# MPLS:
# MultiProtocol Label Switching
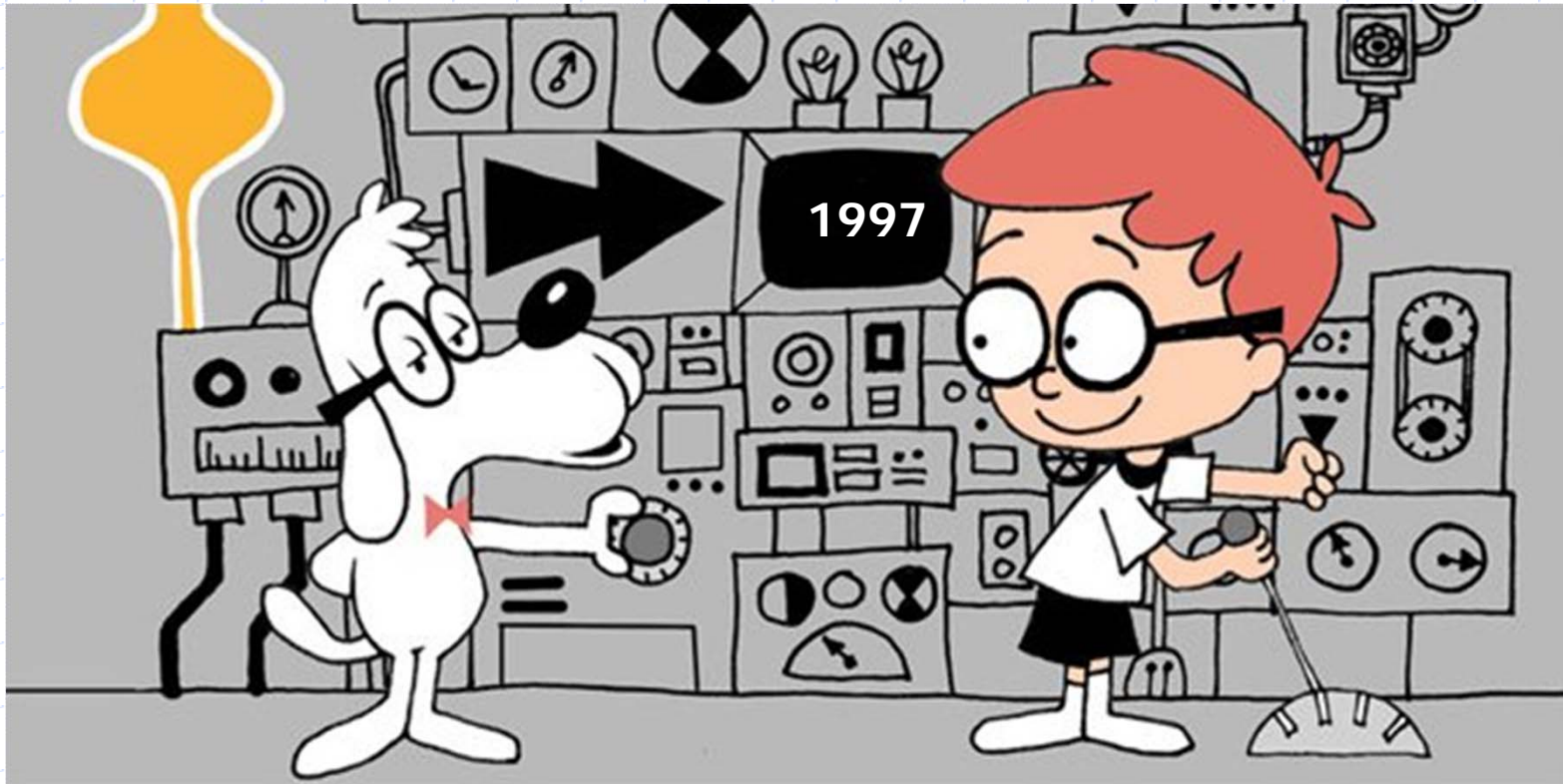
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# MPLS Topics

**Brief History
Drivers
Case Study
Manufacturers**

**Services:
Cpipe
Epipe
VPLS
VPRN**

**Technical Overview:
Terminology
Basic Operations
Quality of Service**
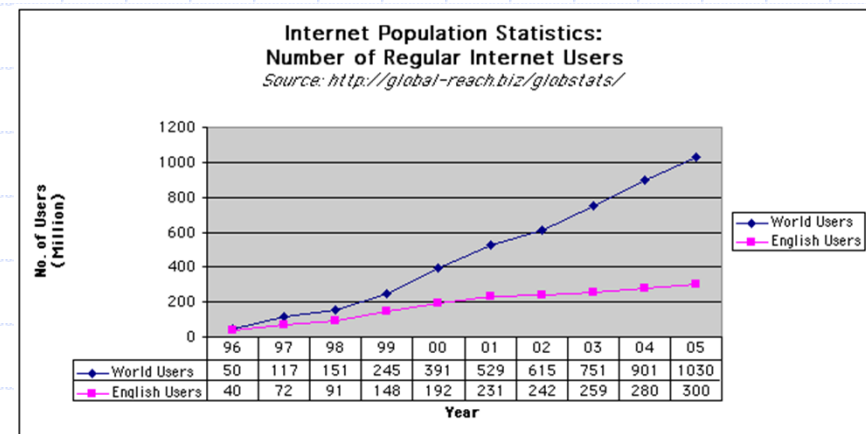
**Is MPLS Right
for You?**

\*

# MPLS - History

1997 – Formation of the IETF MPLS working group
1999 – First MPLS Deployments (L3VPN)

# Drivers of MPLS Development

- **1997: Routers can't cope with 10 Gbit/sec**

- **High Growth in Packet services**
  - Internet
  - Cellular Access
  - Private Networks

