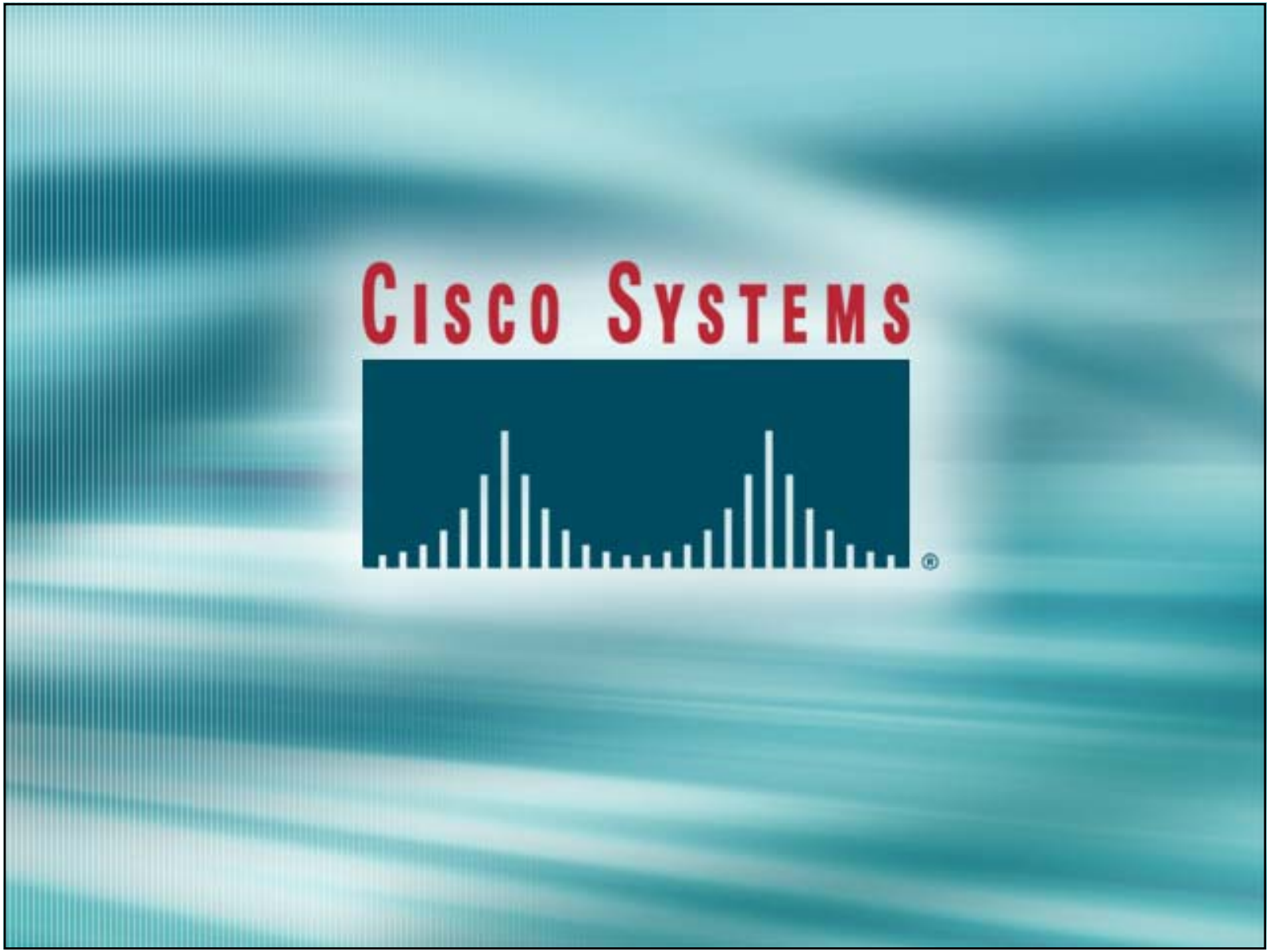
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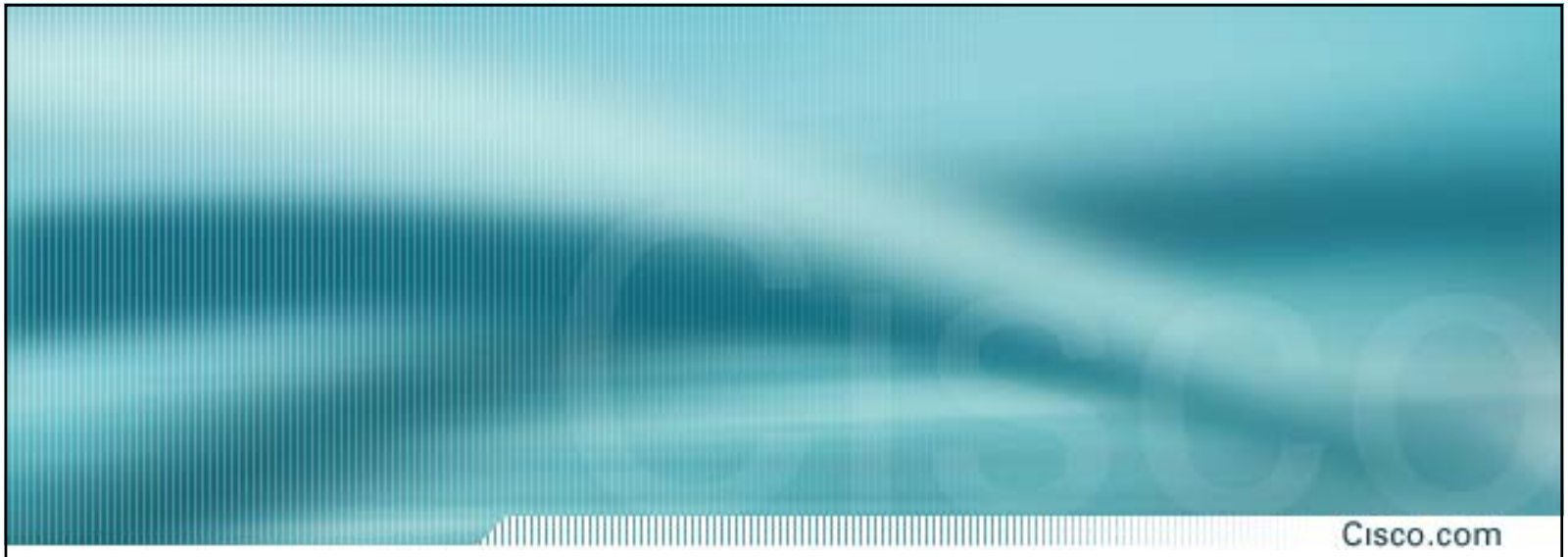


