



# MPLS/TE/ VPN Overview

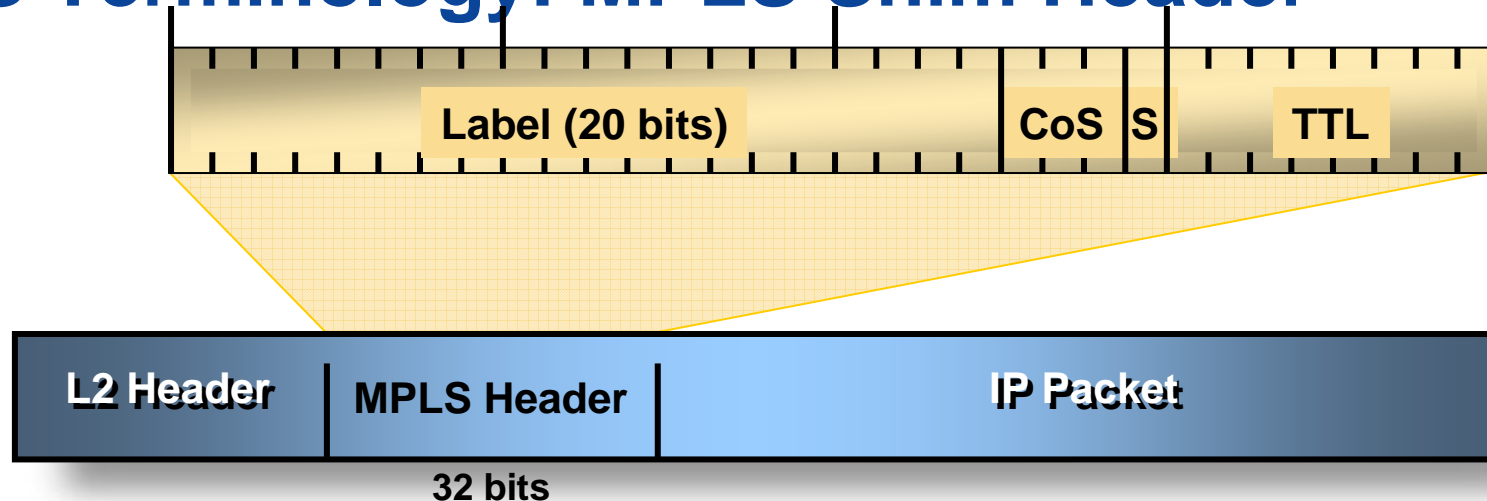
# What is MPLS?

- **Originally designed for improving layer 3 switching performance**
  - ATM-like virtual circuits on an IP network
  - With near-wire-rate router performance, this is no longer an objective
- **Now used for:**
  - Multiservice networks
  - Traffic Engineering
  - ATM/Frame Relay interworking with IP networks
- **Separate control and forwarding planes**

# MPLS Terminology

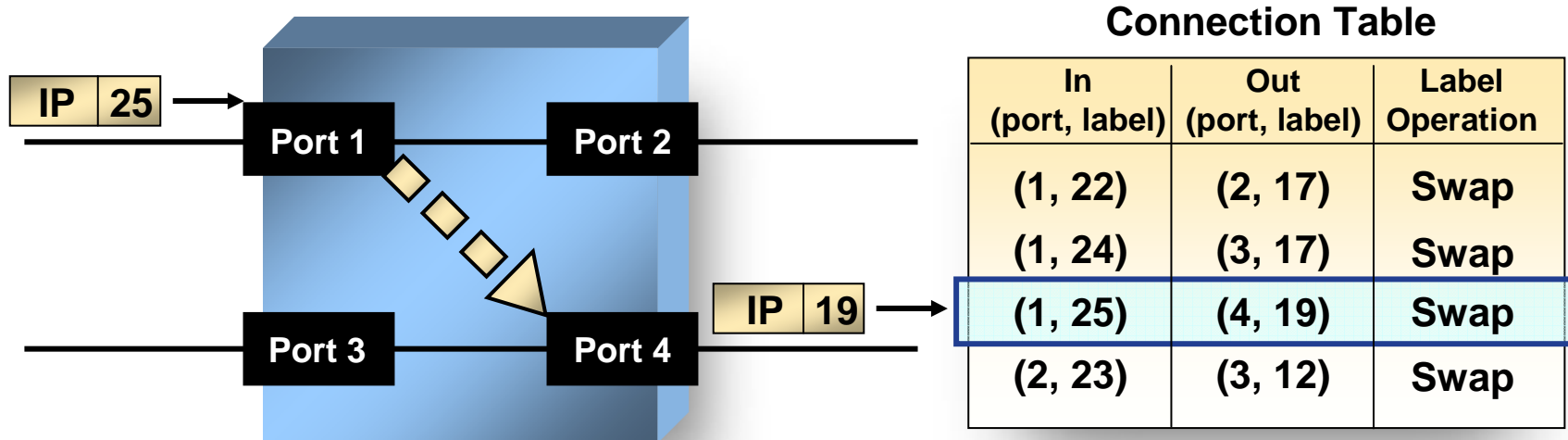
- **Forward equivalence class (FEC)**
  - Stream/flow of IP packets
  - FEC/label binding mechanism
- **Label**
  - Fixed length
  - Local significance
  - Label distribution, retention, and control
    - Downstream on demand/unsolicited downstream
    - Liberal/conservative
    - Independent/ordered
- **LSR label processing**
  - Push/swap/pop/multi-push/swap-push

