the network. The communications links between all the network devices is in duplex mode. They can send and receive data simultaneously.

5. Results & Discussions

The fig 4 shows the queue length of all the nodes in RSVP and LDP protocol. This graph suggests that RSVP module of MPLS provides lesser queue length as compared to LDP module.

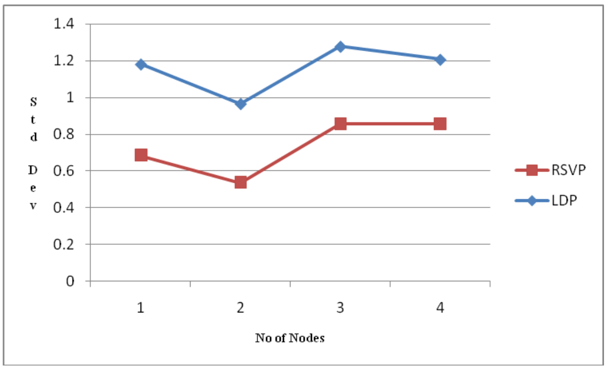

Fig 4: Queue length of the nodes.

This graphs shows the no of transmitted acknowledgements and no. of acknowlegdement received by the sender.The transmitted acknowledements are high in number as compared to received acknowledgements.This means that a little no. of acks are lost or damaged during transmission.fig 5.

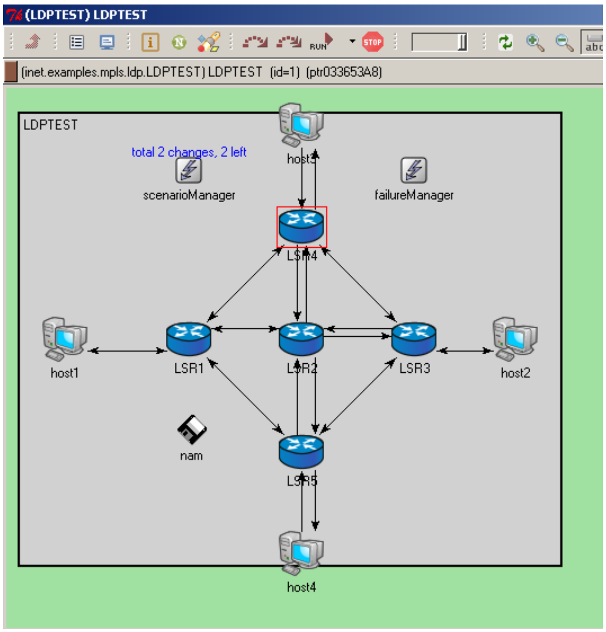

Fig 3: LDP protocol network setup in Omnet ++.

The failure manager handles all the failure occurred during the simulation and calls recovery manager to recover from the errors occurred.

shows the no. of unacknowledge bytes during transmission.

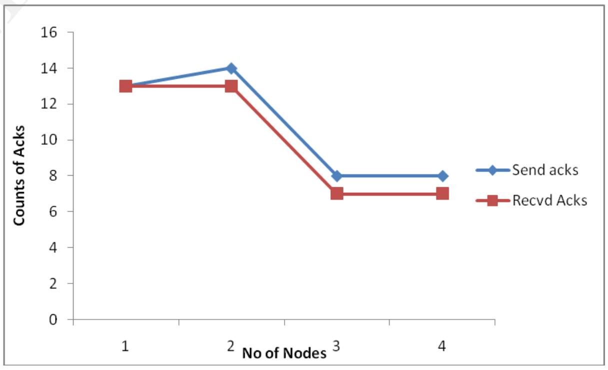

Fig 5: No of Transmitted Acknowledgements in LDP protocol.

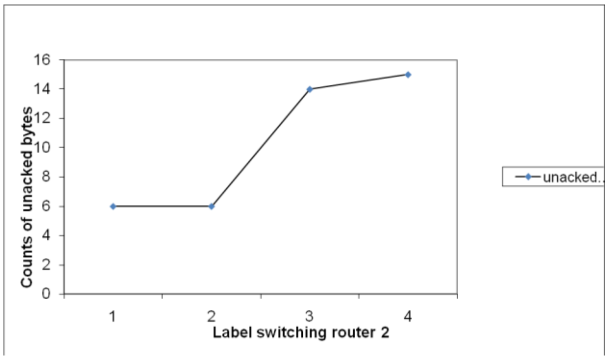

Fig 6: Unacknowledged bytes at the LSR 2.

Fig . 7 shows the througput of the nodes in case of RSVP and LDP module of Mpls protocol.this shows that if the number of nodes are increased from 1 to 50 then throghput is maximised in case of LDP protocol but throughput ofRSVP protocol is very much less as cpompare to LDP.When the no. of nodes is increased from 50 then the throghput level is gradually decresed and becomes the half of previous throghput level achieved.this means that LDP protocol is best suited for network applications.

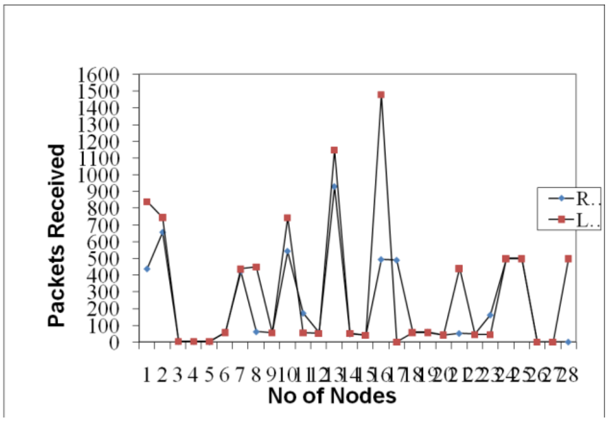

Fig 7: Throughput of all the nodes in RSVP & LDP**.**

6. Conclusion

The initial objective of MPLS was to bring the speed of layer-2 switching at layer-3. Label based switching methods allows routers to make forwarding decision based on the content of label rather than by performing a complex route lookup based on destination IP address. The decision to bind a particular label "L" to a particular FEC "F" is made by the LSR which is DOWNSTREAM with respect to that binding. The downstream LSR informs the upstream LSR of the binding. Thus labels are "downstream-assigned" and label bindings are distributed in the "downstream to upstream" direction. This test bed for MPLS protocol shows that it improves packet-forwarding performance in the network. LDP protocol of MPLS supports good QoS and provides high throughput for service differentiation, It Supports network scalability, Integrates IP and ATM in the network and builds interoperable networks.

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