7.1 MPLS
7.2 NGN

7.1 MPLS

What is MPLS (Multi-Protocol Label Switching)?

Introduction

The exponential growth of the Internet over the past several years has placed a tremendous strain on the service provider networks. Not only has there been an increase in the number of users but there has been a multifold increase in connection speeds, backbone traffic and newer applications. Initially ordinary data applications required only store and forward capability in a best effort manner. The newer applications like voice, multimedia traffic and real-time e-commerce applications are pushing toward higher bandwidth and better guarantees, irrespective of the dynamic changes or interruptions in the network.

To honor the service level guarantees, the service providers not only have to provide large data pipes (which are also costlier), but also look for architectures which can provide & guarantee QoS guarantees and optimal performance with minimal increase in the cost of network resources.

MPLS technology enables Service Providers to offer additional services for their customers, scale their current offerings, and exercise more control over their growing networks by using its traffic engineering capabilities. Putting it simply, MPLS is a switching technology used to get packets from one place to another through a series of hops

Multi-Protocol Label Switching (MPLS) provides a mechanism for forwarding packets for any network protocol. It was originally developed in the late 1990s to provide faster packet forwarding for IP routers (see RFC 3031). Since then its capabilities have expanded massively, for example to support service creation (VPNs), traffic engineering, network convergence, and increased resiliency.

MPLS is now the de-facto standard for many carrier and service provider networks and its deployment scenarios continue to grow.

Traditional IP networks are connectionless: when a packet is received, the router determines the next hop using the destination IP address on the packet alongside information from its own forwarding table. The router's forwarding tables contain information on the network topology, obtained via an IP routing protocol, such as OSPF, IS-IS, BGP, RIP or static configuration, which keeps that information synchronized with changes in the network.

MPLS similarly uses IP addresses, either IPv4 or IPv6, to identify end points and intermediate switches and routers. This makes MPLS networks IP-compatible and easily integrated with traditional IP networks. However, unlike traditional IP, MPLS flows are connection-oriented and packets are routed along pre-configured Label Switched Paths (LSPs).

The evident power of the basic MPLS concepts led the industry to define generalized extensions to MPLS, or Generalized MPLS (GMPLS). This work extended the MPLS concept of a label to include implicit values defined by the medium that is being provisioned, for example a timeslot for a SONET/SDH device. So with GMPLS, there is no need for a switch to "read" the label in each packet header. The label is an inherent part of the switch fabric and the switching operations depend on wavelength, or timeslot etc. This permits the benefits of MPLS to be shared by many different types of switching platform.

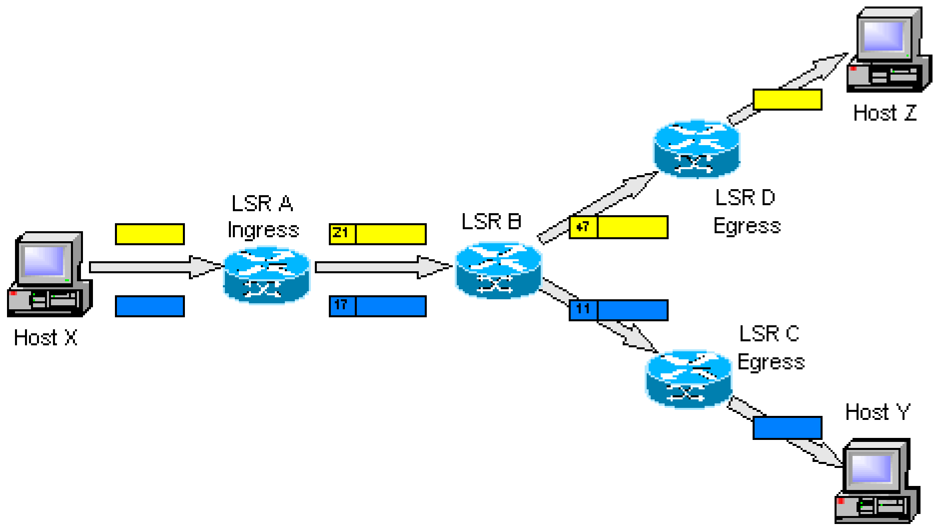
MPLS Operation

How Does MPLS Work?

MPLS works by tagging the traffic, in these example packets, with an identifier (a label) to distinguish the LSPs. When a packet is received, the router uses this label (and sometimes also the link over which it was received) to identify the LSP. It then looks up the LSP in its own forwarding table to determine the best link over which to forward the packet, and the label to use on this next hop.