**Internet Population Statistics:**
**Number of Regular Internet Users**
*Source: http://global-reach.biz/globstats/*

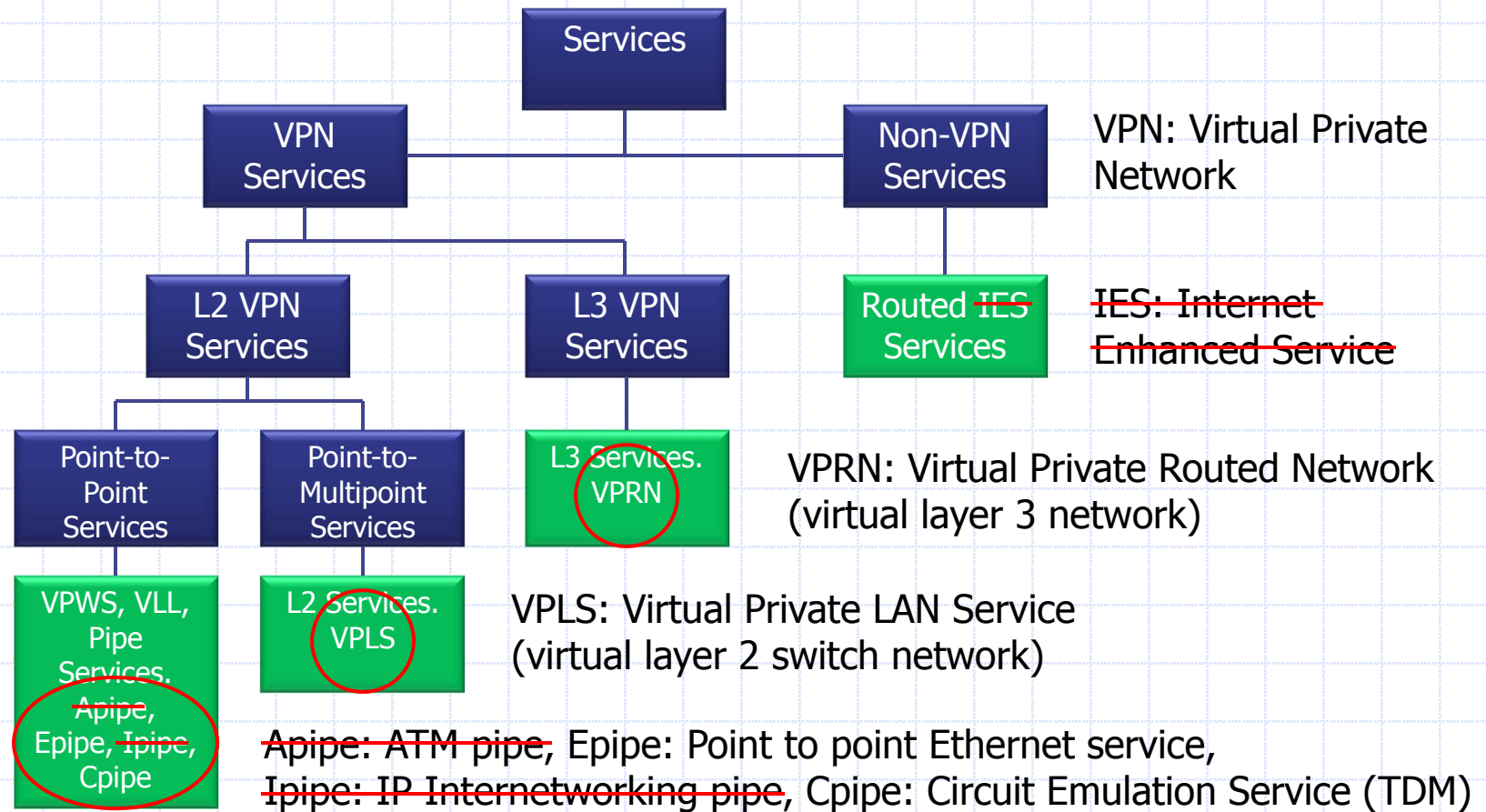| Year | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 |
|---|---|---|---|---|---|---|---|---|---|---|
| World Users | 50 | 117 | 151 | 245 | 391 | 529 | 615 | 751 | 901 | 1030 |
| English Users | 40 | 72 | 91 | 148 | 192 | 231 | 242 | 259 | 280 | 300 |

- **Slow Growth in Circuit-based Services**
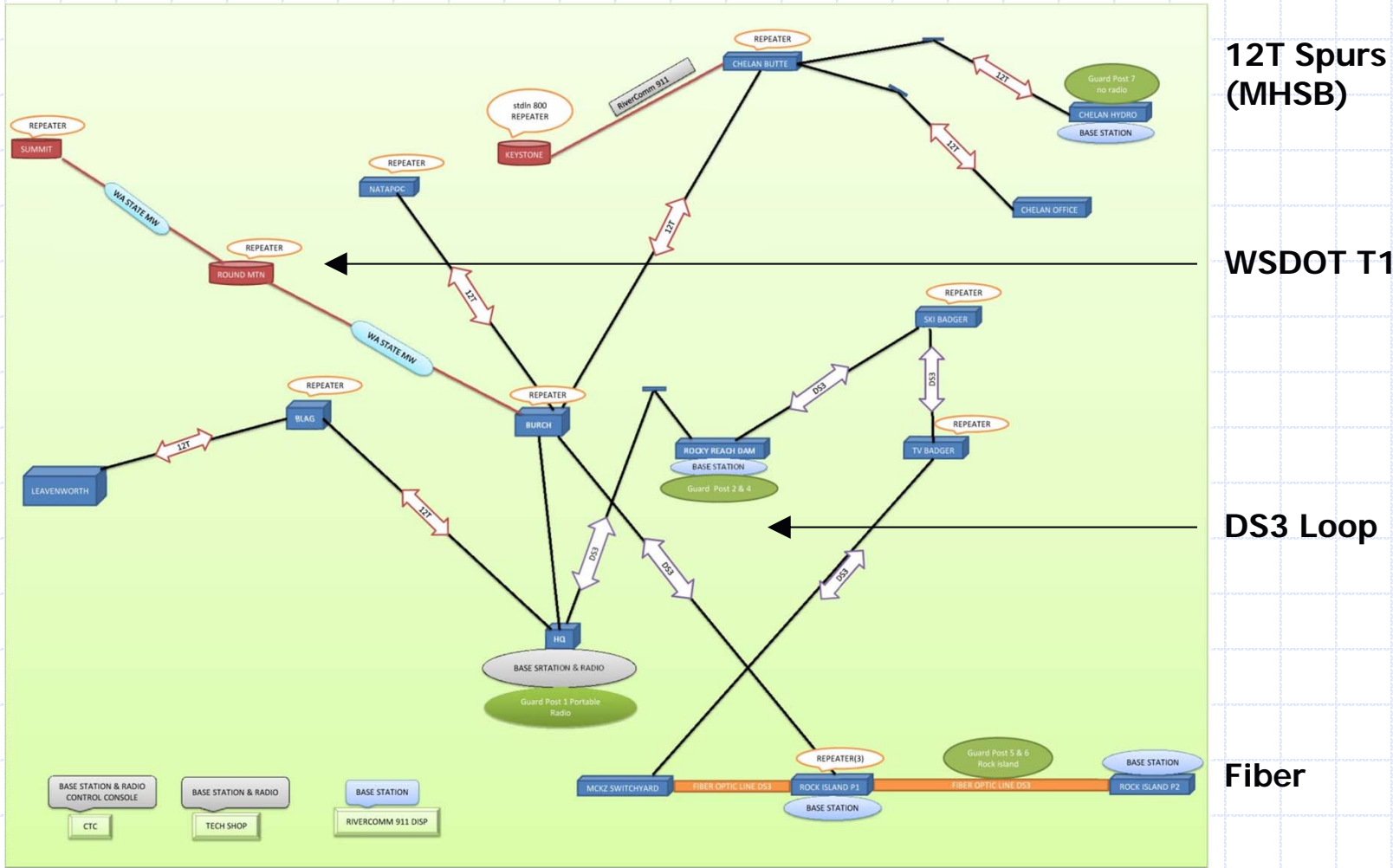  - Peaked in 2000 in the developed world