# MPLS Terminology: MPLS Shim Header

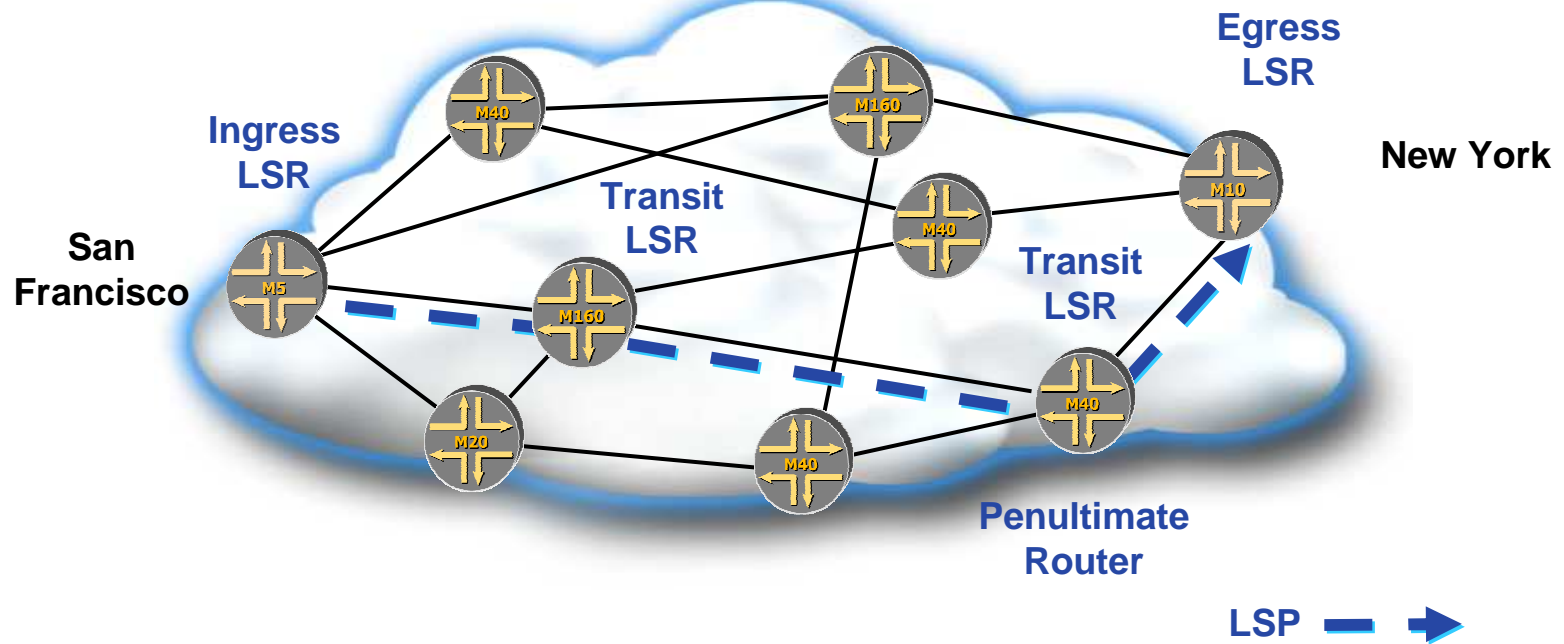


- **MPLS shim header fields:**
  - Label (L)
  - Experimental (CoS)
  - Stacking bit (S)
  - Time to live (TTL)
- **Reserved and pre-defined label values**