# Optimizing the Network for Voice/Video/Data

**Santiago Alvarez**
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**Internet Technologies Division**

# Agenda

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- Introduction
- Designing your Edge
- Designing your Backbone
- Summary and References

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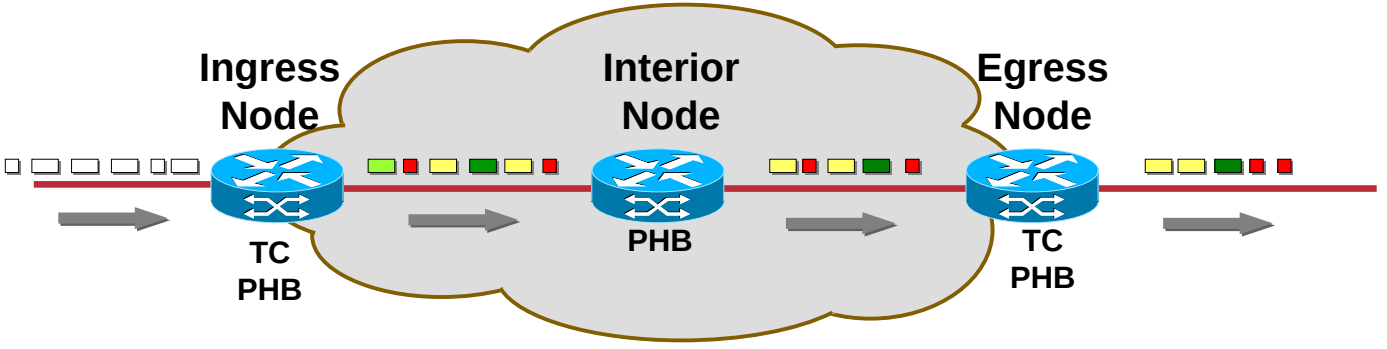
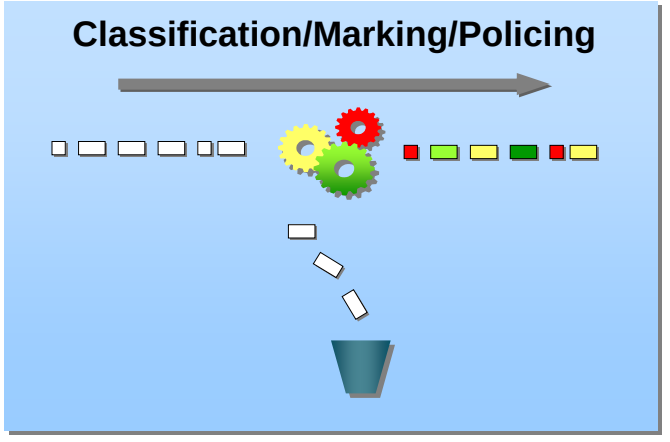
# Differentiated Services Architecture

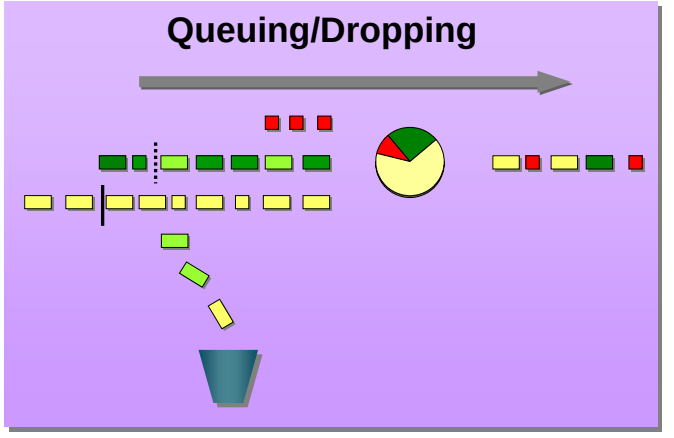





## Traffic Classification and Conditioning




## Per-Hop Behavior (PHB)

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# Per-Hop Behaviors (PHB)



- **Expedited Forwarding (EF)**
  - **Building block for low delay/ jitter/loss**
  - **Served at a certain rate with short/empy queues**
- **Assured Forwarding (AF)**
  - **High probability of delivery if profile is not exceeded**
  - **Four classes and three levels of drop precedence**
  - **Specific resources (BW, buffer space) allocated to each class at each node**
- **Best Effort (BE)**