# Service Provider Demands

- ## Greater Efficiency in Packet Services

- ## Convergent Solution
  - ### Too many technologies already:
    ### Frame Relay, ATM, SONET, DSL

- ## Operational Considerations:
  - ### Billing
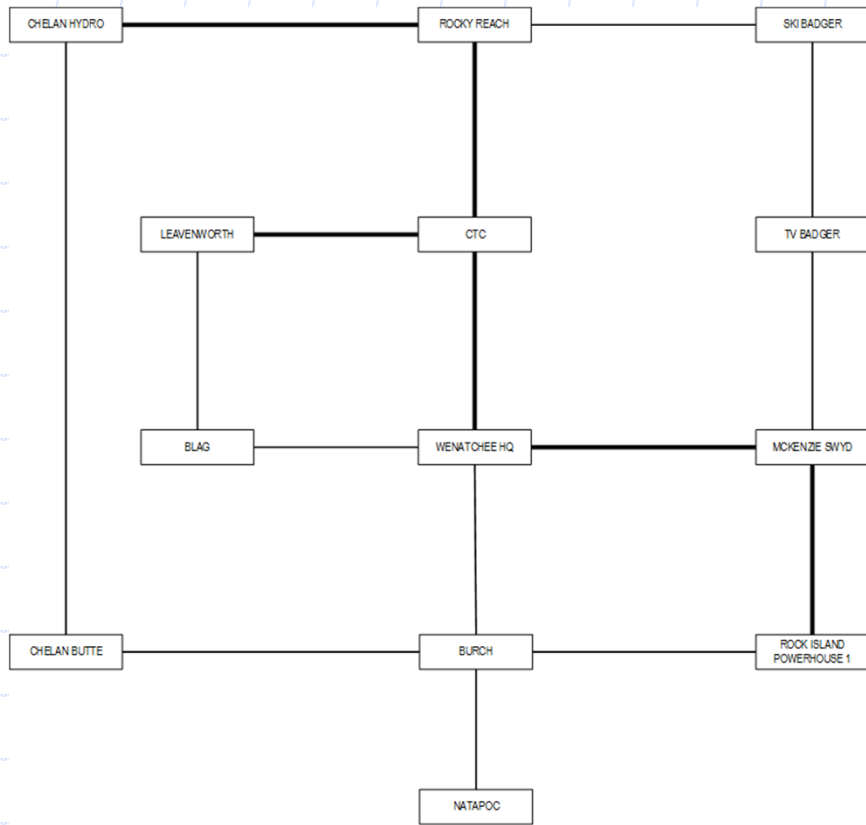  - ### Traffic Management
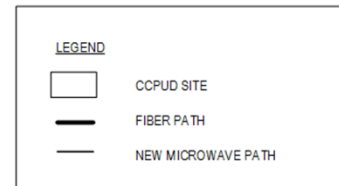  - ### Out of Band Network Management

# MPLS Services

```
                        ┌──────────┐
                        │ Services │
                        └─────┬────┘
          ┌───────────────────┴─────────────────┐
    ┌──────────┐                          ┌───────────┐
    │   VPN    │                          │ Non-VPN   │
    │ Services │                          │ Services  │
    └─────┬────┘                          └─────┬─────┘
   ┌──────┴───────┐                             │
┌─────────┐  ┌─────────┐                   ┌──────────┐
│ L2 VPN  │  │ L3 VPN  │                   │ Routed IES│
│ Services│  │ Services│                   │ Services │
└────┬────┘  └────┬────┘                   └──────────┘
 ┌───┴────┐       │
```

Services (top)

VPN Services — Non-VPN Services

L2 VPN Services — L3 VPN Services — Routed ~~IES~~ Services

Point-to-Point Services | Point-to-Multipoint Services | L3 Services. **VPRN** | L2 Services. **VPLS**

VPWS, VLL, Pipe Services. ~~Apipe,~~ Epipe, ~~Ipipe,~~ Cpipe

VPN: Virtual Private Network

~~IES: Internet Enhanced Service~~

VPRN: Virtual Private Routed Network (virtual layer 3 network)

VPLS: Virtual Private LAN Service (virtual layer 2 switch network)

~~Apipe: ATM pipe,~~ Epipe: Point to point Ethernet service, ~~Ipipe: IP Internetworking pipe,~~ Cpipe: Circuit Emulation Service (TDM)

# Old Backhaul Network



12T Spurs
(MHSB)