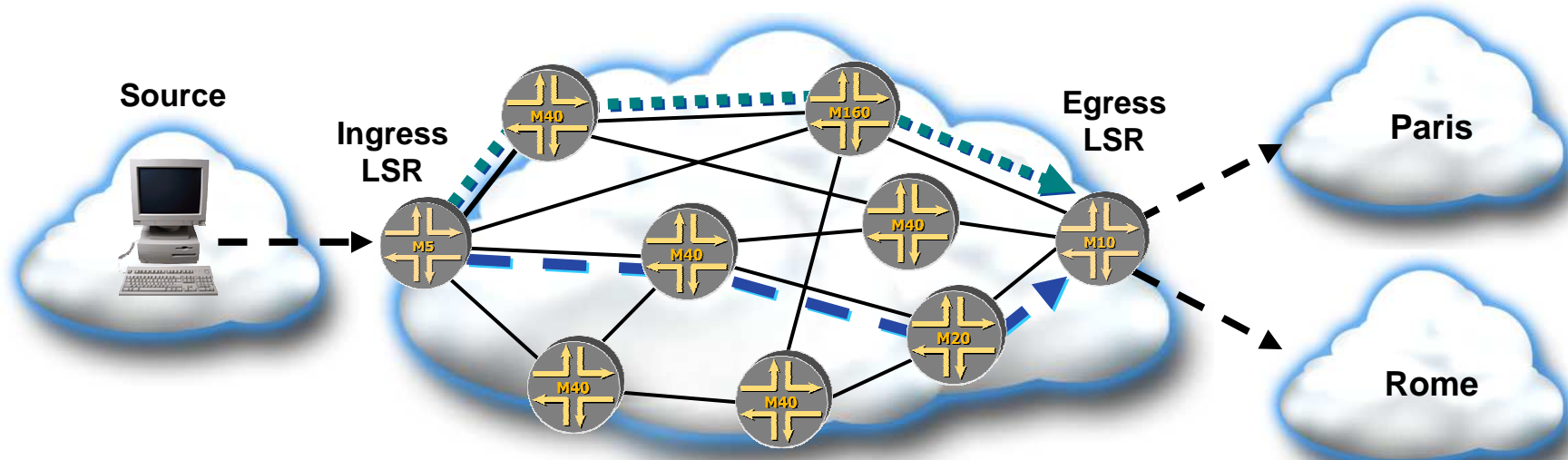
# MPLS Terminology: Label Swapping



# MPLS Terminology: Router Types

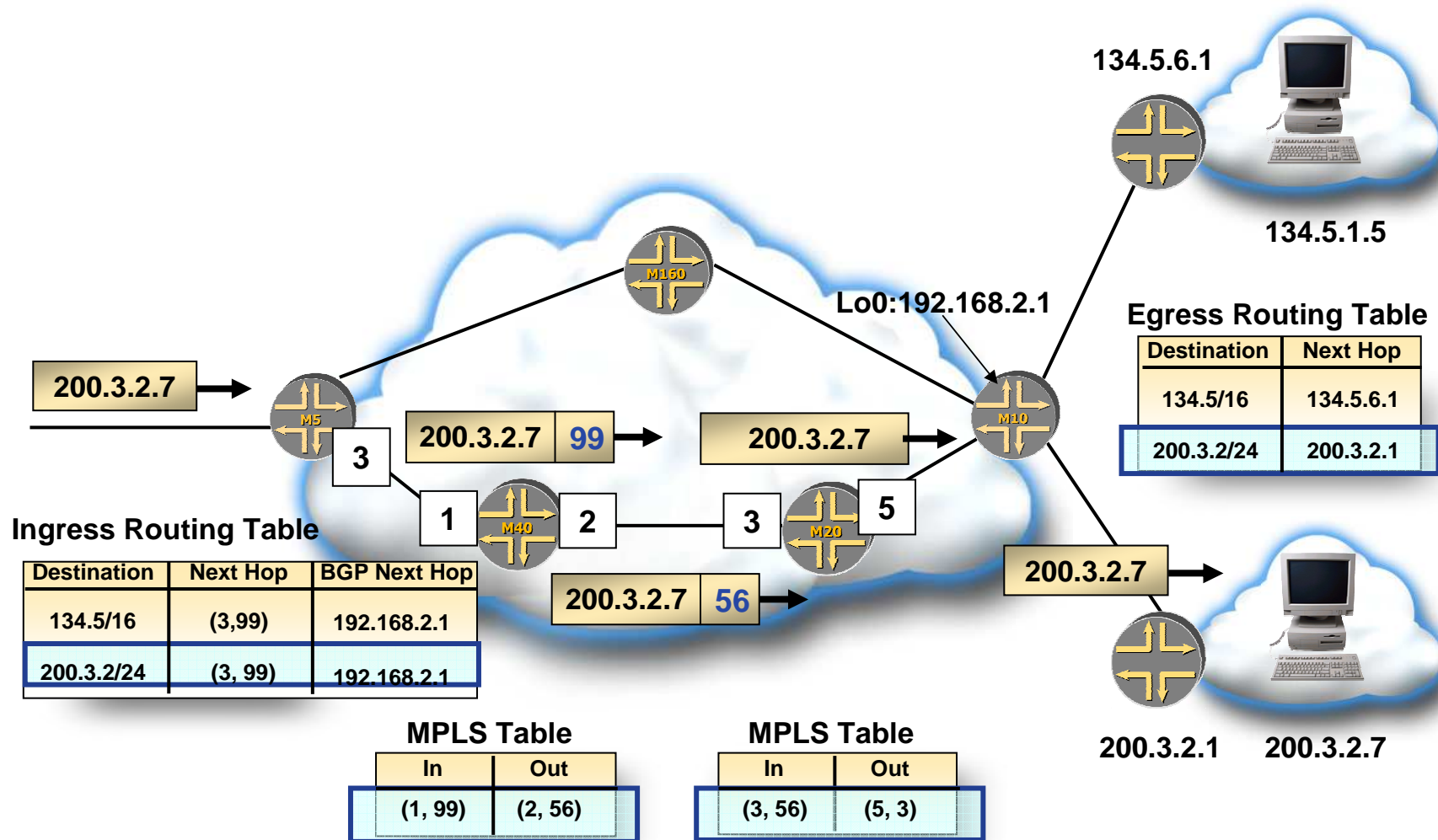


# Packet Forwarding



- **Ingress LSR determines FEC and assigns a label**
  - Forwards Paris traffic on the green LSP
  - Forwards Rome traffic on the blue LSP
- **Traffic is label-swapped at each transit LSR**
- **Egress LSR**
  - Removes MPLS header (dependent upon penultimate hop pop)
  - Forwards packet based on destination address

# Packet Forwarding Example





# MPLS Review

- **MPLS Functional Model**
- **Signaling**
  - RSVP
  - LDP

# Path Signaling

- **Dynamic path creation requires a signaling protocol to:**