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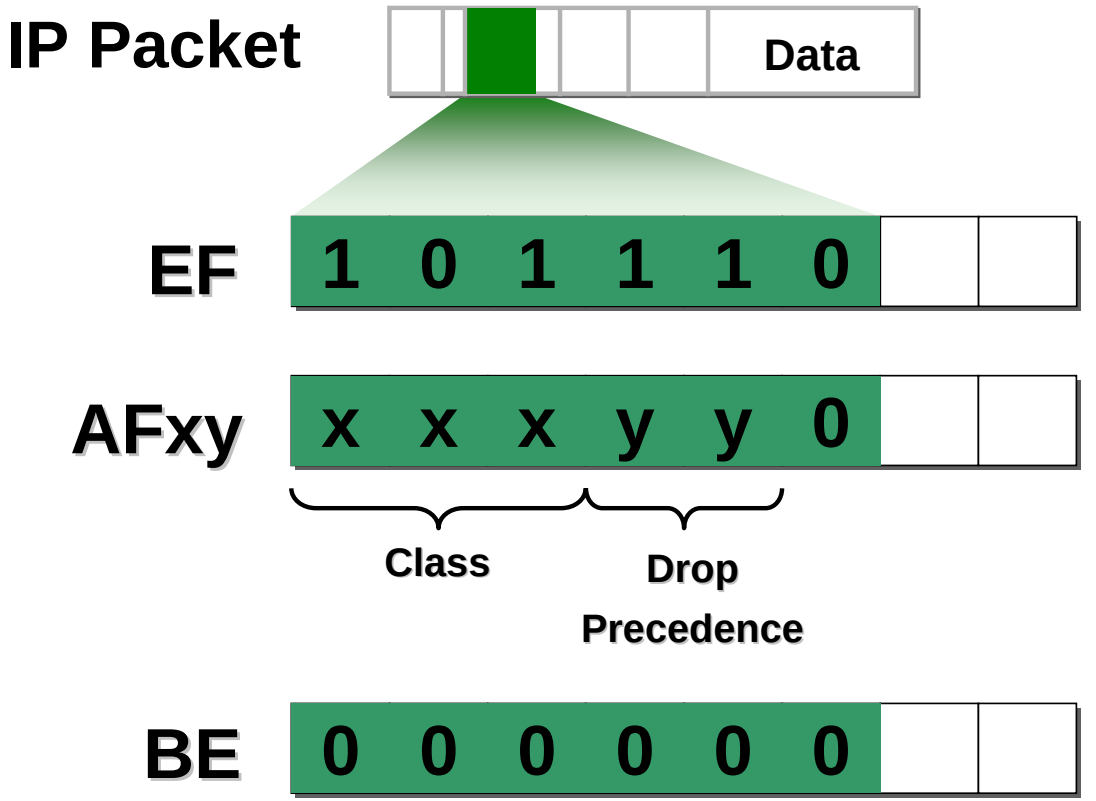
# PHB Recommended Codepoints for IP



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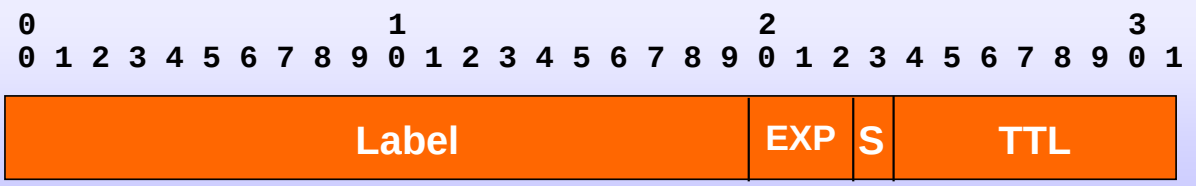
# MPLS Label Header for Packet Media






| | |
|---|---|
| **Label** | **20 bits** |
| **EXP** | **Experimental Field, 3 bits** |
| **S** | **Bottom of Stack, 1 Bit** |
| **TTL** | **Time to Live, 8 Bits** |

- **Can be used over other layer-2 technologies**
- **Contains all information needed at forwarding time**
- **One 32-bit word per label**

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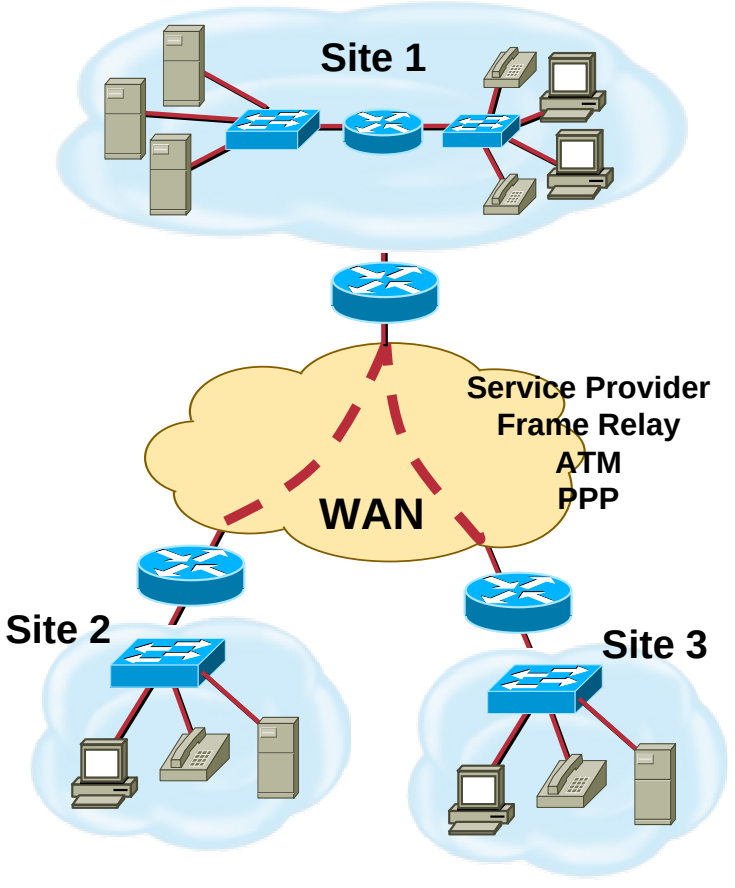
# Traditional Enterprise Network