A different label is used for each hop, and it is chosen by the router or switch performing the forwarding operation. This allows the use of very fast and simple forwarding engines, which are often implemented in hardware.

Ingress routers at the edge of the MPLS network classify each packet potentially using a range of attributes, not just the packet's destination address, to determine which LSP to use. Inside the network, the MPLS routers use only the LSP labels to forward the packet to the egress router.



The diagram above shows a simple example of forwarding IP packets using MPLS, where the forwarding is based only on packet destination IP address. LSR (Label Switched Router) A uses the destination IP address on each packet to select the LSP, which determines the next hop and initial label for each packet (21 and 17). When LSR B receives the packets, it uses these labels to identify the LSPs, from which it determines the next hops (LSRs D and C) and labels (47 and 11). The egress routers (LSRs D and C) strip off the final label and route the packet out of the network.

The above is only one use of MPLS. Since MPLS uses only the label to forward packets, it is protocol-independent, hence the term "Multi-Protocol" in MPLS. It can be used to carry any content (not only packets) over any link technology (using different label encoding for each layer 2 link type).

IP-based networks typically lack the quality-of-service features available in circuit-based networks, such as Frame Relay and ATM. MPLS bring the sophistication of a connection-oriented protocol to the connectionless IP world. Based on simple improvements in basic IP routing, MPLS brings performance enhancements and service creation capabilities to the network.

MPLS techniques are applicable to ANY network layer protocol, of which IP is the most popular.

MPLS Benefits

The initial goal of label based switching was to bring the speed of Layer 2 switching to Layer 3. Label based switching methods allow routers to make forwarding decisions based on the contents of a simple label, rather than by performing a complex route lookup based on destination IP address. This initial justification for technologies such as MPLS is no longer perceived as the main benefit, since Layer 3 switches (ASIC-based routers) are able to perform route lookups at sufficient speeds to support most interface types.

However, MPLS brings many other benefits to IP-based networks. Forwarding packets based on labels rather than routing them based on headers results in several important **advantages**:

- Faster Speed: Due to the labeling technology, the speed of performing lookups for destinations and routing is much faster and without overloading the CPU than the standard IP table lookups (concerned with longest prefix match) non-MPLS routers have to perform, due to simpler label lookup.
- QoS: This is a big one. MPLS networks achieve greater Quality of Service for their customers. Quality of Service (QoS) means exactly that – you can expect a higher standard of service such as reliability, speed, and voice quality. This is for a few reasons, one already mentioned above.

  In addition, MPLS networks are able to assign priorities to the different packets based on what the labels say about that packet. Packets with greater priority, voice over data for example, are given more bandwidth allocation. A packet that which is not deemed as high priority is given less. Obviously sending documents online don't need to be assured of the same bandwidth required for someone who is wanting to have a conversation.
- Faster Restoration: MPLS networks are also able to restore interrupted connections at a faster speed than typical networks.
- Security: MPLS offers greater security and are often required for companies e.g. telecoms which need enhanced privacy and security for their network needs. It's also very popular with organizations that need a scalable WAN that can carry both voice (phone calls) and data.

In addition to all the above advantages, one of the most important advantages of MPLS is that it is independent of the layer 2 and layer 3 technologies and hence allows integration of networks with different layer 2 and layer 3 protocols.

7.2 NGN

A Next Generation Networks (NGN) is a packet-based network able to provide Telecommunication Services to users and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent of the underlying transport-related technologies.

Next generation networks are not just a PSTN replacement but at a minimum they must provide the equivalent voice quality and reliability of today's PSTN.} The NGN will be the foundation for the creation of a new range of multimedia applications that take full advantage of the characteristics of the broadband network and the "always on" capability

The creation of the NGN is no overnight transformation, but it is an evolution that is already underway and gathering pace. The NGN is the shift from separate application-specific networks to a single network capable of carrying any and all services

The NGN is characterized by the following fundamental aspects:

- Packet-based transfer
- Support for a wide range of services, applications and mechanisms based on service building blocks (including real time/streaming/non-real time services and multi-media)
- Broadband capabilities with end-to-end QoS and transparency
- Interworking with legacy networks via open interfaces
- Generalized mobility
- Unfettered access by users to different service providers
- A variety of identification schemes which can be resolved to IP addresses for the purposes of routing in IP networks
- Unified service characteristics for the same service as perceived by the user
- Converged services between Fixed and Mobile networks
- Independence of service-related functions from underlying transport technologies
- Compliant with all Regulatory requirements, for example concerning emergency communications and security/privacy, etc.