  - Coordinate label distribution
  - Route the LSP explicitly
  - Reserve bandwidth (optional)
  - Provide class-of-service capability (DiffServ style)
  - Reassign resources (like bandwidth)
  - Preempt existing LSPs
  - Prevent loops

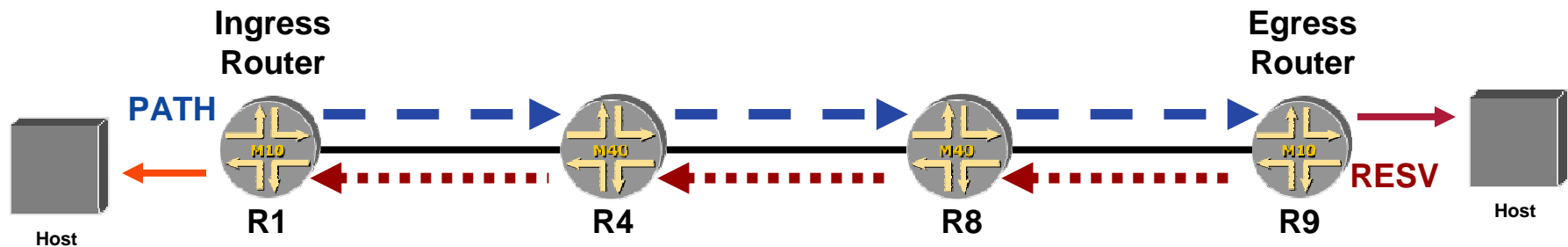
# Path Signaling Protocols

- **The IETF MPLS architecture does not assume a single protocol for assigning and distributing labels**
  - LDP
    - Executes hop by hop
    - Selects same physical path as IGP
    - Supports reduced LSP complexity
  - RSVP
    - Extends easily for explicit routes and label distribution
    - Deployed by providers in production networks
    - A well-known signaling protocol