- SP sells layer-2 service
- Point-to-Point SLA from SP
- Enterprise WAN likely to get congested
- IP QoS required for VVD integration
- SP not involved in IP QoS

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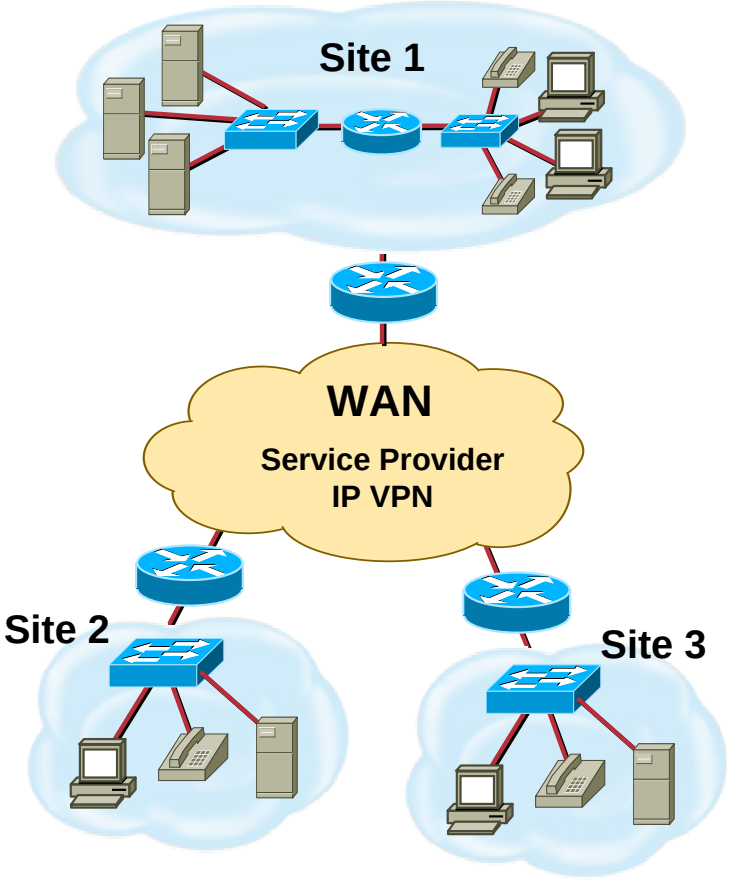
# Enterprise Network with IP Service






- SP sells layer-3 service
- Point-to-Cloud SLA from SP
- Enterprise WAN likely to get congested
- QoS required for VVD integration
- SP involved in IP QoS

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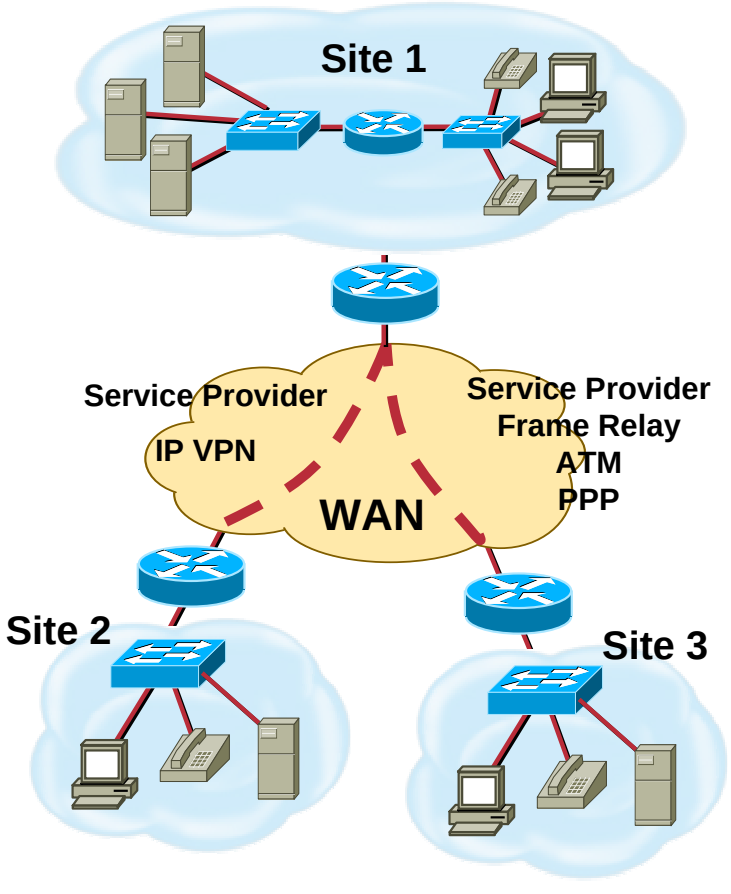
# Enterprise Network with Layer-2 Service



- Enterprise may continue with layer-2 services
- SP needs to consolidate layer-2 and layer-3 services
- Layer-2 and layer-3 SLAs with same IP/MPLS network

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# Agenda



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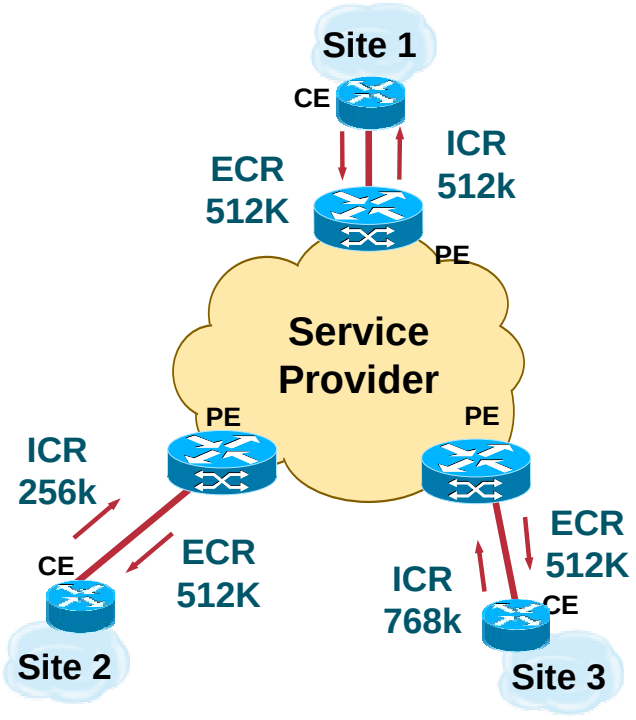
# IP Service SLA