- NGN, by definition, is identified an infrastructure using packet technologies.
  - There is no specific mention which packet technology NGN should use, but generally assuming IP as a dominant packet technology today.
  - There are also no specific statement to specify the version of IP such as 'version 4', 'version 6' or 'version 9,' but most parts of NGN related ITU-T RECs are mainly assumed 'version 4'

Fig. Vision of Next Generation Ubiquitous Networking

NGN Services

Several services that will be important drivers in the NGN environment are:

- **Voice Telephony:** Call Waiting, Call Forwarding, 3-Way Calling
- **Voice Portal**: Provide callers with anywhere, anytime access to information like news, weather, stock quotes, and account balances using simple voice commands and any telephone.
- **Data services**: bandwidth-on-demand, connection reliability.
- **Multimedia services**: This allows customers to converse with each other while displaying visual information.
- **Virtual Private Networks**: allow large, geographically dispersed organizations to combine their existing private networks with portions of the PSTN, thus providing subscribers with uniform dialing capabilities.
- **Public Network Computing**: Provides public network- based computing services for businesses and consumers.
- **Unified Messaging**: Supports the delivery of voice mail, email, fax mail, and pages through common interfaces.
- **E-Commerce**: Allows consumers to purchase goods and services electronically over the network.
- **Call Center Services**: A subscriber could place a call to a call center agent by clicking on a Web page.
- **Interactive gaming**: Offers consumers a way to meet online and establish interactive gaming sessions.

- **Home Manager**: These services could monitor and control home security systems, energy systems, home entertainment systems, and other home appliances.