# Resource Reservation Protocol

- **Internet standard for resource reservation**
  - Originally intended for IP QoS
- **Not a routing protocol**
  - Transports and maintains traffic and policy parameters that are opaque to RSVP
- **Simplex reservations for unicast traffic**
  - Receiver-oriented resource allocation
  - Maintains soft state for graceful changes of:
    - Multicast membership
    - Routing
  - Multiple reservation styles
  - Supports IPv4 and IPv6

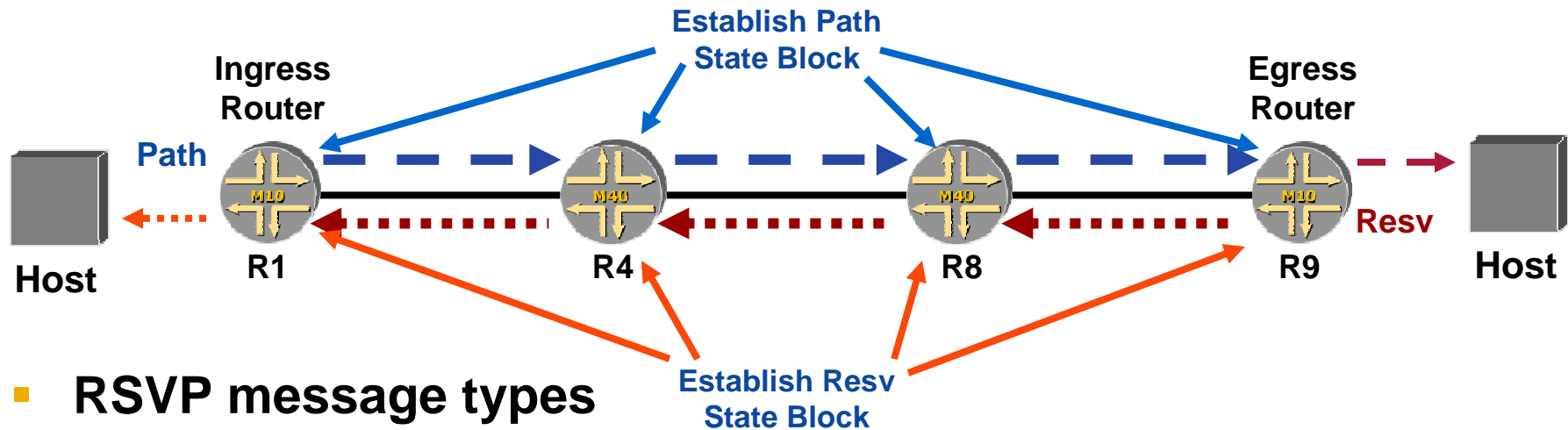
# RSVP Session



- **Can have simultaneous, multiple, independent sessions**
  - Session is data flow defined by three parameters (destination address, protocol ID, destination port)
  - RSVP sessions are between hosts, not just routers
  - Use `traceoptions` to show session creation information:

```
May  8 13:26:42 RSVP new Session 192.168.80.1(port 17) Proto 0
May  8 13:26:42 RSVP new path state, session 192.168.80.1(port 17) Proto 0
May  8 13:26:42 RSVP new resv state, session 192.168.80.1(port 17) Proto 0
```

# RSVP Messaging Protocol



## ■ RSVP message types

- Path: establishes state
- Resv: reserves resources
- PathTear: removes path state
- ResvTear: removes reservation state
- PathErr: error message sent upstream to sender
- ResvErr: establishes blockade state
- ResvConf: message confirming reservation request