ECR – Egress Committed Rate
ICR – Ingress Committed Rate

- Point-to-cloud guarantees for conforming traffic
- Any site can transmit up to ICR into the cloud
- Any site can receive up to ECR from the cloud

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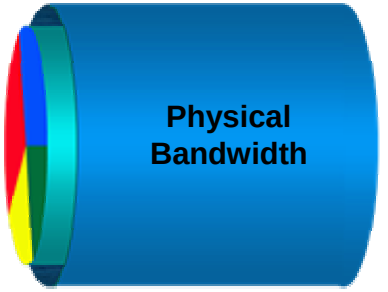
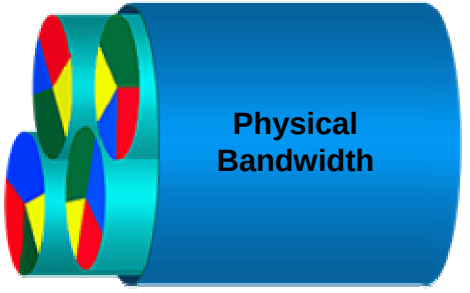
# IP Service SLA (cont.)



SLA per interface (possibly sub-rate)




SLA per PVC / VLAN




- SLA typically includes between 3 and 5 classes (real time, video, business, bulk, BE)
- Real-time traffic gets fixed bandwidth allocation
- Data traffic gets variable bandwidth allocation with minimum guarantee
- Frequently, bandwidth allocations defined as percentage of sub-rate (e.g. PVC CIR, shaped rate)
- Additional classes not visible to customer may exist at the edge (e.g. management/control traffic)

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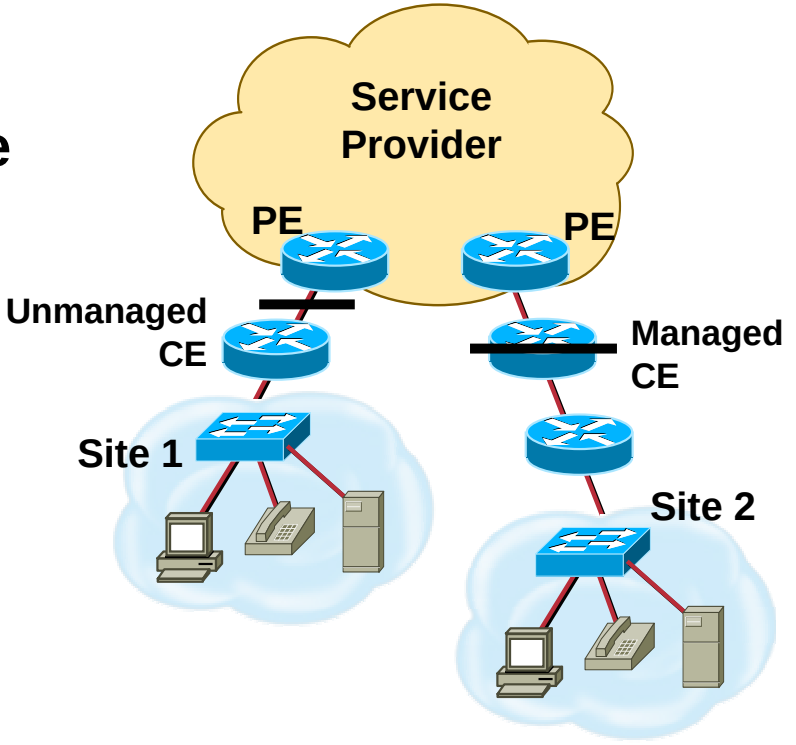
# Where is the SP edge?



- Managed vs. unmanaged IP service
- Trust boundary implications
- Different QoS design options
- Edge QoS policies offloaded to CE for managed IP

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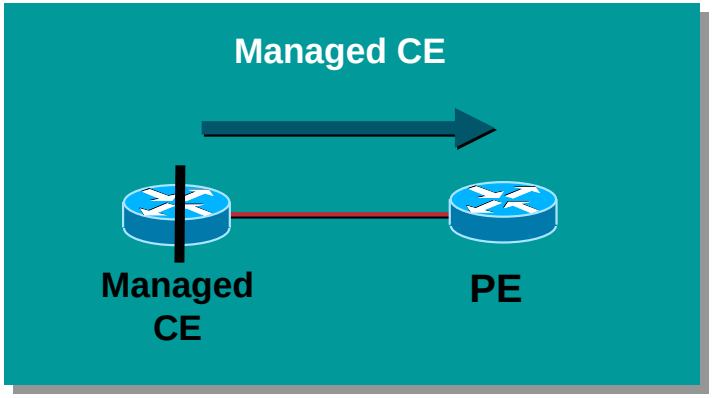
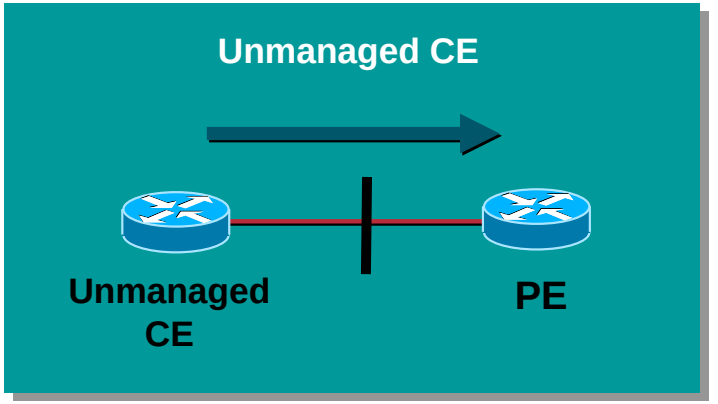
# Traffic Leaving Enterprise Network






