Survey on Working of MPLS and ATM Network

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ABSTRACT: *Multiprotocol Label Switching (MPLS) is a type of data-carrying technique for high-performance telecommunications networks. MPLS directs data from one network node to the next based on shortest path by applying labels on routes rather than long network addresses, avoiding complex lookups in a routing table. MPLS can provide applications including VPNs (Virtual Private Networks), traffic engineering (TE) and Quality of Service (QoS).This paper presents working of MPLS for an ATM network on FPGA which replaces the virtual circuits by use of labels in the network.*

Keywords: MPLS, Asynchronous Transfer Mode, Ingress packet processing module, Egress packet processing module. labels

1. INTRODUCTION

Now a day's utilization of internet is increasing exponentially in our daily life .The exponential growth of the Internet over the past several years has placed a tremendous strain on the service provider networks. As we all know there has been an increase in the number of users with that there has been a multi-fold increase in newer applications, backbone traffic, connection speeds. At the begging of communication ordinary data applications required only store and forward capability in a best effort manner. Now days there are many newer applications like voice, multimedia and real-time ecommerce applications are pushing toward higher bandwidth and services, irrespective of the dynamic changes or interruptions in the network.

Multi Protocol Label Switching (MPLS) in simple terms, which enables a Service Provider (SP) to offer scalable and internetworking solutions for its clients. In addition to scalability, MPLS offers Traffic Engineering (TE) and Quality of Service (QoS). While TE is more oriented towards SP, scalability and QoS features will benefit both SP and its customers. What MPLS does is an addition of one or more labels which is inserted between Layer 2 header and Layer 3 header in a datagram. An additional label offers one more way of packet forwarding in addition to the traditional IP lookup. Since the MPLS label is placed just before Layer 3 header and after Layer 2 header, an SP router uses MPLS label in its core to make forwarding decisions, instead of Layer 3 information.

IP-based networks typically lack the QoS features available in circuit-based networks, such as ATM and Frame Relay. MPLS brings the sophistication of a connection-oriented protocol to the connectionless IP world. MPLS brings performance enhancements and service creation capabilities to the network. MPLS technology enables Internet Service Providers to offer additional services for their customers, scale their current offering, and exercise more control over their growing networks by using its traffic engineering capabilities.

2. ATM- Asynchronous Transfer Mode

A high performance cell oriented switching and multiplexing technology that utilizes fixed length packets to carry different type of traffic. It contains voice, data and video signals. It was designed for a network that must handle both traditional high-throughput data traffic (e.g., file transfers), and low-latency content, real-time such as voice and video.ATM is a core protocol mainly used over the SONET/SDH backbone of the public switched telephone network (PSTN) and Integrated Services Digital Network (ISDN).

