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Integrating Internet Protocol (IP) Multicast over Multiprotocol Label Switching (MPLS) for Real Time Video Conferencing Data Transmission

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Abstract: Providing guaranteed Quality of Service in the current internet has become extremely essential to fulfill the requirements of current internet services. With increase in the number of users and demand for real time applications like video streaming, VoIP, audio video conferencing there is high demand for larger bandwidth for these applications. Many schemes have already been put forth and implemented for such real time applications but with some disadvantages. The project proposes integrating of the IP multicast over MPLS with different Quality of Service QoS techniques to guarantee essential QoS parameters like the bandwidth, delay, and through put. The project implements a non-traffic engineered approach using Label Distribution Protocol (LDP) instead of Resource Reservation Protocol (RSVP) as RSVP has scalability issues when it comes to real time video conferencing application. The network so designed has been simulated using the simulation tool OPNET modeler. The results obtained from the simulation clearly show that use of IP multicast over MPLS while using different QoS techniques has better performance in terms of bandwidth, throughput and delay when compared with convention IP data transfer approach.

Keywords: MPLS, IP, Multicasting, QoS, LDP, RSVP, PIM-SM, ASM, SSM

I. INTRODUCTION

Internet today has become an integral part of one`s life with the increasing number of applications and services it provides to its customers. With the increase in the number of services the number of internet users has also increased by leaps and bounds. The numbers represent an annual growth rate of over 65 percent [1]. With increase in the number of users and demand for real time applications like video streaming, VoIP, audio visual conferencing there is high demand for larger bandwidth for these applications. The conventional Internet Protocol (IP) i.e. IP version 4 (IPv4) has some constraints with regards to providing such real time applications. The use of IP, along with Multiprotocol Label Switching (MPLS) can however be considered as a viable solution for such applications. Internet Protocol (IP) is a layer three i.e. a network layer protocol which provides connectionless best effort service. In present internet two internet protocols are known mostly namely IPv4 and IPv6. IPv4 address is 32 bits long and as such can provide 2^{32} addresses i.e. it has an address space of 2^{32} .With the address space of 2^{32} bits which is somewhat equivalent to about four billion addresses, it was considered that these number of addresses are much more than that would be required by the internet users all over the world. However with time the number of internet users has increased in such a way that these four billion addresses will be inadequate to accommodate this increasing number of user in the near future. This led to the development of new protocol namely IPv6. Ipv6 address in 128 bit long which as such can provide 2^{128} addresses i.e. it has an address space of 2^{128} bits which in a lot more than that provided by IPv4. Even though the new internet protocol provides higher address space but it is going to take a considerable amount of time to convert the internet to a complete IPv6 based internet as the whole internet today is based on IPv4. Although there are some techniques by way of which the two internet protocols can be used together in the internet supporting each other with good efficiency.

MPLS which is a newer technology comparatively is considered to be ideal for real time applications. Multi-Protocol Label Switching (MPLS) is a new method used in package exchanging network and widely accepted as one of the core technologies in the Next Generation Internet (NGI) [2]. Multi-Protocol Label Switching is a method that directs data from one system node to the next based on short path labels rather than long network addresses in high-performance telecommunications association [3]. The use of labels instead of the routing table information for the transfer of data helps in reducing the amount of time required for delivery of data from source to the destination. In an MPLS network the packets are assigned labels and these packets are the being forwarded on the basis of these labels to the next router wherein label swapping takes place and the packet is forwarded again and so on. The routers which assign the labels are called Label Edge Routers (LER`s) and the routers which switch the labels are called Label Switch Routers (LSR`s). The path established by way of this label assignment and switching is called as Label Switched Path (LSP). Moreover, in addition to IP and MPLS another factor that can be used to enhance the performance of the system is the use of multicasting technique. In traditional internet, point to point communication has been used mostly but with increasing demands for bandwidth the use of point to point communication poses some sort of problems like utilization of large amount of bandwidth in case where

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limited amount of bandwidth is available. The use of multicasting which is a point to multipoint or multipoint to multipoint communication provides a better way out in such cases as the data needs not to be sent again by the source thus conserving the all-important bandwidth.

Quality of Service (QoS) involves certain parameters like delay, bandwidth, jitter i.e. variation in delay etc. which are an essential part of the internet, even more important when it comes to real time application services. Various QoS techniques and scheme are there which can be used to enhance the system performance.