- Output QoS policy on CE controlled by SP
- SP enforces SLA using the output QoS policy on CE
- Output policy uses queuing, dropping and optionally, shaping
- Elaborate traffic classification or mapping of existing markings
- Slow links require LFI / cRTP




- Output QoS policy on CE not controlled by SP
- SP enforces SLA using input QoS policy on PE
- Input policy uses policing and marking
- Elaborate traffic classification or mapping of existing markings on PE

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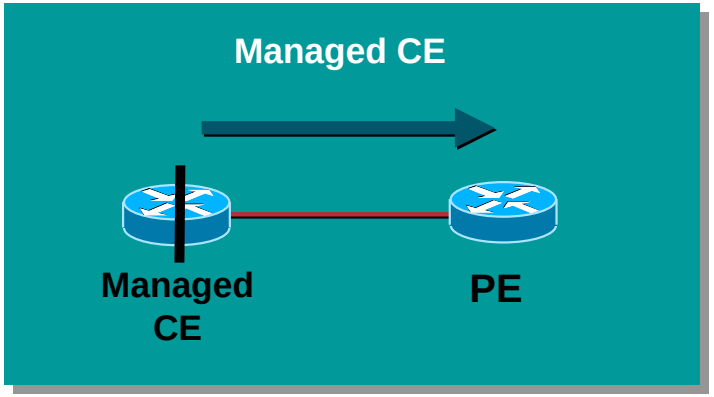
# Traffic Leaving Enterprise Network






**CE Output Policy**

Classification / Marking / Mapping

LLQ

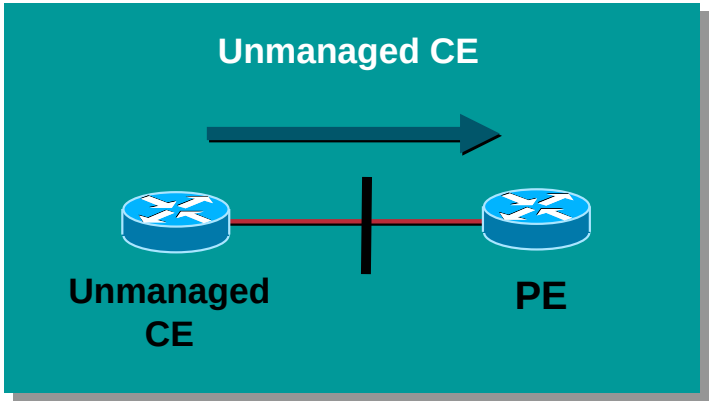
WRED

[Shaping]

[LFI / cRTP]

**PE Input Policy**

<Not required>




**CE Output Policy**

<irrelevant>

**PE Input Policy**

Classification / Marking / Mapping

Policing

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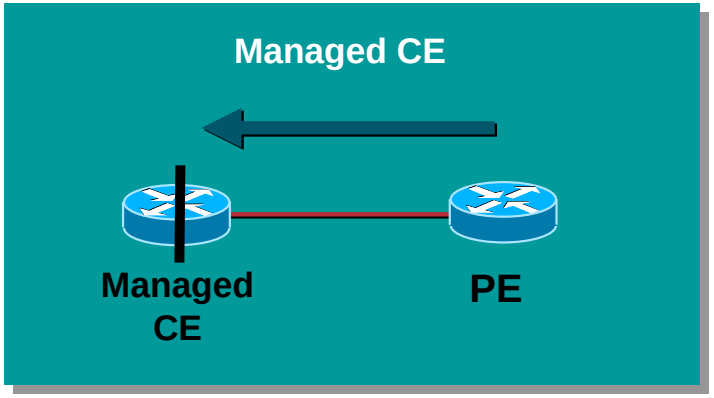
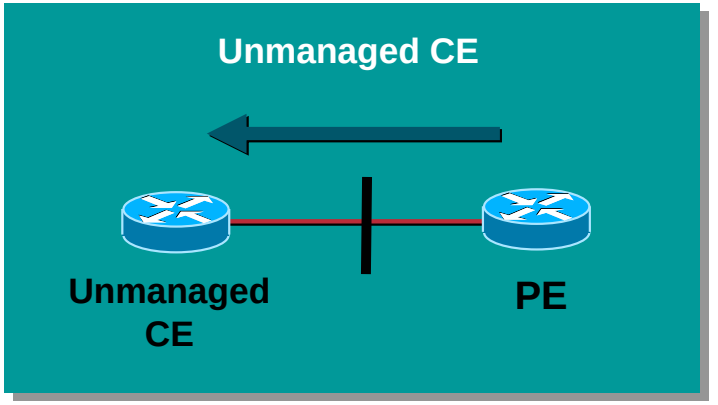
# Traffic Leaving Service Provider Network






- SP enforces SLA using the output QoS policy on PE
- Output policy uses queuing, dropping and optionally, shaping
- Slow links require LFI / cRTP
- No input QoS policy on CE needed




- SP enforces SLA using the output QoS policy on PE
- Output policy uses queuing, dropping and optionally, shaping
- Slow links require LFI / cRTP
- Input QoS policy on CE irrelevant