WSDOT T1

DS3 Loop

Fiber

# New Backhaul Network



MICROWAVE SYSTEM BLOCK DIAGRAM

- **Hybrid Mesh**

- **Loop Protection**

- **One Spur Site (MHSB)**

- **Bandwidth: Gigabit Fiber 277 Mbps Microwave**

# MPLS – How Does It Work?

# Building Blocks:
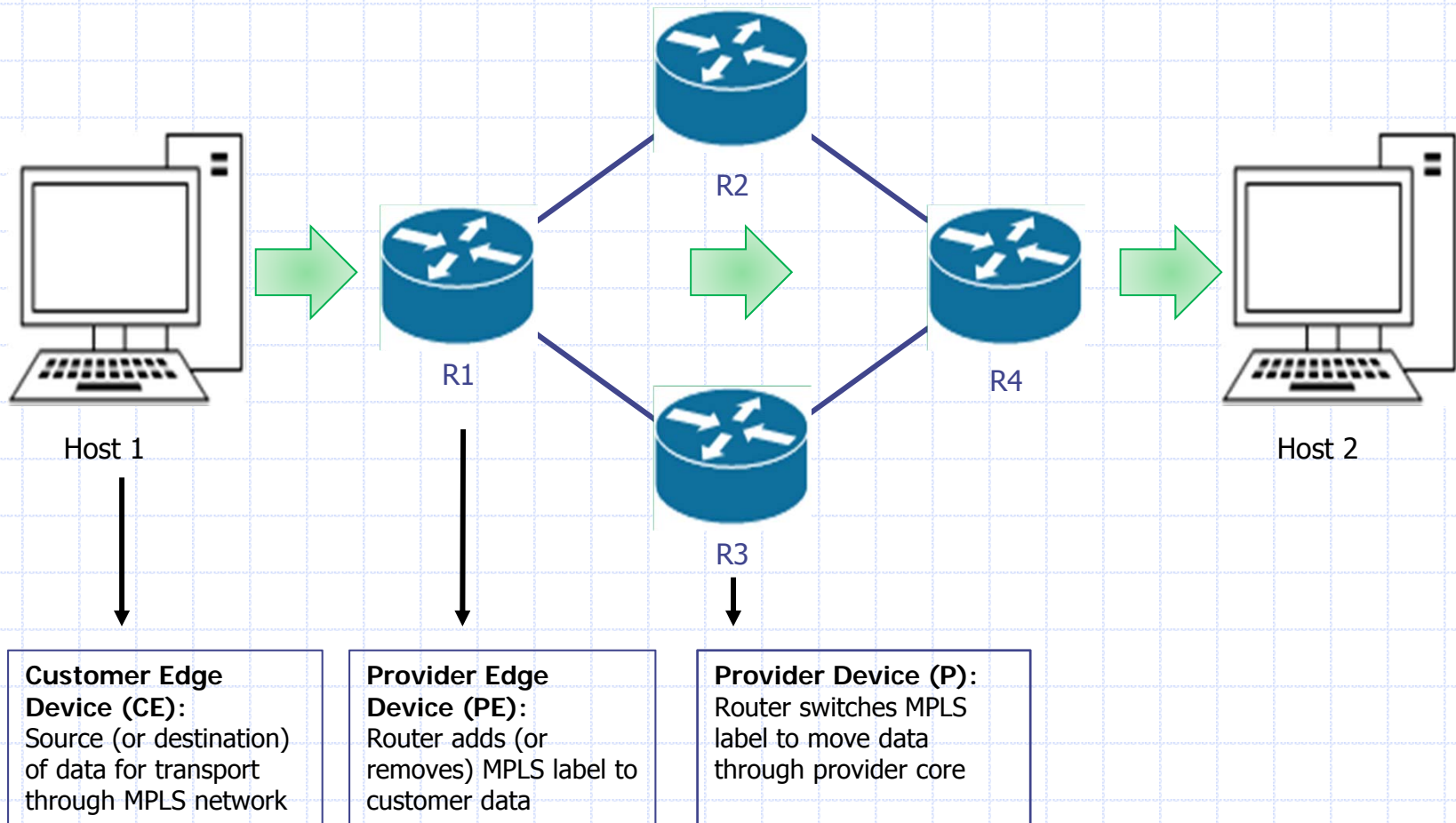# Routers and Circuits

Aviat

Cisco

Juniper

Nokia

+ MPLS Licenses

+ Circuits:
- Fiber
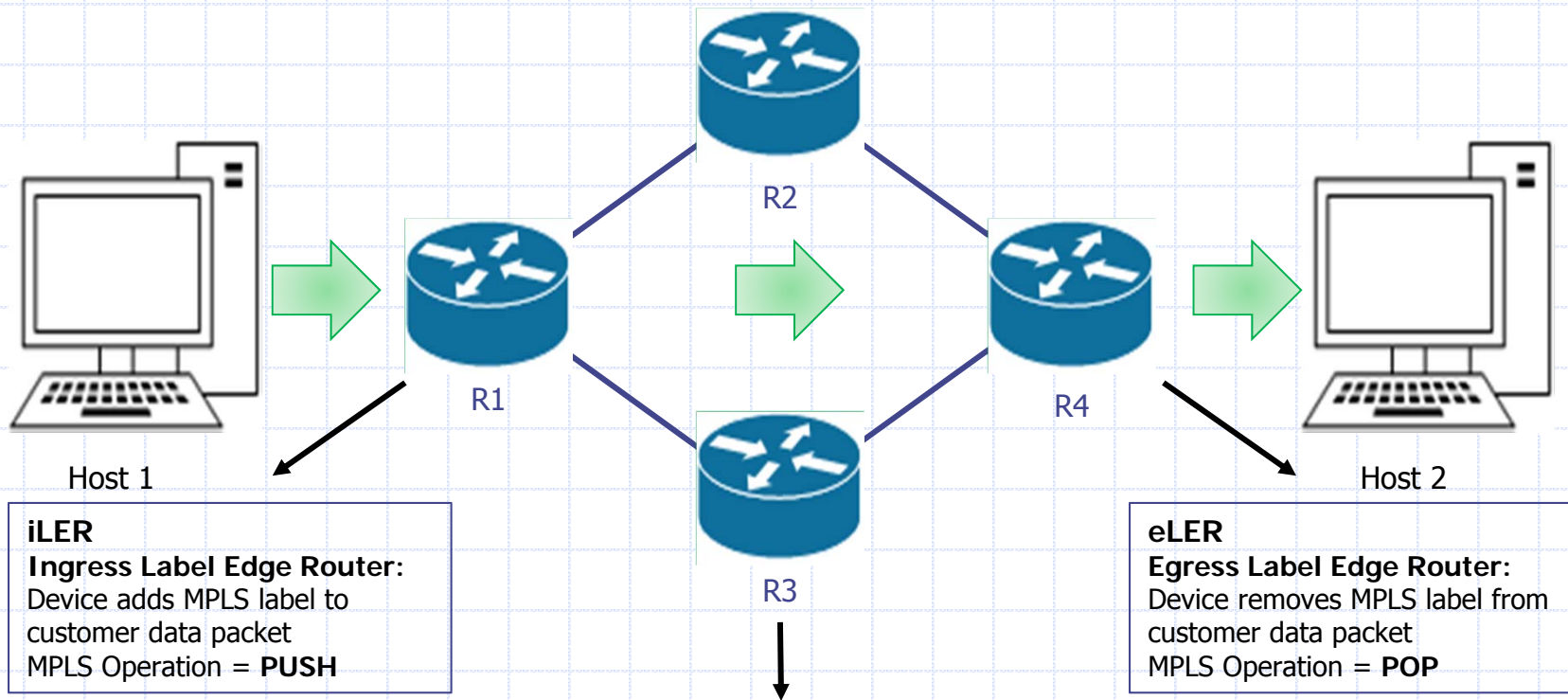- Microwave
- Copper
- Other