II. BACKGROUND

The MPLS protocol was initially proposed in RFC 3031 by Rosen, E.Viswanathan, and A. Callon [3]. A lot of work has been done with regards to MPLS being used in a multicasting environment. that Multi-Protocol Label Switching (MPLS) shows a better response in wireless network as compared to IP [4].Multicast is technique where a source host sends data to group of destination hosts. The first major advantage of using multicasting is the decrease of the network load [5] PIM-SM is one the multicasting protocols used. Even though a number of multicast routing protocols have been put forth but PIM-SM is said to be more efficient of all the available routing protocols.

III.IP MULTICASTING

Internet protocol is a layer three protocol used in the internet networking for data delivery from source host to the destination host. Internet protocol is a connectionless service as no connection is established between source host and the destination host before the transmission of data takes place. The reason for this connectionless service is that the internet is made up of so many heterogeneous networks that it is almost impossible to create a connection from source to destination without knowing the nature of the network in advance . Multicasting has been a topic of research for a while now. Different multicasting techniques have been proposed to allow for multicast transmission of data from source to destination. Two models have been so far put forth for multicast communication in internet networks

A. Any source Multicast.

Any source multicast (ASM) is a traditional IP multicast service model proposed by Deering. This model supports one to many and many to many multicast communication [6]. In this model the receiver simply joins the group without knowing the identity of the source [7]. In a multicast group, the multicast capable routers construct distribution trees by exchanging messages by way of different routing protocols. The most commonly used protocol being PIM-SM which constructs the spanning tree from rendezvous point (RP) to all group members. The receiver entering a group can receive data from any source of the group. PIM-SM also allows designated routers serving a particular subnet to switch to a source based shortest path tree for a given source once the source address is learned from the data arriving on the shared tree [6] A RP can learn about the source in other PIM domain by using Multicast source discovery protocol (MSDP).

B. Source Specific Multicast.

One of the most recent developments in multicast is the proposal of Source Specific Multicast (SSM) [8]. SSM was proposed by Internet Engineering Task Force (IETF) in order to improve on features present in ASM. In SSM the packets that are delivered to the receiver are those which are requested by the receiver from a particular source. In source Specific Multicast the packets are transmitted from source (S) to the SSM address (G) and the receiver can receive this datagram by subscribing to the channel (S, G) [6]. The key distinguishing property from ASM is that listeners subscribe to a channel identified by the combination of a unicast source address and a multicast destination address (S,G), thus eliminating the cross-delivery of traffic and need for an RP [9].

IV. PIM-SM PROTOCOL

PIM-SM is a routing protocol for efficient routing of data packets to multicast groups that span a wide area [10]. PIM-SM has two key differences with existing dense-mode protocols (DVMRP, MOSPF, and PIM-DM) [5]. In PIM-SM protocol routers need to explicitly announce their will for receiving multicast messages of multicast groups, while dense-mode protocols assumes that all routers need to receive multicast messages unless they explicitly send a prune message [5]. The other difference is that it makes use of Rendezvous Point (RP) to which the sender directs the information and receives the request information. Each group has a single RP at any given time [5]. A router that intends to receive a multicast message needs to send a join message to the RP.

. PIM-SM was designed to support the following goals:

- Maintain the traditional IP multicast service model of receiver-initiated multicast group membership. In this model, sources simply put packets on the first-hop Ethernet, without any signaling. Receivers signal to routers in order to join the multicast group that will receive the data.
- Leave the host model unchanged. PIM-SM is a router-to-router protocol, which means that the hosts don't have to be upgraded, but that PIM-SM-enabled routers must be deployed in the network.
- Support both shared and source distribution trees. For shared trees, PIM-SM uses a central router, called the Rendezvous Point (RP), as the root of the shared tree. All source hosts send their multicast traffic to the RP, which in turn forwards the packets through a common tree to all the members of the group. Source trees directly connect sources to receivers. There is a separate tree for every source. Source trees are considered shortest-path trees from the perspective of the unicast routing tables. PIM-SM can use either type of tree or both simultaneously.
- Use soft-state mechanisms to adapt to changing network conditions and multicast group dynamics. Soft-state means that, unless it is refreshed, the router's state configuration is short-term and expires after a certain amount of time [11]