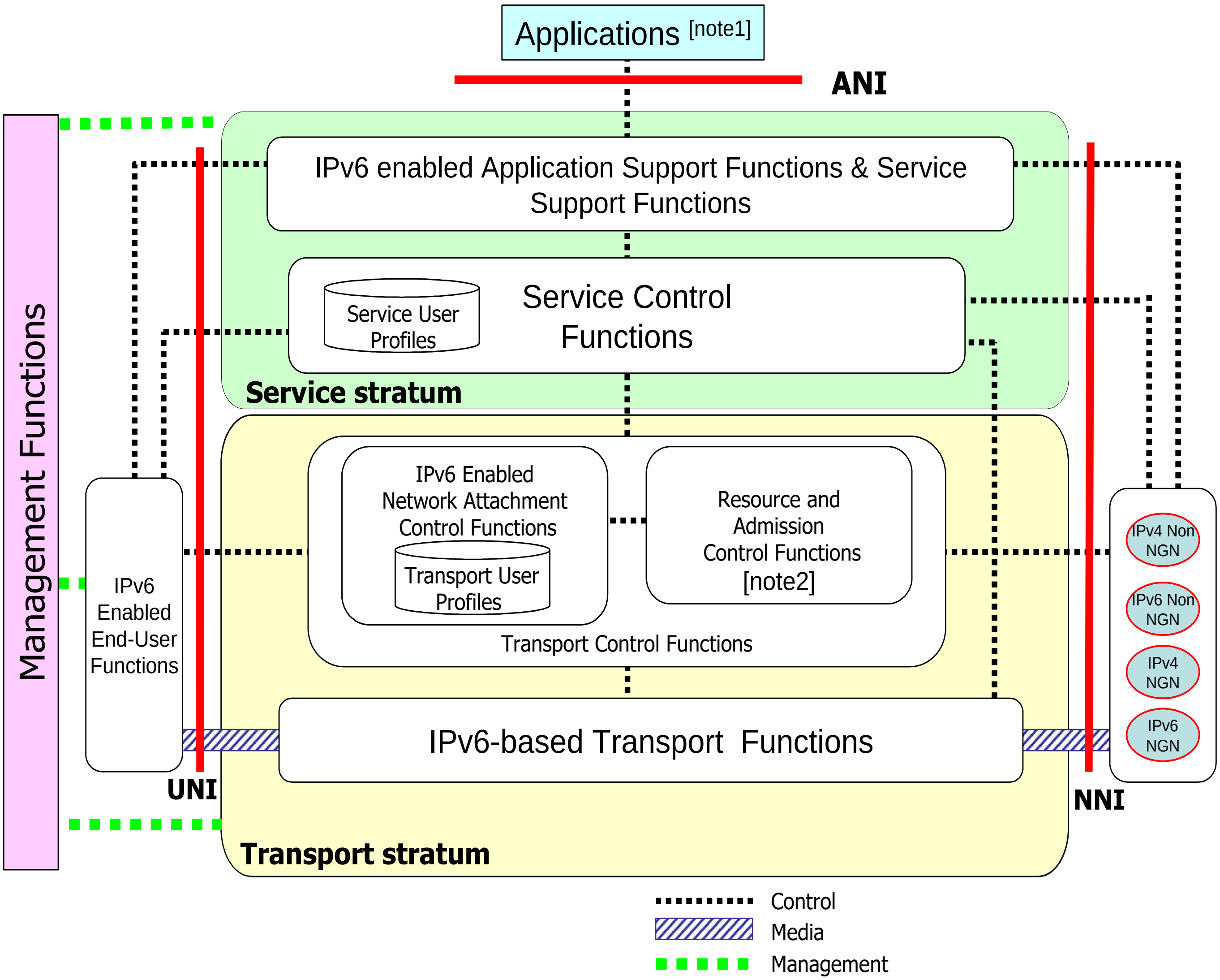


Fig. Architecture of IPv6 based NGN

IPv6 features affecting NGN

There are key features of IPv6 which may significantly impact NGN in various ways, such as addressing schemes, header format, QoS, security and mobility.

• **Simplified packet format** IPv6 headers are simplified from IPv4 headers. Some IPv4 header fields have been dropped or made optional to limit their bandwidth cost. They also have a constant size to reduce the common processing cost of packet handling.

• **Expanded addressing scheme** IPv6 addressing schemes have a large addressing space due to an increased size of the IP address fields to support more levels of addressing hierarchy, a much greater number of addressable nodes and interfaces, and a simpler autoconfiguration of addresses. The scalability of multicast routing is improved by adding a "scope" field to multicast addresses. In addition, a new type of address called an "anycast address" is defined and is used to send a packet to any of a group of nodes.

• **QoS** A flow label and traffic class fields in IPv6 header are added to enable the labeling of packets belonging to particular traffic "flows" for which the sender requests special handling, such as non-default quality of service or "real-time" service. In addition, IPv6 hop-by-hop header with router-alert option will indicate the contents of IPv6 packets to support the selective processing of the intermediate nodes.

• **Security support** IPv6 supports built-in IPsec services such as authentication, data integrity and data confidentiality using authentication header (AH) and encapsulating security payload (ESP) extension headers. These enable end-to-end security services via global IP addresses even though intermediate nodes do not understand the IPsec headers.

• **Mobility support** IPv6 capabilities such as neighbour discovery, address resolution and reachability detection support the mobility services using destination option, routing and mobility extension header

Impact of IPv6 to NGN

- **Enhanced service capabilities**

IPv6 enables congestion/flow control using additional QoS information such as flow label. The flow label field of IPv6 header enables IPv6 flow identification independently of transport layer protocols. This means that new enhanced service capabilities can be introduced more easily in NGN. IPv6 supports better mobility. IPv6 supports secure networking using embedded IPv6 security solution such as ESP and AH.

- **Any-to-any IP connectivity**

IP connectivity will be one of the vital features in order to cope with the increasing number of end users/devices. Using globally routable IPv4 addresses to network millions of devices is not feasible. On the other hand, IPv6 offers the advantages of localizing traffic with unique local addresses, while making some devices globally reachable by assigning addresses which are scoped globally. Therefore, the greatest potential of IPv6 will be realized in the objects-to-objects communications. IPv6 can satisfy this end-to-end principle of the Internet

- **Self organization and service discovery using autoconfiguration**

IPv6 can provide autoconfiguration capability using neighbour discovery protocol, etc. Through linking together the IP layer and lower layers, autoconfiguration enables with ease self-organization and service discovery of network management and reduces management requirements. In addition, address autoconfiguration of IPv6 protocol will facilitate NGNs to support dynamic address assignments and multiple user/network identities. That is, NGN end-users will be able to have multiple public and private identities by using the expanded addressing schemes of IPv6.

- **Multi-homing using IPv6 addressing**

IPv6 can handle multiple heterogeneous access interfaces and/or multiple IPv6 addresses through single or multiple access interfaces. Multi-homing can provide redundancy and fault tolerance.