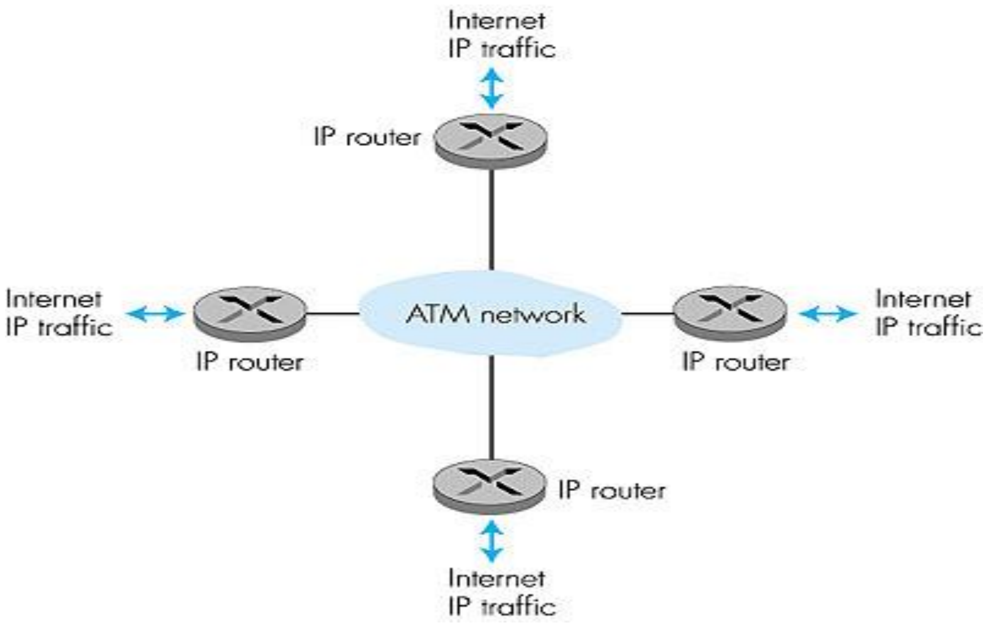

Fig 1 ATM Network

2.1 ATM Architecture –

ATM is a network technology its vision is end to end transport . it is used to connect backbone routers (IP over ATM) . ATM is a switched link layer, connecting IP routers.

ATM Adaptation Layer (AAL): "adapts" upper layers (IP or native ATM applications) to ATM layer below.AAL presents only in end systems, not in switches. AAL layer segment (header/trailer fields, data) fragmented across multiple ATM cells**.**

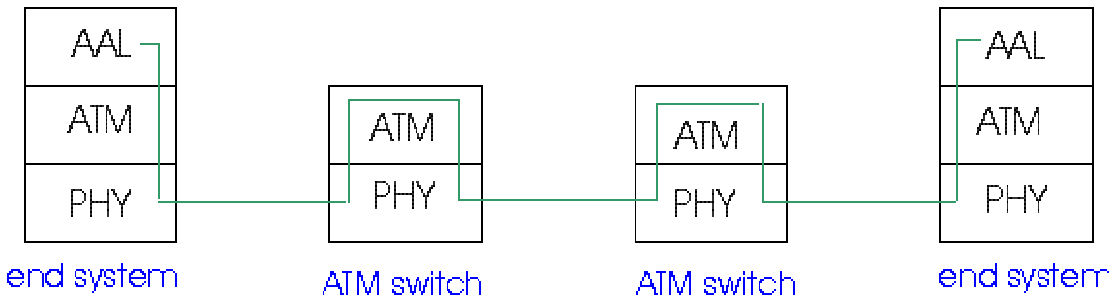

Fig 2 ATM Architecture

Adaptation layer(AAL): only at edge of ATM network

data segmentation/reassembly

roughly analogous to Internet transport layer

ATM layer: “network” layer

cell switching, routing

Physical layer

2.2 Structure of an ATM cell

An ATM cell is of 53 bytes which consist of 5-byte header and a 48-byte payload.

GFC = Generic Flow Control (4 bits)

(Default: 4-zero Bits)

VPI = Virtual Path Identifier (8 bits UNI) or

(12 bits NNI)

VCI = Virtual Channel identifier (16 bits)

PT = Payload Type (3 bits)

CLP = Cell Loss Priority (1-bit)