## ■ Path and resv state block data structures store soft state information

# Traffic Engineering Extensions

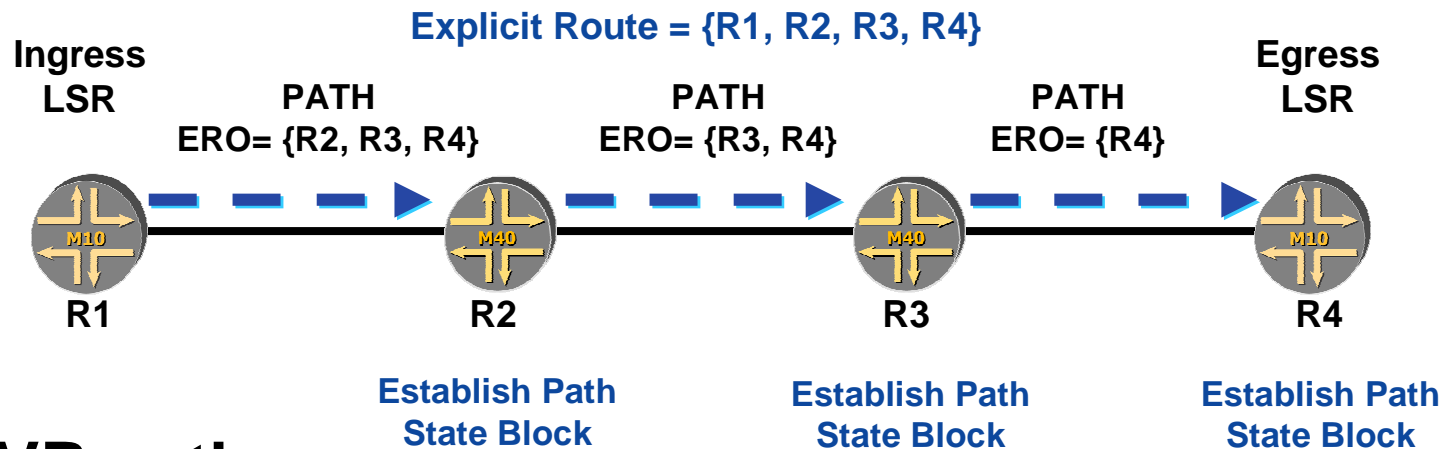
## ■ Path message extensions

- Mandatory:
  - Session object: identifies that the RSVP session will be an LSP tunnel
  - Label request object: requests LSRs to provide a label binding
- Optional:
  - Explicit route object (ERO): specifies predetermined path, independent of IGP path
  - Record route object (RRO): lists the LSRs that the LSP tunnel traverses
  - Session attribute object: aids in session identification, and also controls path setup priority, holding priority, and local-rerouting features

## ■ Resv message extensions

- Mandatory:
  - Label object: performs the upstream-on-demand label distribution process
  - Session object: uniquely identifies the LSP being established
  - Style object: specifies the reservation style (fixed-filter or shared-explicit)
- Optional:
  - Record route object: returns the LSPs path to the sender of the path message