+ Interfaces

# MPLS Terminology



Host 1

R1

R2

R3

R4

Host 2

**Customer Edge Device (CE):**
Source (or destination) of data for transport through MPLS network

**Provider Edge Device (PE):**
Router adds (or removes) MPLS label to customer data

**Provider Device (P):**
Router switches MPLS label to move data through provider core

# More Terminology



Host 1

Host 2

R1   R2   R3   R4

**iLER**
**Ingress Label Edge Router:**
Device adds MPLS label to
customer data packet
MPLS Operation = **PUSH**

**eLER**
**Egress Label Edge Router:**
Device removes MPLS label from
customer data packet
MPLS Operation = **POP**

**LSR**
**Label Switch Router:**
Device switches MPLS label to move
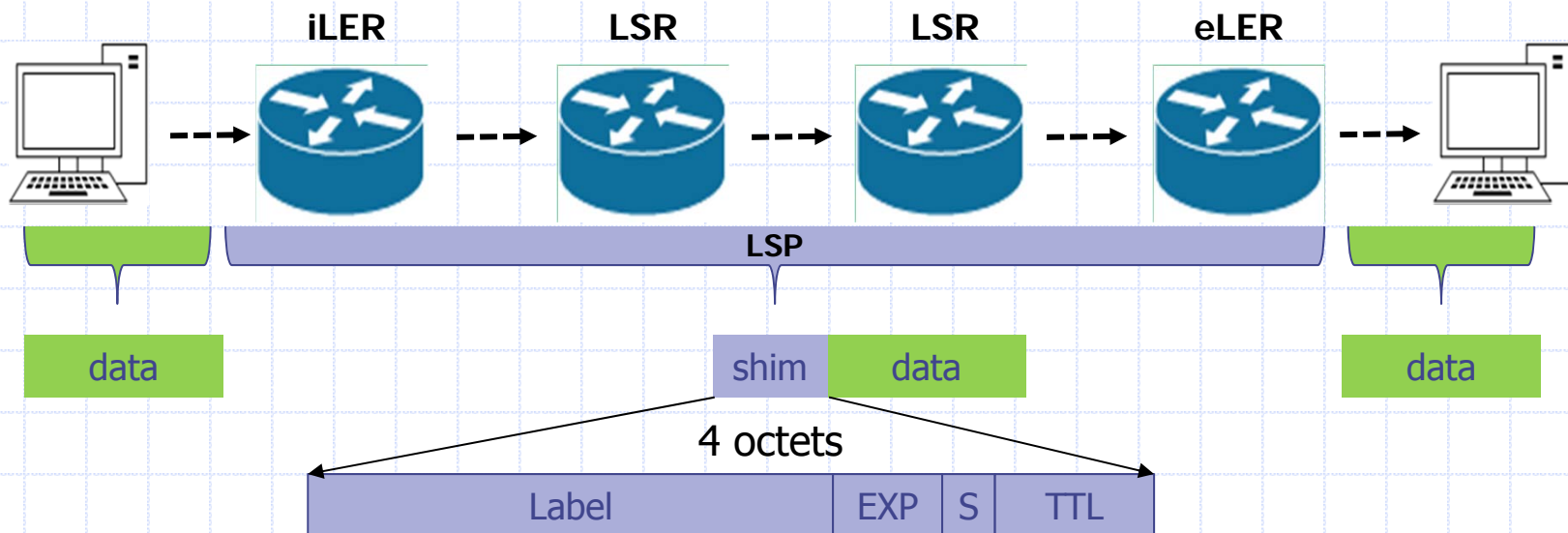customer data through core network
MPLS Operation = **SWAP**