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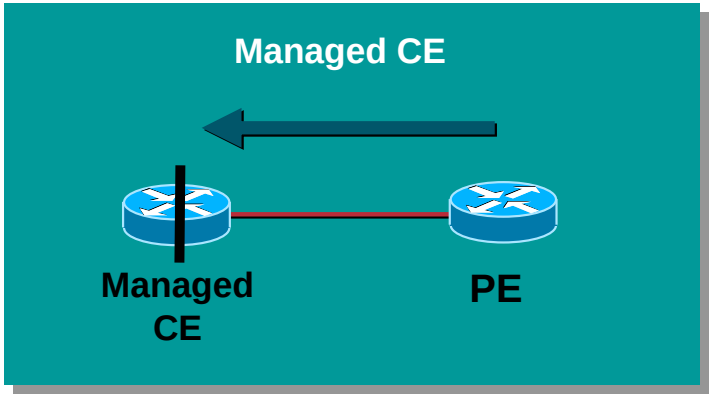
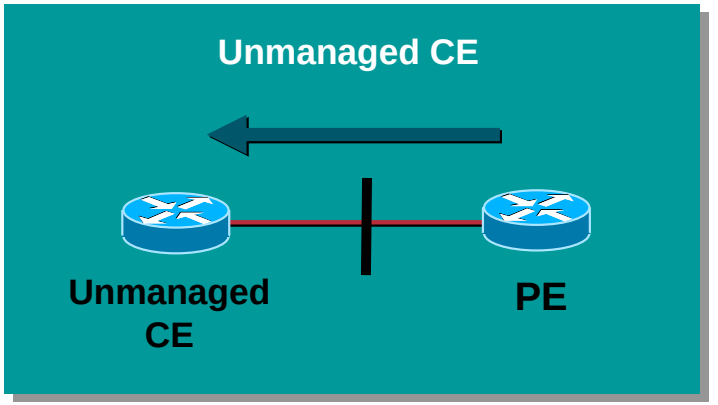
# Traffic Leaving Service Provider Network






| CE Input Policy | PE Output Policy |
|---|---|
| <Not needed> | LLQ |
| | WRED |
| | [Shaping] |
| | [LFI / cRTP] |




| CE Input Policy | PE Output Policy |
|---|---|
| <Irrelevant> | LLQ |
| | WRED |
| | [Shaping] |
| | [LFI / cRTP] |

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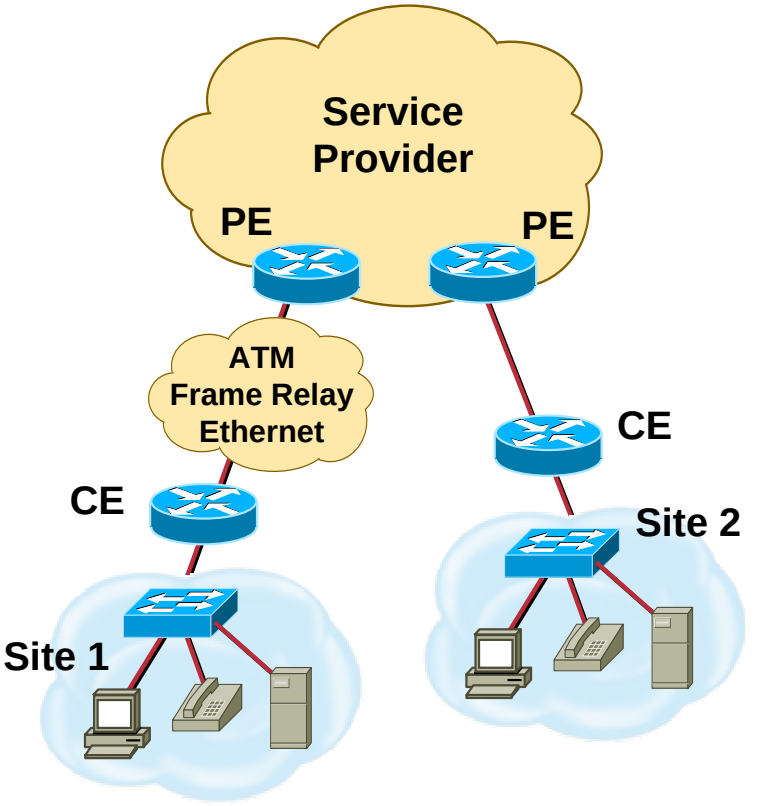
# Layer-2 SLA



- FR / ATM customers receive traditional SLA
- FR / ATM / Ethernet access network may enforce SLA
- Pay-as-you-grow services can be implemented for PPP / HDLC
- Service is typically unmanaged

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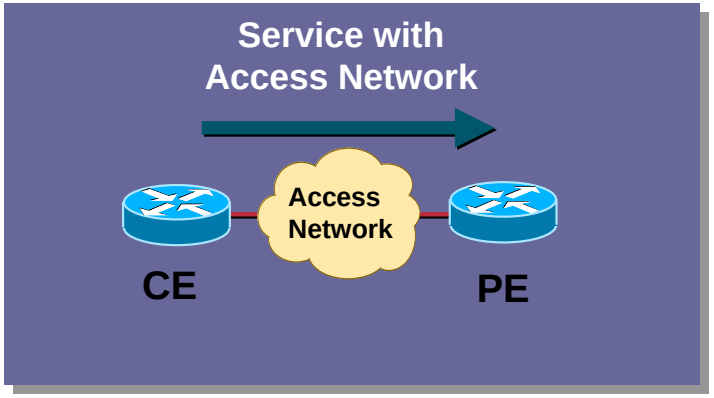
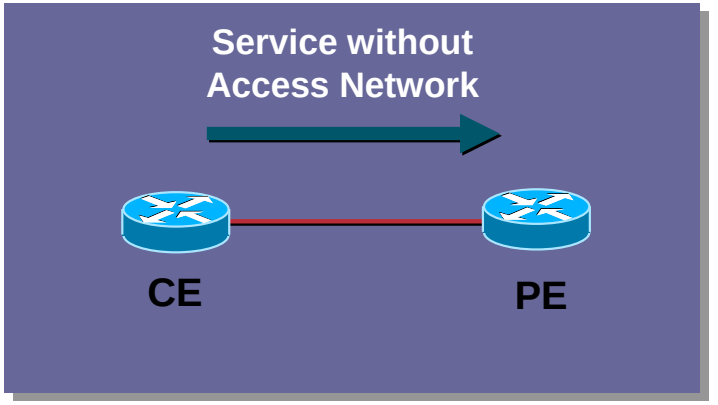
# Traffic Leaving Enterprise Network