# Path Message



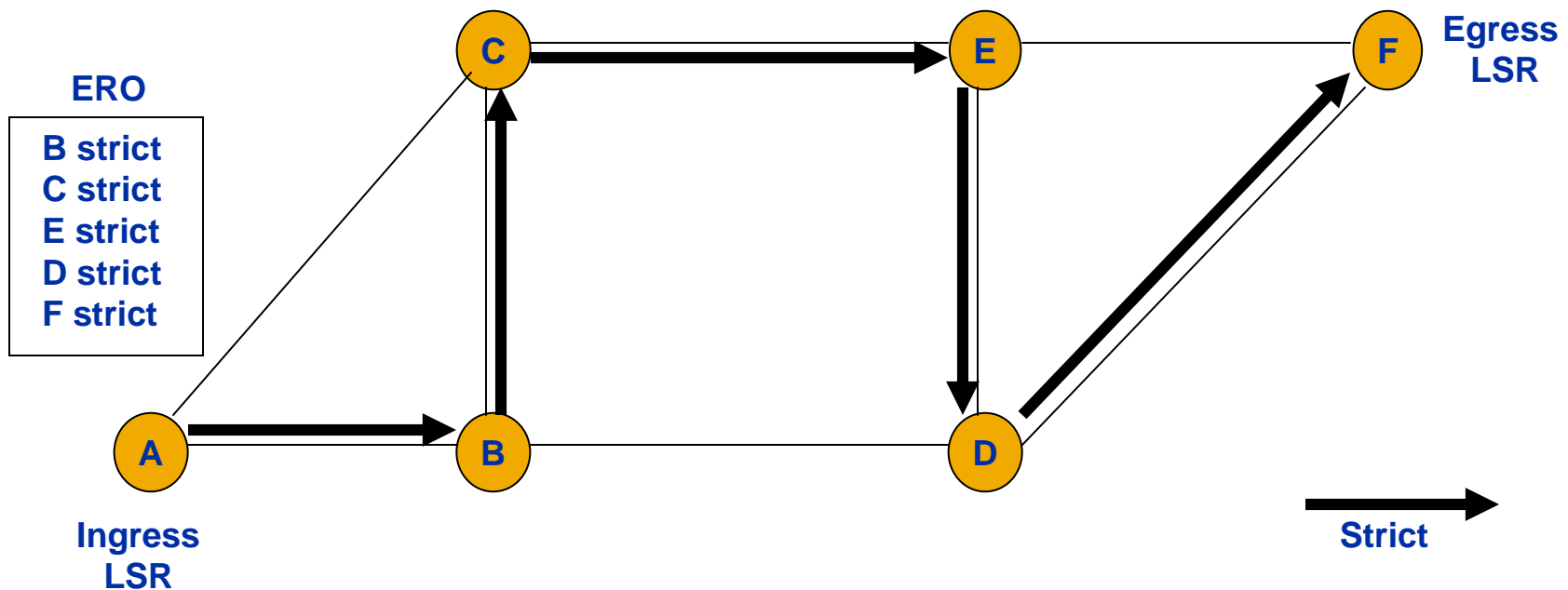
## ■ RSVP path message

- Explicit route is passed to R1
- R1 transmits a path message addressed to R4
  - Label request object requests label binding
  - ERO = {strict R2, strict R3, strict R4} (optional field)
  - Record route object lists nodes visited (optional field)
  - Session object identifies LSP name
  - Session attributes controls priority, preemption, fast reroute (optional field)
  - Sender Tspec requests bandwidth reservation
- Each router acts on RSVP packet because of router alert option