# Basic Operation



|  | PUSH | SWAP | SWAP | POP |
|--|------|------|------|-----|
|  | iLER | LSR | LSR | eLER |

Label Switched Path

| data | label | data | label | data | label | data | label | data | data |

IP Forwarding | Label Switching | IP Forwarding

# Basic Operation

| iLER | LSR | LSR | eLER |
|------|-----|-----|------|

**LSP**

data      shim   data      data

4 octets

| Label | EXP | S | TTL |
|-------|-----|---|-----|
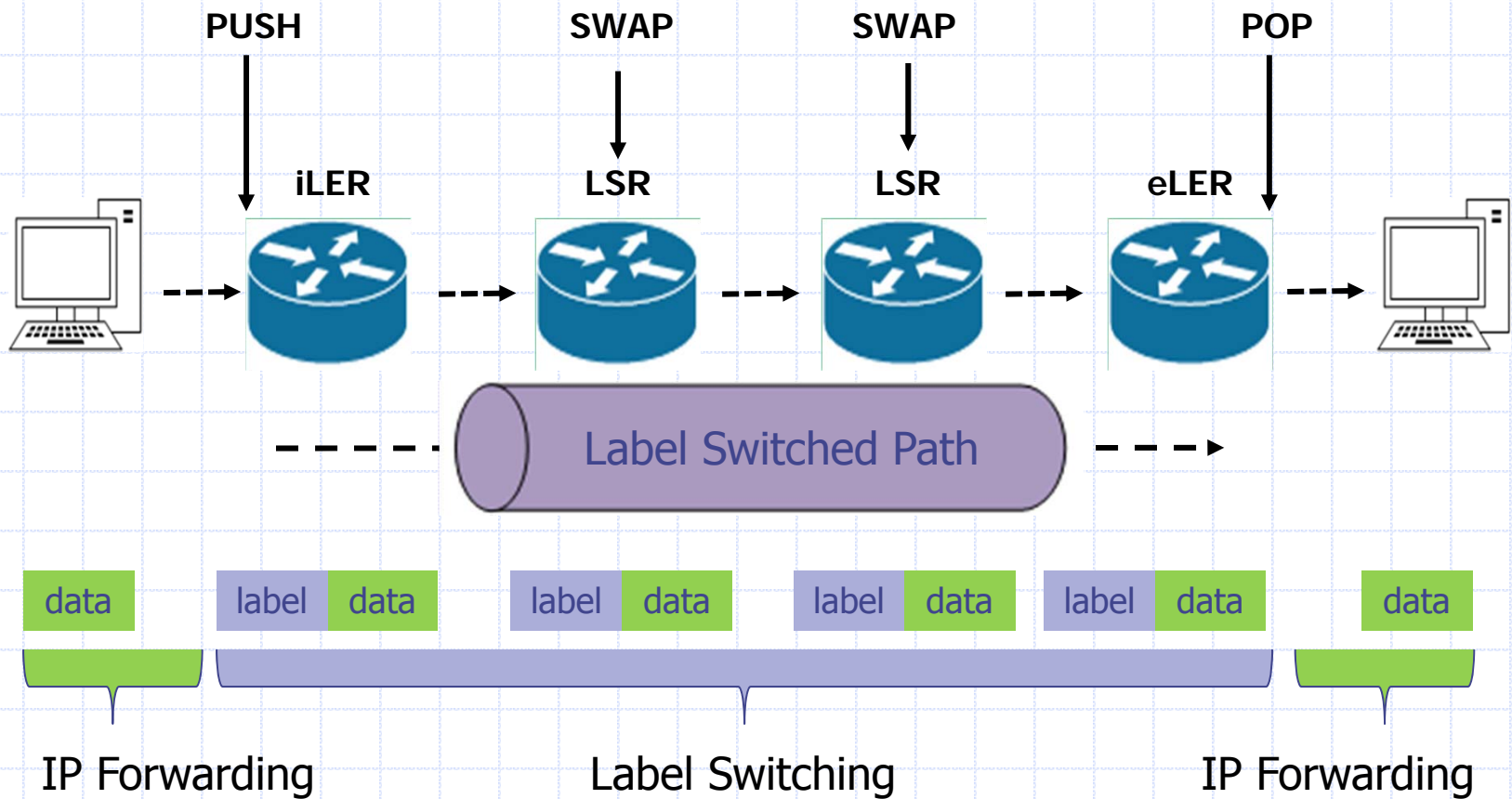
Label – 20 bits (0-15 reserved)
EXP – 3 bits (Class of Service)
S – 1 bit (Bottom of Stack)
TTL – 8 bits (Time To Live)

# Path Protection and Routing Options

**iLER**   **LSR1**   **LSR2**   **eLER**

**LSR3**   **LSR4**   **LSR5**
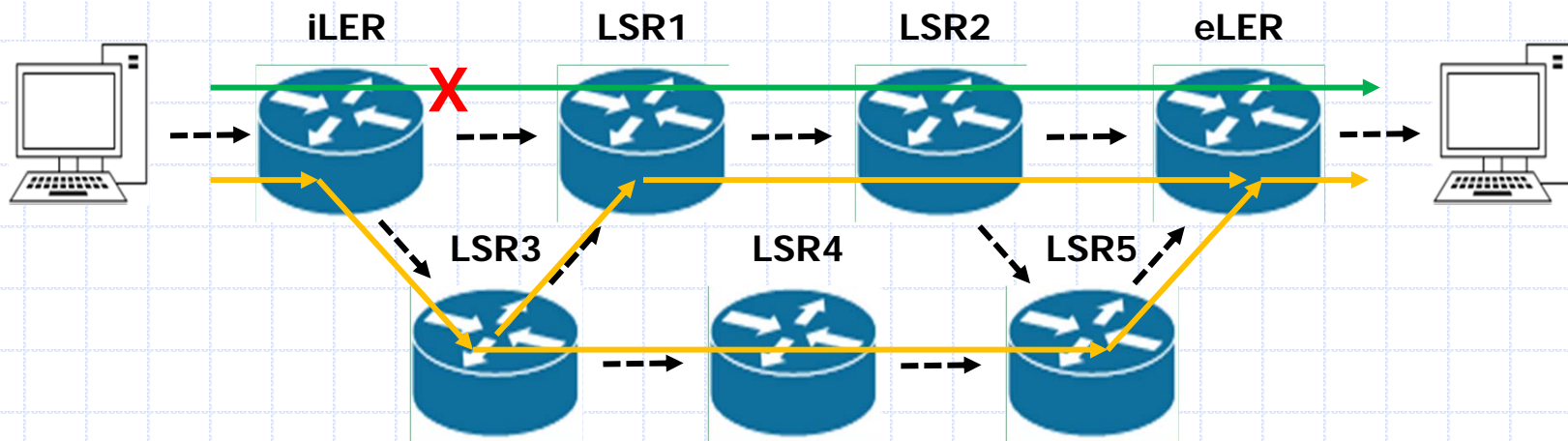
## Path Protections:

1. Primary with up to 7 Secondary
2. Primary with Hot Standby Secondary
   (signaled in advance)

Fast Re-route predetermines the backup
for each link or node
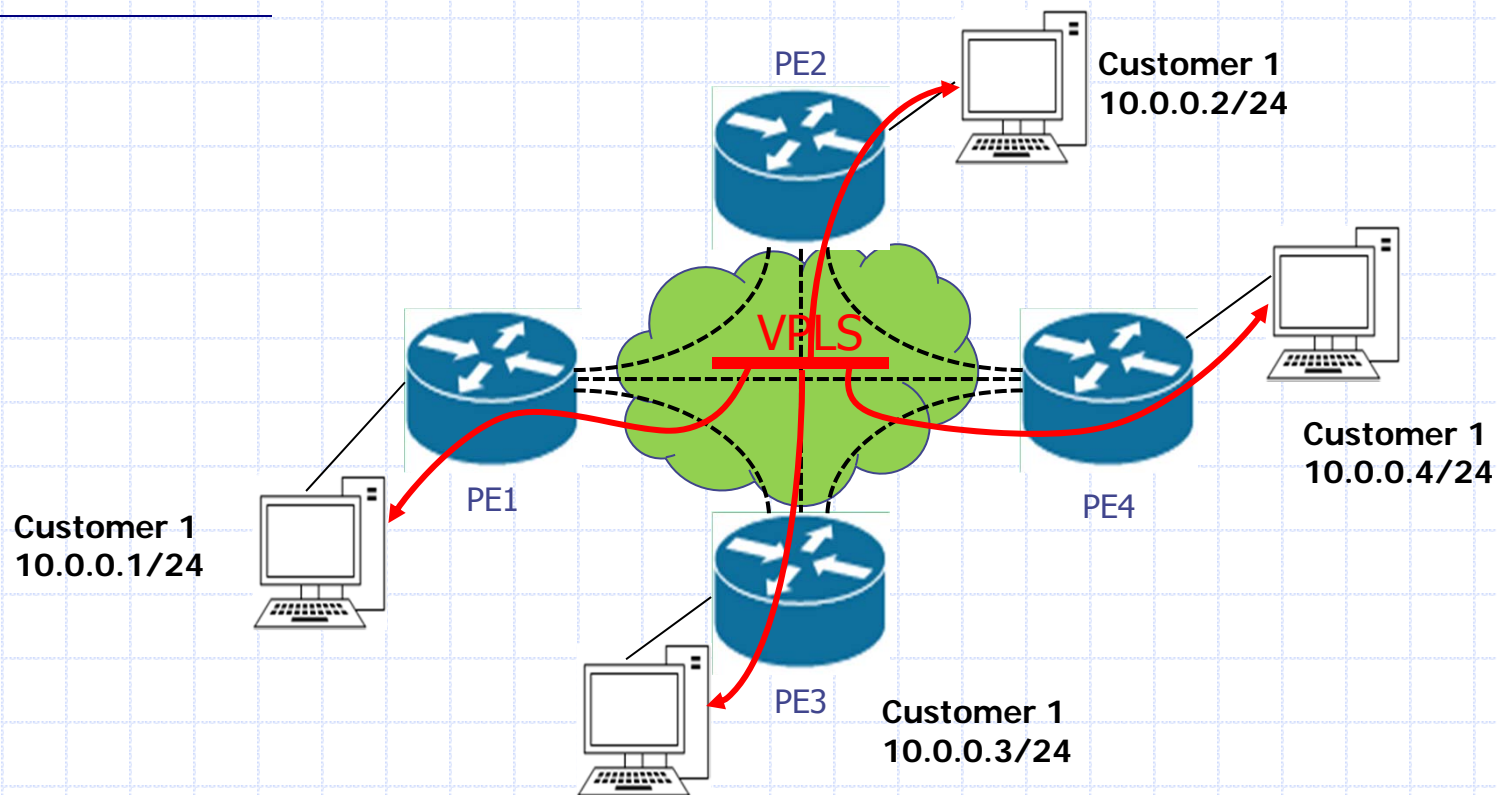
## Routing through the Network:

1. Static
2. Dynamic
   a. Best Effort (LDP)
   b. Resource Reserved (RSVP-TE)
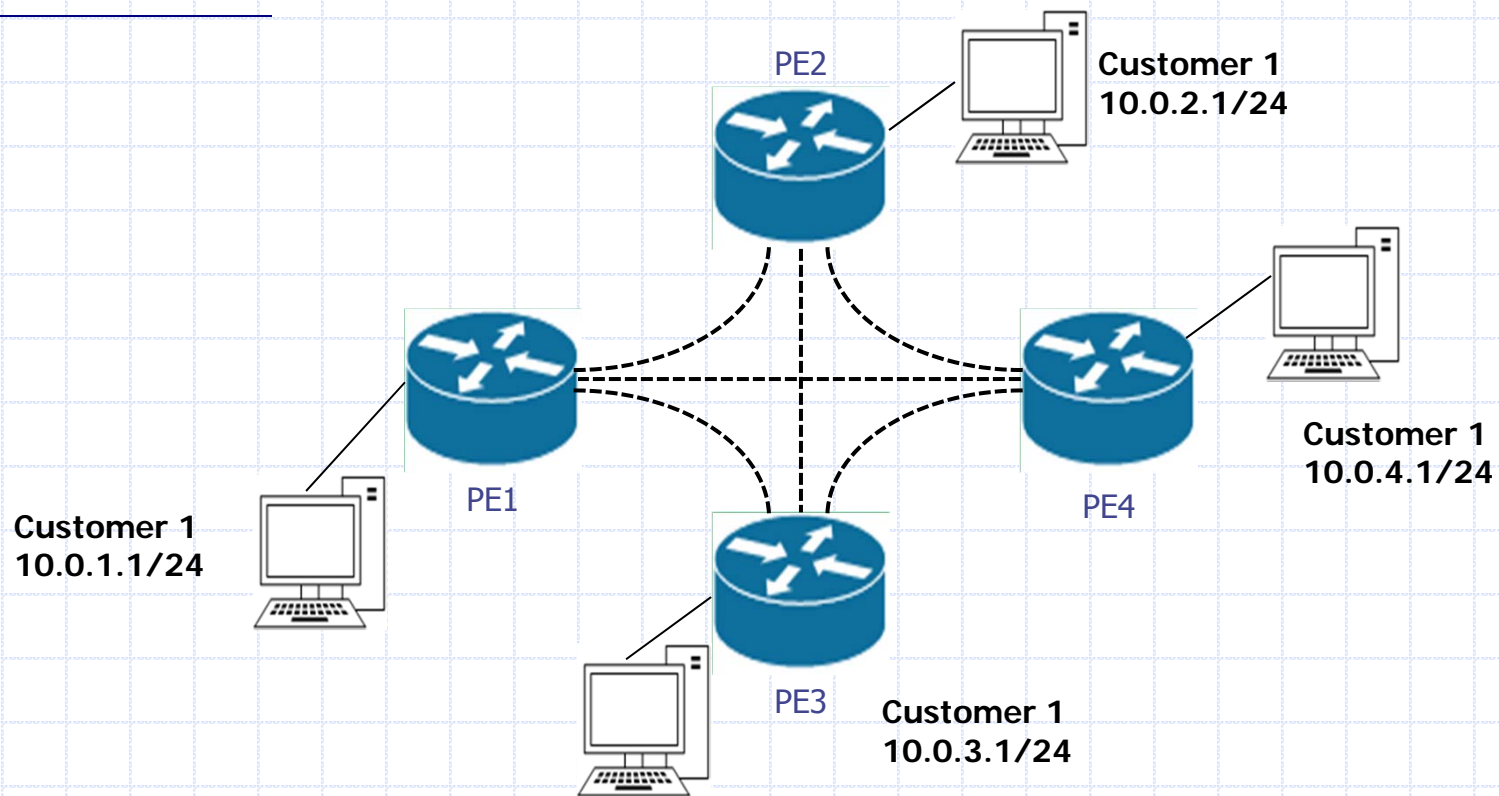      Traffic Engineered

# Services - Epipe
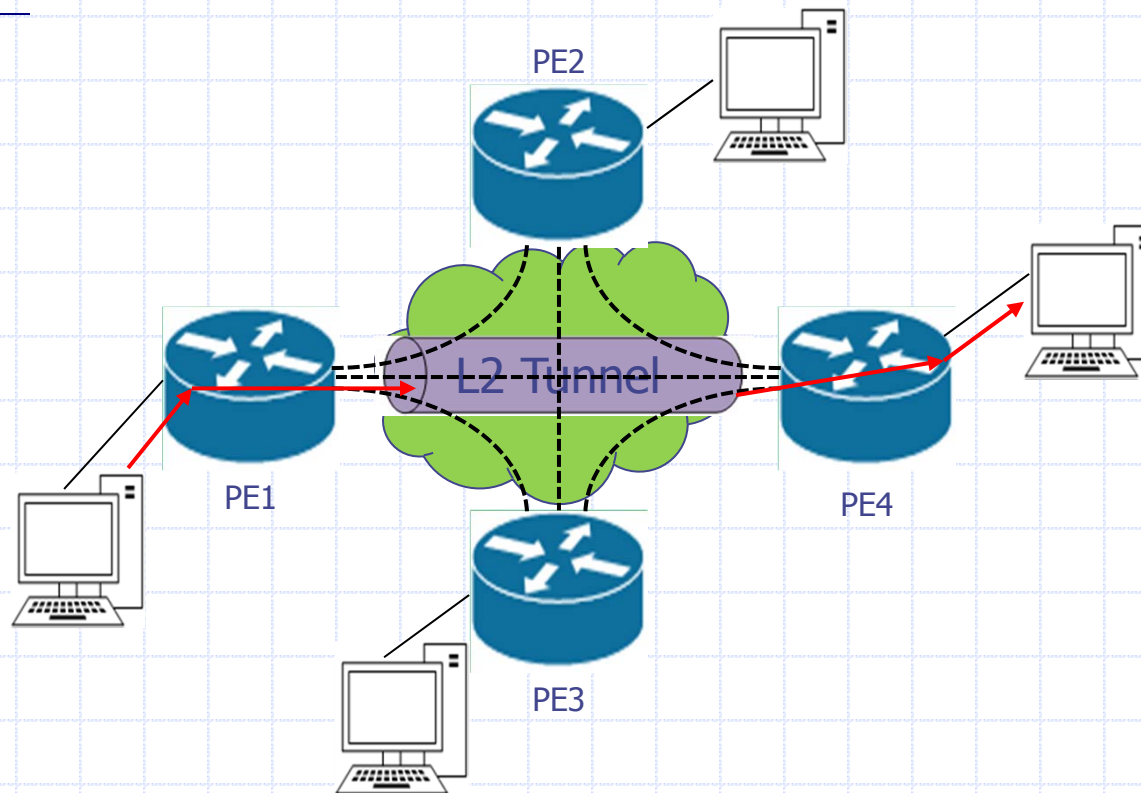


**Epipe** provides point-to-point connection with no MAC learning

# Virtual Private LAN Service



**VPLS** provides a point-to-multipoint Layer 2 Virtual Private Network.
All sites appear connected to a single switched VLAN.

# Virtual Private Routed Network



**VPRN** provides a virtual Layer 3 Routed Network.
IP routing information available between customer routers.

# Forwarding Classes - QOS

| FC | Name | Class Type | Notes |
|----|------|-----------|-------|
| NC | Network Control | Real-time | For network control traffic |
| H1 | High 1 | Real-time | For delay/jitter sensitive data |
| EF | Expedited Forwarding | Real-time | For delay/jitter sensitive data |
| H2 | High 2 | Real-time | For delay/jitter sensitive data |
| L1 | Low 1 | Non real-time - Assured | For assured traffic |
| AF | Assured Forwarding | Non real-time - Assured | For assured traffic |
| L2 | Low 2 | Non real-time - Best Effort | For best effort traffic |
| BE | Best Effort | Non real-time- Best Effort | For best effort traffic |

# Applying Quality of Service

| # | Service name | FC | Service | CIR (Mbps) | PIR (Mbps) |
|---|---|---|---|---|---|
| | | EF | VPLS | 1/10* | 1/10* |
| 1 | Trunked Radio | AF | VPLS | 1/10* | 1/10* |
| | | BE | VPLS | 0 | max |
| 2 | Teleprotection | H1 | Cpipe | max | max |
| 3 | Corporate LAN | EF | VRFN | max | max |
| | | BE | VRFN | 0 | max |
| 4 | TDM Voice | EF | Cpipe | 1 | 1 |
| 5 | SCADA Telemetry | EF | Cpipe | max | max |
| 6 | SCADA IT | H2 | Epipe | 10 | 100 |
| 7 | Low Speed Data (LSD) | H2 | Epipe | max | max |
| 8 | SCADA Fault Management (FMS) | AF | Epipe | 10 | 10 |
| 9 | NMS (Management Access) | AF | VRFN | 6 | 10 |
| 10 | Fiber Broadband | BE | VRFN | 0 | 5 |

*Note: 1/10 means that 1Mbps at Remote sites while 10Mbps at both trunking controller sites

# MPLS: Not for Everyone

## Benefits

- Robust mission critical solution

- Flexible - Provides all types of legacy services:
  - T1 (cpipe)
  - Ethernet (epipe)
  - L2 switching (VPLS)
  - L3 routing (VPRN)

- Longer design life than IT and consumer grade equipment

## Costs

- Complex design, configuration, and operation

- High lifecycle costs
  - Support contracts for software and hardware
  - Hardware refresh
  - Training

- Scarce experienced technicians and engineers

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