MPLS [RFC 3031]

- IP Switching
  - Use labels; works with other protocols [not just with IP]
  - Use labels to determine forwarding action instead of 32/128 bit addresses
- 20 bit label

MPLS Network

- Generic MPLS Header (32 bits)
- IP Header
- IP Payload

Ingress Router

Add MPLS header

Ingress Label Switched Router adds a label (header)

LSRs switch based on label values

Egress router removes the MPLS header

Plain IP Network

Remove MPLS header
Examine LSR 2:
How does LSR2 process each packet with MPLS header?

Look at interface it came on (why?), label L2
Consult switching table associated with incoming interface
Action: Replace L2 by L3, forward on output interface O2
Other actions: Push new MPLS header; Pop MPLS header
Processing done in hardware (very fast)

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Layer 3 routing vs. MLPS

- **Lookup Time**
  - Longest prefix matching
  - 20 bits vs. 32 or 128 bits

- **Label has local significance only**
  - IP addresses have global significance
Two important questions

- How does an ingress router select a label?
- How do the intermediate routers make up their switching/forwarding tables?

Forwarding Equivalence Class

- FEC:
  - Group of packets that receive same treatment by routers
  - FEC controls packet’s path through network and packet’s forwarding treatment on that path
  - Examine an Ingres router.
    - For each destination one FEC? (all packets to that destination will get same treatment)
    - What if some need to be treated differently?
      - Examine source, destination ids, application protocol, incoming link, QoS, current network condition, VPN requirements, … and find FEC

- FEC and quick forwarding are two greatest advantages of MPLS
- Force packets to go through a certain path
MPLS message format

<table>
<thead>
<tr>
<th>Label (20 bits)</th>
<th>Res(3)</th>
<th>B</th>
<th>TTL(8)</th>
</tr>
</thead>
</table>

IP Header

B=1: Stack bottom (no more MPLS headers below)

Reserved Labels

Some labels have special significance

- 0 to 15
  - 0: IPv4 null label (pop stack, treat rest as IPv4 packet)
  - 1: router alert: pkt needs special handling, route based on next label
  - 2: IPv6 null label
  - 3: Multicast null label
  - 4-15 reserved
TTL handling

- Copy TTL from IP header to TTL of first MPLS header at first ingress.
- Decrement TTL for each hop.
- When popping, copy TTL of MPLS header into TTL of IP header.
- Same when pushing a stack of MPLS headers.

Packet handling at Ingres

- Determine FEC.
- Map FEC to LSP.
- Assign a label (or encode FEC in a label).
- Label binding: FEC -> Label.
Label assignments

- Always downstream assigned
  - Why?
- Downstream unsolicited or
- Downstream on demand

Downstream Unsolicited
**Downstream on demand**

- Upstream
- Need a label
- Here is label
- OK

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**Label Stack**

- Hierarchical MPLS networks
  - One MPLS network completely inside another
  - Example
Example

LSP i

Action at C?

Action at D?

LSP j
Multiple MPLS headers

- Multiple MPLS headers for an IP packet
- Fragmentation because of this:
  - Ingres node must take care of this
- Why not single MPLS header?
  - Don’t mix LSP i and LSP j
  - AS does not need to know complete routing strategy

LDP

- Label Distribution Protocol
- Similar to combination of OSPF and BGP
- LSR does a neighbor discovery
  - Send hello messages containing LDP id on all interfaces; Use UDP to send messages to far away routers
- LDP id identifies label space appropriate for this message
  - IP address of LSP + 2 bytes to identify label space within same route
- Loop detection/FEC merging
LDP Messages

- Discovery
  - Hello messages; find other LSRs
- Session
  - Establish, maintain and terminate sessions
- Advertisement
  - Create, change and delete mapping for FEC
- Notification
  - Advisory info

Misc

- Loop detection
- FEC merging/aggregation