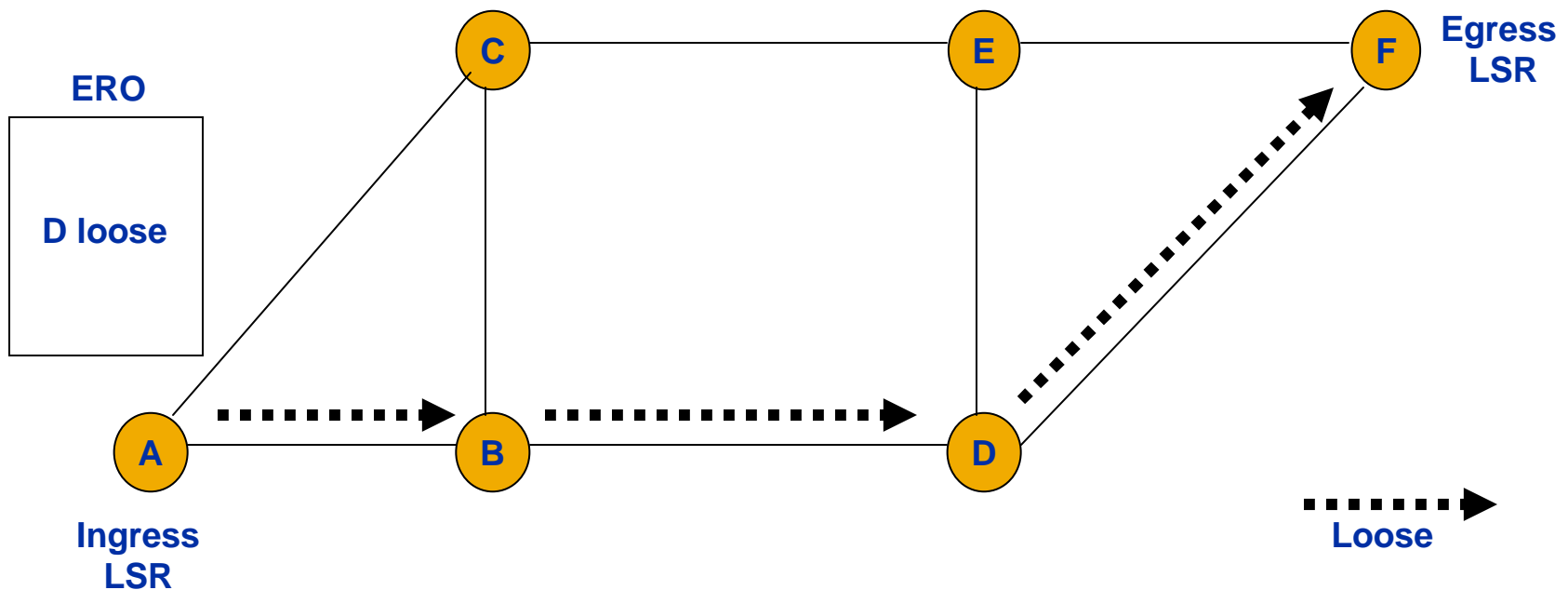
## Named Path ERO: Strict Route

Next hop must be directly connected to previous hop



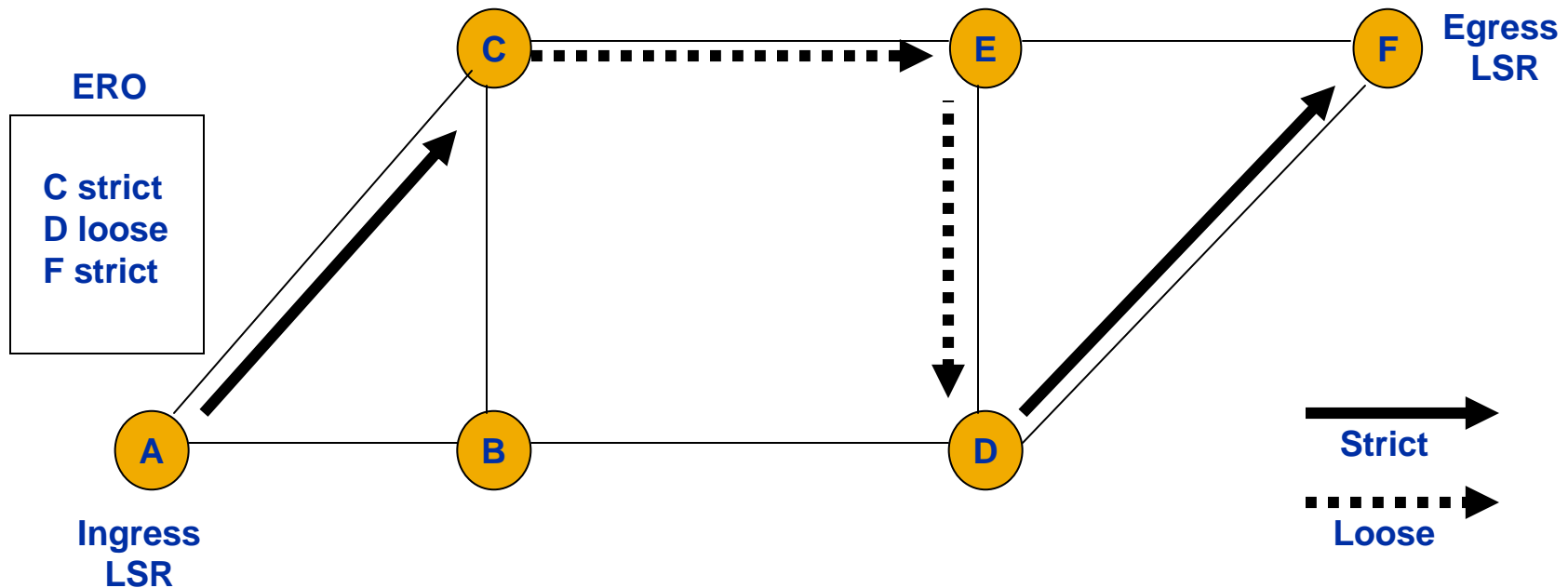
## Named Path ERO: Loose Route

Consult the routing table at each hop to determine the best path



# Named Path ERO: Strict/Loose Path

Strict and loose routes can be mixed



# Named Path Code

```
mpls {  
    traffic-engineering bgp-igp;  
    label-switched-path Blue1 {  
        to 192.168.24.1;  
        primary one;  
    }  
    label-switched-path Blue2 {  
        to 192.168.12.1;  
        primary one;  
    }  
    path one {  
        192.168.20.1 loose;  
    }  
isis {  
    traffic-engineering shortcuts;  
    interface all {  
        level 1 disable;  
    }  
}
```

Use loopback address  
instead of interface address,  
so loose section of path  
can reroute if necessary

## Purpose of LDP (1 of 2)

- **Creates forwarding equivalence class**
  - A group of IP packets which are forwarded in the same manner (RFC 3031)
- **Manages LSP to egress router**
  - New concept
    - LDP associates the FEC with each LSP it creates
  - Solves problems
    - Enables VPNs
    - Allows traffic class mapping



ERROR: ioerror  
OFFENDING COMMAND: image  
STACK: