

# **Computer Networks**

## **Lecture on**

## **MPLS, GMPLS**

## Plan of This Lecture

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- Why MPLS appeared?
- What is it?
- Virtual Private Networks based on MPLS
- MPLS advantages
- What is Generalized MPLS?

# Motivation & Evolution

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Applying fast switching to IP networks

1994	first attempts to control ATM switching by routing protocols	Toshiba
	FastIP - switching on the base of MAC addresses	3Com
1996	virtual connection for recognized packet stream (more than 10 p.)	Ipsilon
	Tag Switching	CISCO IBM
1997	IETF MPLS group	
2001	RFC 3031	

Principles:

1. Every packet gets a label on a network border
2. Label identifies destination point
3. Internal nodes switch packet using the label
4. Boarder router restore the original packet

In layer 2 can be: ATM, FrameRelay, HDLC, PPP, Ethernet

# MPLS Labels

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A label identifies FEC (*Forwarding Equivalence Class*)

i.e. set of destination addresses related with:

- outgoing router
- CoS !!! possibility to guarantee a bandwidth for packet flows

Label can be

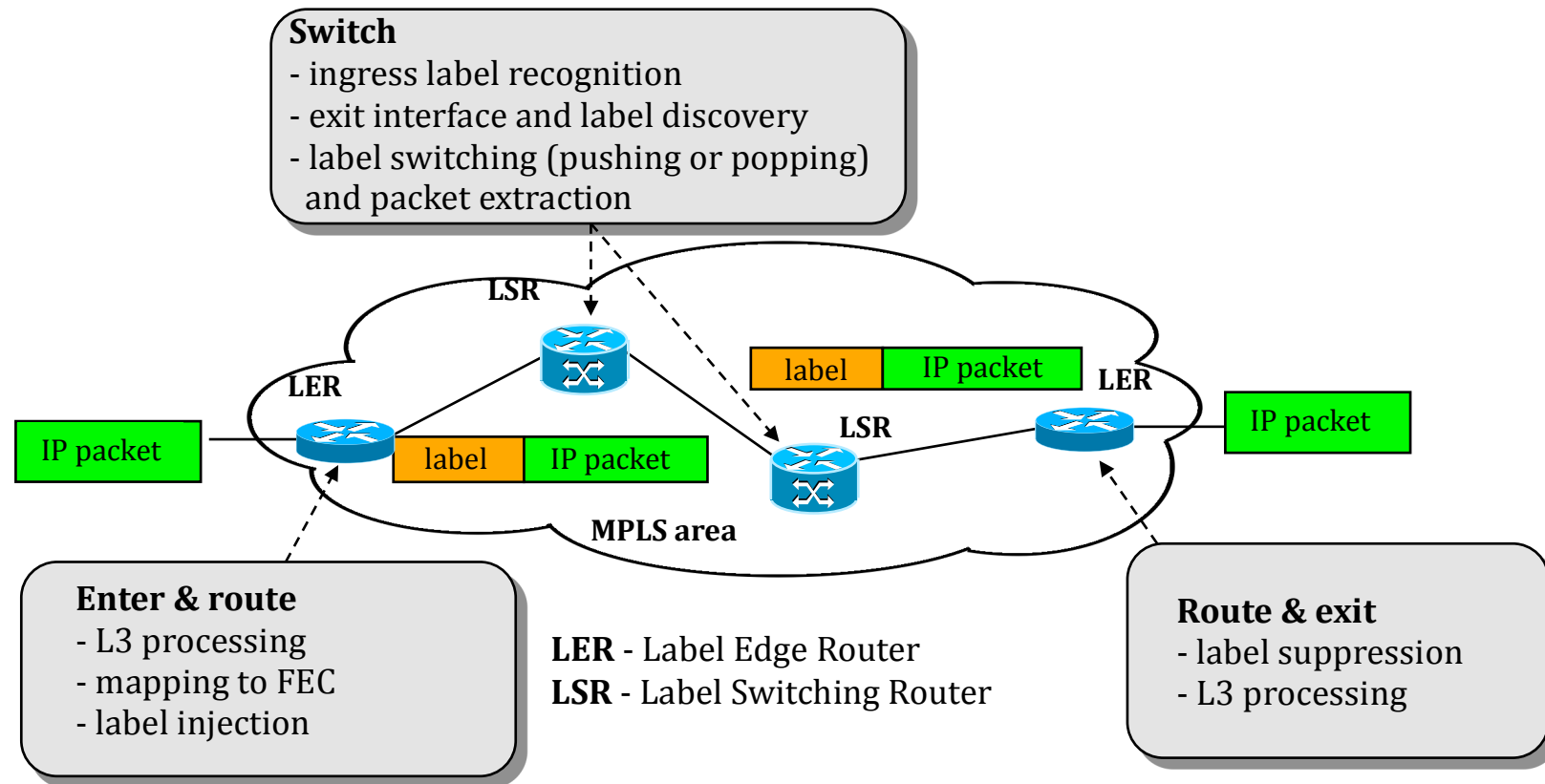
- built in a header e.g.: in ATM or Frame Relay header
- encapsulated 32 bits just after layer 2 header

Of-line label distribution

- LDP (*Label Distribution Protocol*)
- BGP, PIM, RSVP extensions

20	3	1	8
label	EXP (e.g. priority)	S (nested)	TTL

# Packet Flow in an MPLS Network



# Interconnections That MPLS Supports

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Regarding LER implementation

- ATOM – Any Transport Over MPLS e.g.
  - Layer2 pseudo wires (ATM, Ethernet, SDH)
  - Any 3<sup>rd</sup> layer protocol

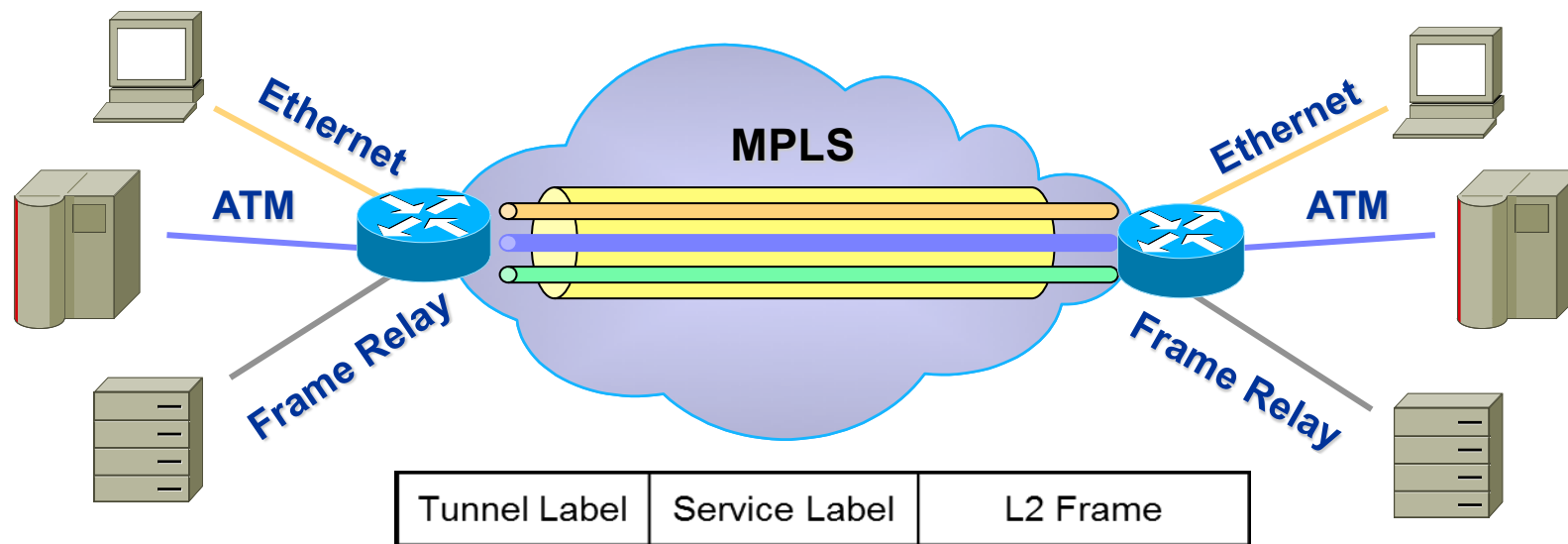
- VPLS – Virtual Private LAN Service

Appears as a private Ethernet switch to the attached MPLS end sites

- IP L3 VPN
  - Inside AS, or an ISP core
  - Inter-AS

## MPLS Layer 2 VPNs

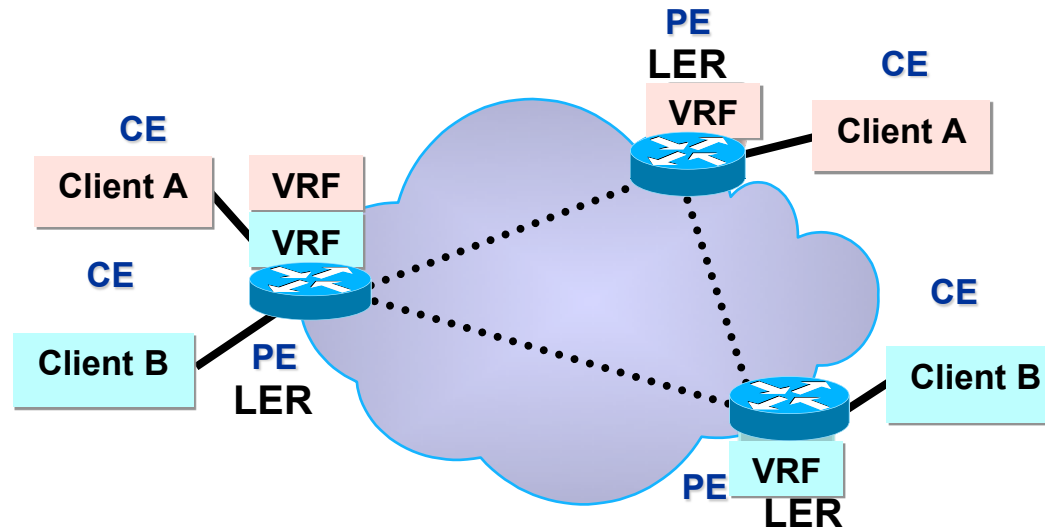
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- P2P pseudo-wire service
- Any layer 3 protocol can be used
- Provider responsibility is to guard layer 2 connection parameters

# MPLS Layer 3 VPNs

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PE has many routing tables

- LDP or RSVP builds PE-PE paths
- BGP extensions allows for
  - VPN discovery
  - client MPLS labels distribution
  - routing inside VPNs
- Topology = full mesh of PEs

*CE - Customer Edge*

*PE - Provider Edge*

*VRF - Virtual Routing and Forwarding*



# MPLS Advantages

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- Well suited to service VPNs
- Class of Services
- Efficient traffic engineering mechanisms allow for
  - redundant paths between nodes
  - very fast path switching
  - inter-provider protection, load balancing
- Support in core multicast
- Possible optimizations, e.g.
  - penultimate hop popping – to lower LER processing load

## Disadvantage

- Very laborious in configurations

# GMPLS – *Generalized MPLS Network*

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Called also: Automatic Switched Transport Network

GMPLS for: packet | frame | TDM | optical switches

- Uses out of band signalling
- Allows for lambda or light switching
- Path can be set only for endpoints of the same kind
- Paths can be nested passing through the same or different kind of switches

A generalized label can represent a single:

- wavelength
- fibre
- time-slot
- traditional MPLS label

# GMPLS Protocols

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- Routing protocols: OSPF-TE or ISIS-TE
  - accept and advertise links with no IP addresses
  - advertise link protection types
  - route discovery for back-up paths
- Reservation/label distribution protocol: RSVP-TE
  - generalized label exchange
  - signalling of a back-up path establishment
  - waveband switching support (set of contiguous wavelengths switched together)
- Link management protocols: LMP (Link Management Protocol)
  - negotiation of link parameters
  - ensuring health of a link: keep-alive messages
  - ensuring connectivity: ping-like messages
  - fault isolation

# Summary

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- Motivation & evolution
- MPLS labels
- Packet flow in an MPLS network
- Interconnections that MPLS supports
- MPLS layer 2 VPNs
- MPLS layer 3 VPNs
- MPLS advantages
- Generalized MPLS network
- GMPLS protocols

# Questions

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1. Explain the MPLS principles.
2. What is a Forwarding Equivalence Class?
3. What for MPLS labels are nested?
4. What are the advantages of MPLS?
5. What services offer Network Service Providers, which operate an MPLS infrastructure?
6. What is the idea of Generalized MPLS?