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Each host has a Designated Router (DR) which is the router connected to the same sub network with the highest IP address [5]. Once the DR receives an IGMP message, it finds the RP of that group and forwards the join message to that RP. The DR and intermediate routers create an entry in their multicast forwarding table for the (*, group) pair (* means any source) such that they can know how to forward multicast messages coming from the RP of that multicast group to the DR and group members. When a source sends a message to a certain group, the designated of that source encapsulates the first message in a PIM-SM-Register packet and sends it to the RP of that group as a unicast message [5]. Once this message is received the RP sends a join message back to the designated router of the source. During this time all the intermediate nodes update their multicast forwarding table. Even though forwarding of multicast message by way of shared tree in enough but once the number of participants increases the use of shared tree is not an appropriate option. PIM-SM also provides a way of using shortest path trees for some or all of the receivers. . PIM-SM routers can continue using the RP-tree, but have the option of using source-based shortest-path trees on behalf of their attached receiver(s). In these situations, the PIM-SM router sends a Join message to the source node. After the source-based shortest-path delivery tree is constructed, the router can send a prune message to the RP, removing the router from the RP-tree [5].

V. MPLS OVERVIEW

Multiprotocol Label Switching (MPLS) is a new technology for transfer of data packets from source to destination where the packets are forwarded on the basis of labels attached to them. MultiProtocol Label Switching is a method that directs data from one system node to the next based on short path labels rather than long network addresses in high-performance telecommunications association [3]. MPLS was primarily developed to avoid slow IP look ups and also to improve the scalability. The MPLS labels are advertised between routers so that they can build a label to label mapping [12]. The use of labels enables the forwarding of the packets by just looking at the labels rather than looking for destination addresses. The packets are forwarded by label switching rather than IP switching [12]. The use of label switching technique removes the need of look up at every router and thus makes the forwarding of packets faster. Keeping in consideration the OSI reference model MPLS operates between the second and the third layer of the model. MPLS has evolved into an important technology for efficiently operating and managing IP networks because of its superior capabilities in providing traffic engineering (TE) and virtual private network (VPN) services[13]. It is referred to as multiprotocol because of the fact that it works with IP, ATM and frame relay network protocols [14]. MPLS label is a field of 32 bits. The syntax of MPLS label is shown in figure below:

0 19	20 22	23 24	31
Label	Exp	BoS	TTL

Figure 1: MPLS Label Format

The first 20 bits represent the label value. The bits 20 to 22 are the three experimental bits and are used for the purpose of Quality of Service (QoS). The 23rd bit is the Bottom of Stack (BoS) and is 0 unless this is the bottom label in the stack. If so, the BoS bit is set to 1. Stack is nothing but the collection of labels.

The bits 24 to 31 represent time to live (TTL). It is same as in case of IP header and is decremented by 1 at each hop. Once the TTL of the label reaches 0, the packet is discarded. TTL helps avoid looping. MPLS works by prefixing packets with an MPLS header as shown above having one or more label known as label stack [15]. The forwarding of packets involves two important parameters namely Label Switch Router (LSR) and Label Switch Patch (LSP). A LSR is a router that can support MPLS and is capable of understanding and differentiating the labels and of receiving and transmitting a labeled packet on data link [12].

The path established to forward the packets from source to the destination in case of MPLS is referred to as Label Switched Path (LSP). Another important term used in MPLS is the Forwarding Equivalence Class (FEC). It is a group of IP packets which are forwarded in the same manner (e.g., over the same path, with the same forwarding treatment) [3]. It is a set of packets which have somewhat similar characteristics and are given similar priority while being forwarded along the same path.

This group of packets is associated with same MPLS label. Every packet is assigned a FEC only once at the Ingress router in an MPLS network. Same routing treatment is given to the packets of FEC[16].

VI. NETWORK DESIGN AND SIMULATION

The model consists of IPv4 network integrated with an Multiprotocol Label Switching (MPLS) core network with multicast enabled for delivery of data packets from source to group of multicast receivers.

The network is provided with different quality of service parameters like queuing and type of service to be provided. This feature is added by using IP QoS attribute config. The protocol used to allow multicasting over the network is PIM-SM.

The network is designed to enable the delivery of real time video conferencing traffic. The application config and profile config objects are used to define the type of traffic used.

After the designing of the network model, the model is configured as per the requirements like the protocol to be used, traffic to be sent, QoS service to be provided etc.
The network model (Model 1) so designed is shown in figure below

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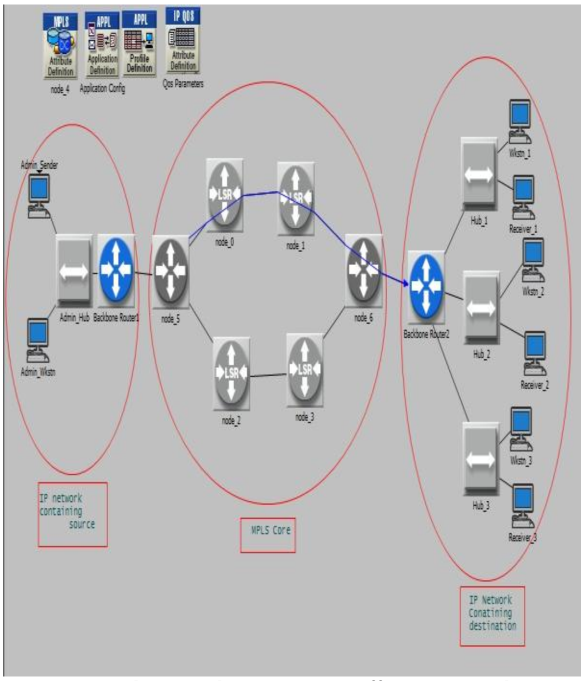

Figure 2: IP multicast with MPLS using Different QoS Techniques.

The network topology shown above consists of an IP source and three IP destinations connected via Hubs. The two backbone routers are connected to the Hubs on one side and an MPLS core on the other side. The MPLS core network consists of six routers where node 5 and node 6 represent Label Edge Routers (LER`s) and node 0, node 1, node 2 and node 3 represent the Label Switch Routers (LSR`s).

The network so designed is further compared with IP network without using an MPLS core network (model 2). However, multicasting has been enabled over the entire network and a conventional unicast IP network with no MPLS configured on any of the nodes (model 3).

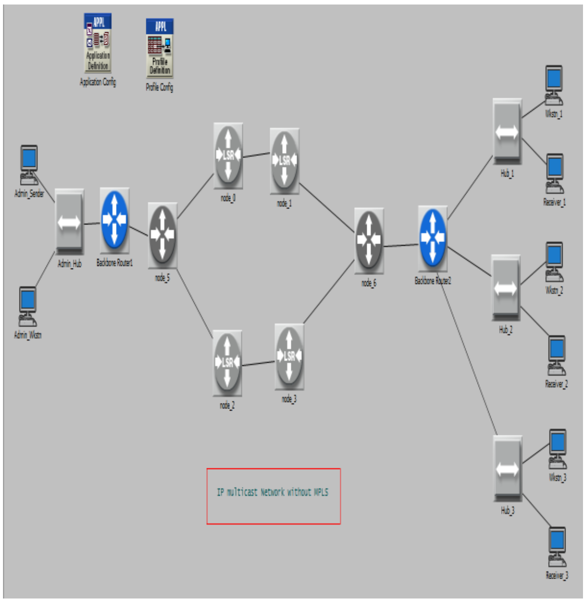

Figure 3: IP Multicast without MPLS.

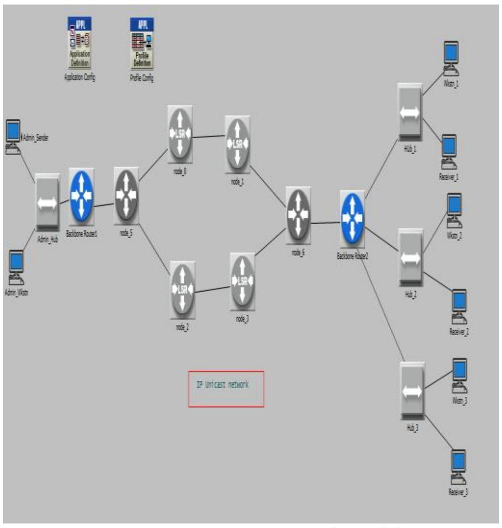

Figure 4: IP Unicast network model

However, multicasting has been enabled over the entire network. The simulation tool used for analyzing the results is OPNET^{TM}.

VII. RESULTS

Various QoS parameters like throughput, delay and bandwidth have been studied while simulating the network over a period of two hours. The results obtained are shown in the figures below

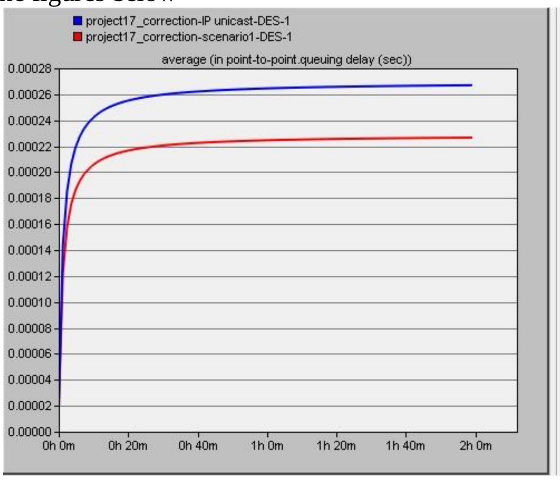

Figure 5: Comparison of queuing delay in experiment model 1 and 3.