HEC = Header Error Control

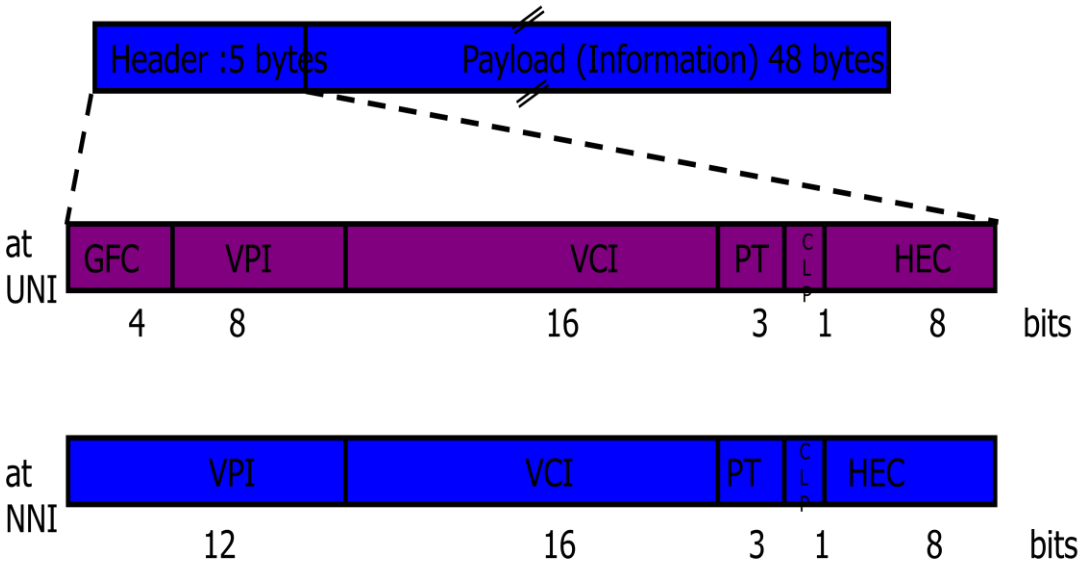

Fig 3 ATM Cell

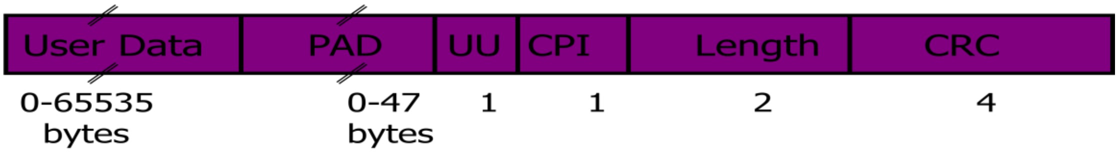

Fig 4 AAL Packet

PAD : padding

User Data

8 Bytes header

3.MPLS – Multi Protocol Label Switching

IP-based networks typically lack the quality-of-service features available in circuit-based networks, such as ATM and Frame Relay. MPLS replaces the virtual circuits (VC) which reduces the hardware components for connection between routers in the ATM network. MPLS provides an increase in the performance enhancements and service creation capabilities to the network.

MPLS stands for Multiprotocol Label Switching here are some of the terms which are used extensively in MPLS-

3.1. MPLS header: The 32-bit MPLS header contains the following fields:

- The label field (20-bits) carries the actual value of the MPLS label.

- The Experimental bits (3-bits) can affect the queuing and discard algorithms applied to the packet as it is transmitted through the network. Since this field has 3 bits, therefore 8 distinct service classes can be maintained.

- The Stack field (S) (1-bit) supports a hierarchical label stack. This MPLS supports the processing of a labeled

packet is always based on the top label. An unlabelled packet can be thought of as a packet whose label stack is

empty (i.e., whose label stack has depth 0). If a packet's label stack is of depth n, we refer to the label at the bottom

of the stack as the level 1 label, to the label above it then as the level 2 label if such exit, and to the label at the top

of the stack as the level n label. The label stack is used for routing packets through LSP Tunnels.

- The TTL (time-to-live) field (8-bits) provides conventional IP TTL functionality.

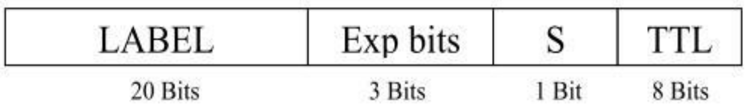

Figure 5 MPLS header format

3.2 Forwarding Equivalence Class (FEC):
A group of IP packets which are forwarded in the same manner (e.g., over the same path, with the same forwarding treatment). The "Forwarding Equivalence Class" is an important concept in MPLS. An FEC is any subset of packets that are treated the same way by a router. By "treated" this can mean, forwarded out the same interface with the same next hop and label. It can also mean given the same class of service, output on same queue, given same drop preference, and any other option available to the network operator. When a packet enters the MPLS network at the ingress node, the packet is mapped into an FEC. The mapping can also be done on a wide variety of parameters, address prefix (or host), source/destination address pair, or ingress interface. This greater flexibility adds functionality to MPLS that is not available in traditional IP routing. FECs also allow for greater scalability in MPLS. In Ipsilon's implementation of IP Switching or in MPOA, their equivalent to an FEC maps to a data flow (source/destination address pair, or source/destination address plus port no.). The limited flexibility and large numbers of (short lived) flows in the Internet limits the applicability of both IP Switching and MPOA. With MPLS, the aggregation of flows into FECs of variable granularity provides scalability that meets the demands of the public Internet as well as enterprise applications.
In the current Label Distribution Protocol specification, only three types of FECs are specified:
- IP Address Prefix
- Router ID
- Flow (port, dest-addr, src-addr etc.)
The spec. states that new elements can be added as required.

3.3. MPLS- Architecture

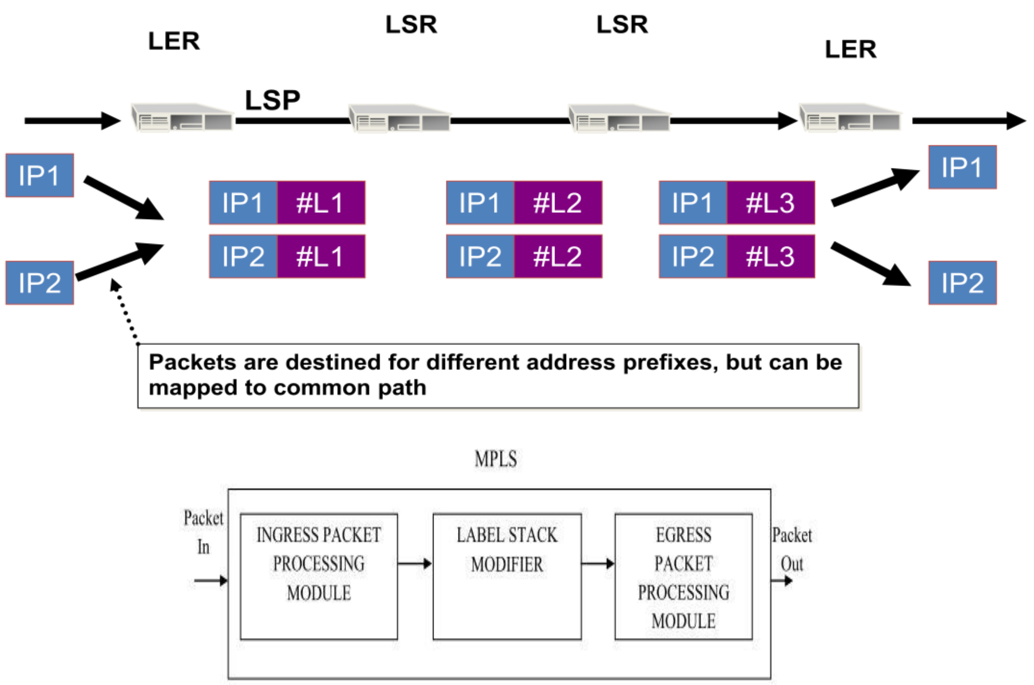

Fig 6 MPLS Architecture

An LSP (label-switched path) is a one-way flow of traffic, carrying packets from beginning to end. Packets must enter the LSP at the beginning of the path, and can only exit the LSP at the end. Packets cannot be injected into an LSP at an intermediate hop.

A LER (label-edge Router) is edge router . At the beginning of LSP it is called ingress – router and at the end of the LSP it is called egress router.

A LSR (label-switching router) forwards MPLS packets which are part of a LSP. In addition, an LSR participates in constructing LSPs for the portion of each LSP entering and leaving the LSR.

Throughout this course, we use LSR and "router" interchangeably.

Each router in an MPLS path performs a specific function based on whether the packet enters, transits, or leaves the router. At the beginning of the tunnel, the "ingress router" encapsulates an Internet Protocol (IP) packet within an MPLS layer 2 frame and forwards it to the first router in the path. There can be only one ingress router in a path and it is always at the beginning of the path A "transit router" forwards a received MPLS packet to the next hop in the MPLS path. There may be zero or more transit routers in a path. The MPLS protocol enforces a maximum limit of 253 transit routers in a single path. At the end of label-switched path, the "egress router" removes the MPLS encapsulation and forwards the packet towards its final destination using the normal IP forwarding table. There can be only one egress router in a path.

MPLS is responsible for directing a flow of IP packets along a predetermined path across a network. This path is called a label-switched path. Label-switched paths are similar to ATM PVCs in that they are simplex in nature; that is, the traffic flows in one direction from the ingress router to a egress router. Duplex traffic requires two label-switched paths; that is, one path to carry traffic in each direction. A label-switched path is created by the concatenation of one or more label-switched hops, allowing a packet to be forwarded from one label-switching router to another label-switching router across the MPLS domain. A label-switching router is a router that supports MPLS-based forwarding.

When an IP packet enters a label-switched path, the ingress router examines the packet and assigns it a label based on its destination, placing the label in the packet's header. The label transforms the packet from one that is forwarded based on its IP routing information to one that is forwarded based on information associated with the label. The packet is then forwarded to the next router in the label-switched path. The key point in this scheme is that the physical path of the LSP is not limited to what the IGP would choose as the shortest path to reach the destination IP address.