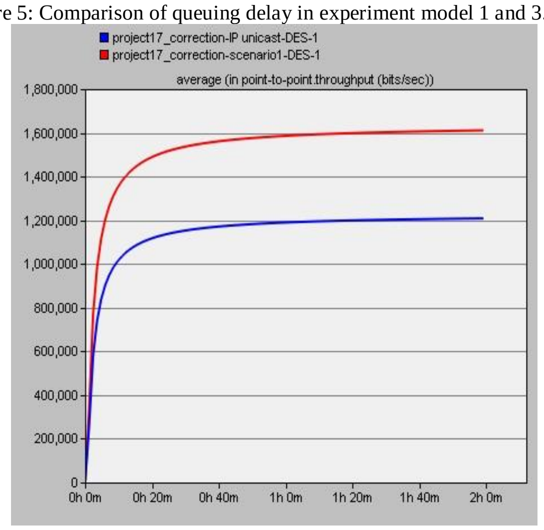

Figure 6: Throughput comparison of experiment model 1 and 3.

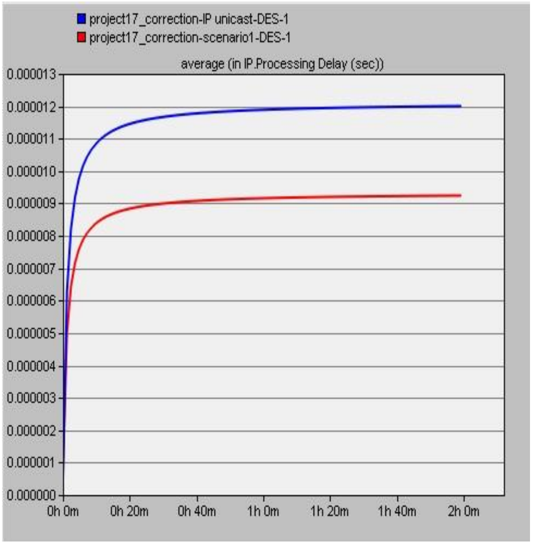

Figure 7: Processing delay comparison of experiment model 1 and 3.

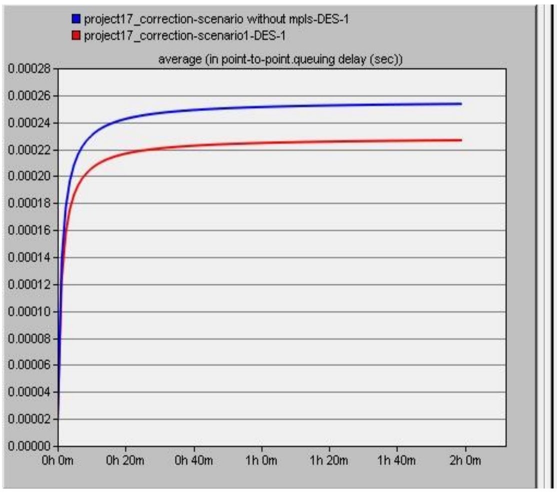

Figure 8: Comparison of queuing delay in experiment model 1 and 2.

The results obtained in terms of throughput delay and utilization show that the proposed network shows better response in all the cases and can be considered to be the efficient mechanism of data transmission over a network involving large number of receivers intending to receive the data simultaneously.

VIII. CONCLUSION

The internet today is growing by leaps and bounds not only in terms of users but also in terms of the services it provides. The users of today demand for real time applications like video, voice over IP, video on demand etc. The conventional internet has certain limitations in terms of bandwidth, delay when it comes to real time applications. In the project a different approach has been used which comprises of IP and MPLS network with multicasting enabled over the network and also making use of weighted fair queuing algorithm as a QoS technique. The results when compared with the conventional IP network show that the implemented network shows better performance as compared to the conventional internet thus justifying the use IP multicast with MPLS with queuing QoS technique and streaming multimedia as type of service.

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