3.4 MPLS Packet Processing -

The MPLS packet processing includes label lookups, packet forwarding, label manipulation and routing protocol functionality. Below figure illustrates a high level description of MPLS architecture.

The architecture consists of two packet processing modules, and a separate module to modify the label stack. Ingress packet processing module will process the packet and separate the label with the packet, in the label stack modifier will replace the label with new label. The packet with the new label will transfer to the next router, the egress packet processing module is the last router before the destination will process the packet and then it will remove the label from the packet and transfer packet with no label to the destination. Label and an Egress LER has not outgoing label. Those values are presumed to be zero.

3.4.1. Ingress Packet Processing Module

The input to Ingress packet processing module is the incoming packet with a valid destination address. When the packet arrives the packet processing unit separates the address and the data part. The data is stored in the data buffers while the control information is passed on to next unit for verifying its correctness. If the packet received is valid then it is passed on to label stack modifier where the labels are modified based on the control information available. If the packet received is invalid then the packet is drop.

The following Figure shows the flowchart of the ingress packet processing module.

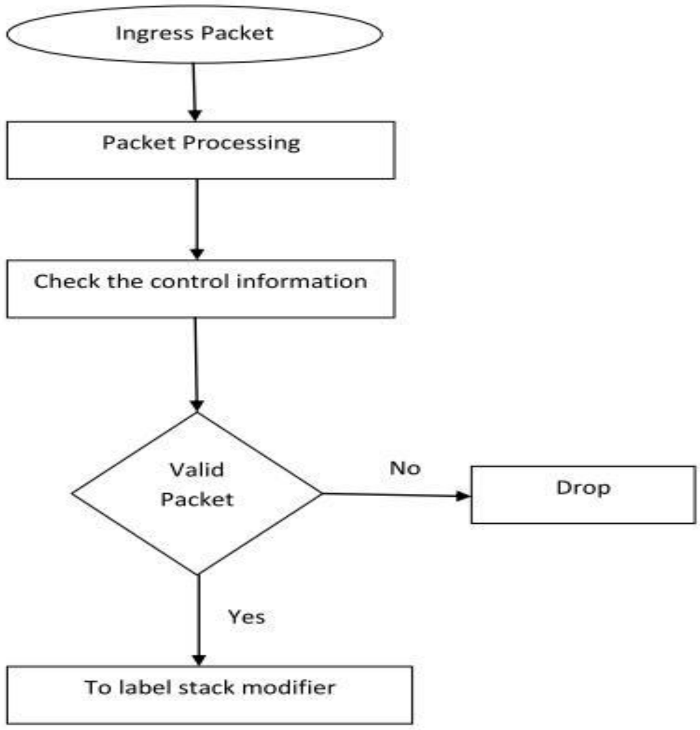

Figure 7 Ingress packet processing module flowchart

3.4.2. Label Stack Modifier

The control unit of the label stack modifier is composed of four state machines. Those state machines are the label stack interface, information base interface, information base search module and main module illustrated in below Figure.

The main module is used to ensure that the remaining state machines are not working concurrently and generating inconsistent results. When the main module is not active, it has enabled the label stack interface or the information base interface and waits for the module in question to finish its activity before allowing subsequent operations to happen.

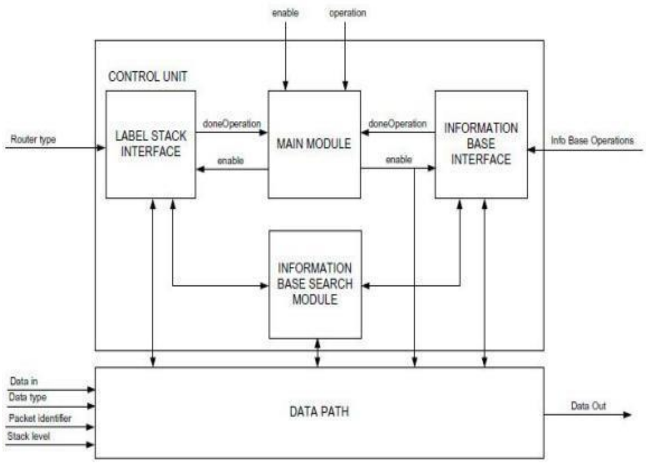

Figure 8 Label stack modifier architecture

The label stack interface is used to insert label entries directly into the stack and to update the stack given the existing state of the information base. The packet is discarded (i.e. the label stack is reset) if the relevant entries are not found in the information base or if the TTL has expired. Updating the label stack involves searching the information base for the desired new label (if necessary) and operation. If information is found the top entry in the stack is removed and the TTL is updated before information is verified. If there are any inconsistencies in the information or if the TTL is expired, the packet is immediately discarded.

The information base interface remains idle until it is enabled by the main module and proceeds to either search or save data to the information base. To search the information base, the search module is enabled. Once the operation is complete a transition back to the idle state occurs where the information base interface indicates that the operation has completed. The search module is enabled by either the label stack interface or the information base interface. Once it has been enabled, the search module iterates through the label pair entries of a specified level. External data enters the data path and is interpreted as a label stack entry, a label pair (old label/new label) for the information base or a search index when the user wants to read the contents of the information base directly. Label stack entries can be stored from external data or from a register that holds the label entry currently being modified.

3.4.3. Egress Packet Processing Module

The Egress Packet Processing Module gets the input from label stack modifier for further processing of the packets. Figure 8 shows the flowchart of Egress Packet Processing Module. The Egress Packet Processing Module constructs the header as per the required format and replaces the fields such as TTL and CRC based on the control information. The packet generator block basically construct the packet by padding the data and control information together. Then the packet is sent to data buffer for forwarding through the output ports.

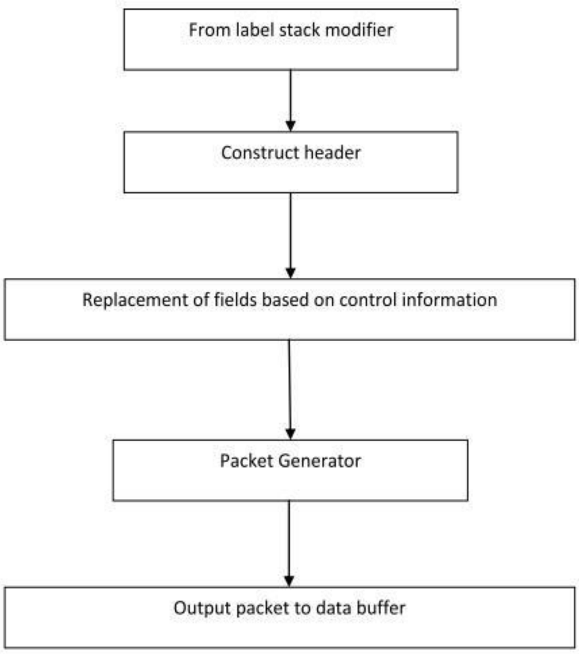

Figure 9 Egress packet processing module flowchart

4. RELATED WORK

MPLS is comprised of different protocols, each performing a different task in the MPLS work flow. Each protocol have been researched differently with respect to hardware implementation. The work in [2] describes hardware implementation of IS-IS protocol. In [3] research on hardware implementation of OSPF protocol is discussed. Research in [4] and [5] discuss the hardware implementation of subset of RSVP-TE and CR-LDP protocols respectively. The work in [7] describes the hardware implementation of reconfigurable MPLS router.

The work in [6] has introduced a hardware processor for the implementation of MPLS using RSVP-TE as its signalling protocol. In [8], an embedded architecture for the MPLS protocol was proposed. The design uses both hardware and software to implement different aspects of MPLS. The architecture proposed implementing routing functionality in software, label switching functionality in hardware.

5. CONCLUSION

Multiprotocol Label Switching (MPLS) is a protocol-agnostic routing technique designed to speed up and **shape** traffic flows across enterprise wide area and service provider networks

ATM network is a connection oriented which gives better quality-of-service features available in circuit-based networks. MPLS over ATM network replaces the VC by inserting a label in each packet and forwards the packet with label throughout network which performs as connection-oriented protocol from this it maintains the QOS. Based on simple improvements in basic IP routing, MPLS increases performance enhancements and service creation capabilities to the network. So ATM with MPLS usage into the enterprise can meet emerging requirements for scalable transport for end user services, including data, voice and video.

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