- SP enforces SLA on access network preferably
- Drop precedence may be marked for FR / ATM / Ethernet
- Ethernet may support multiple classes
- PE may mark traffic after encapsulation
- No elaborate traffic classification or mapping of existing IP markings




- SP enforces SLA using input QoS policy on PE
- Input policy uses policing and marking
- Drop precedence may be marked for FR / ATM / Ethernet
- Ethernet may support multiple classes
- PE may mark traffic after encapsulation
- No Elaborate traffic classification or mapping of existing markings on PE

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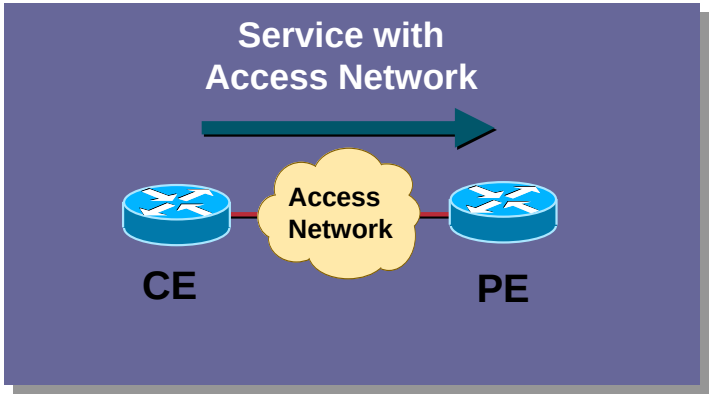
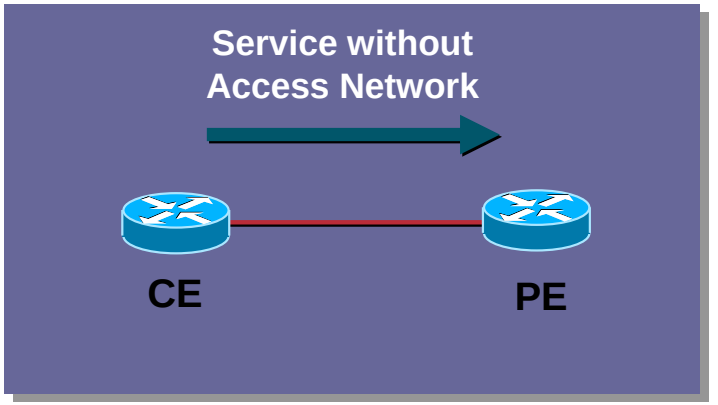
# Traffic Leaving Enterprise Network






| CE Output Policy | Access Network Input Policy | PE Input Policy |
|---|---|---|
| <irrelevant> | Policing | [Marking] |
| | [Marking] | |




| CE Output Policy | PE Input Policy |
|---|---|
| <irrelevant> | Policing |
| | [Marking] |

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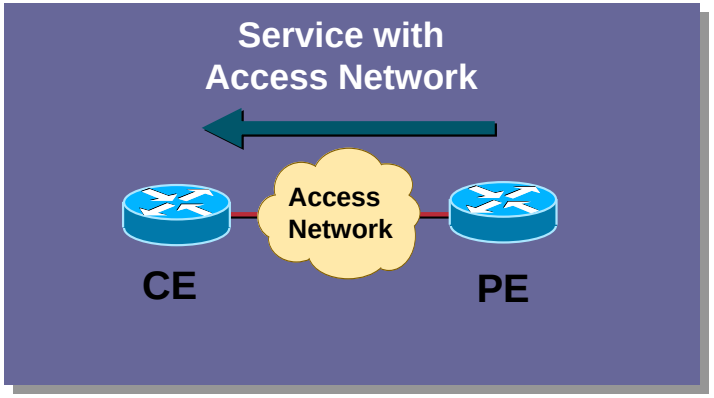
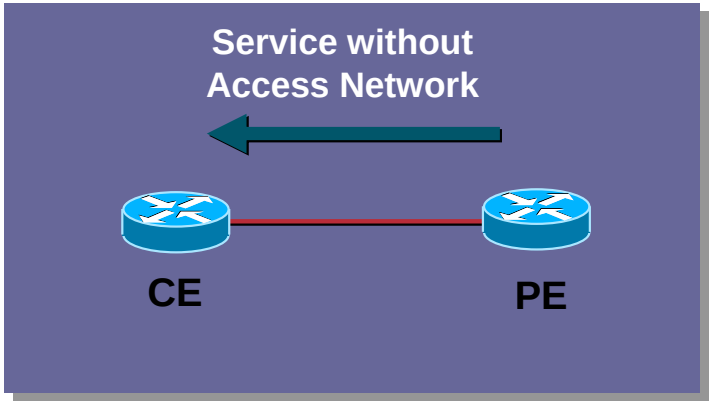
# Traffic Leaving Service Provider Network






- SP enforces SLA on access network preferably
- Access network should serve packets according to their marking (class / drop precedence) where applicable




- SP enforces SLA using the output QoS policy on PE
- Output policy uses queuing, dropping and optionally, shaping

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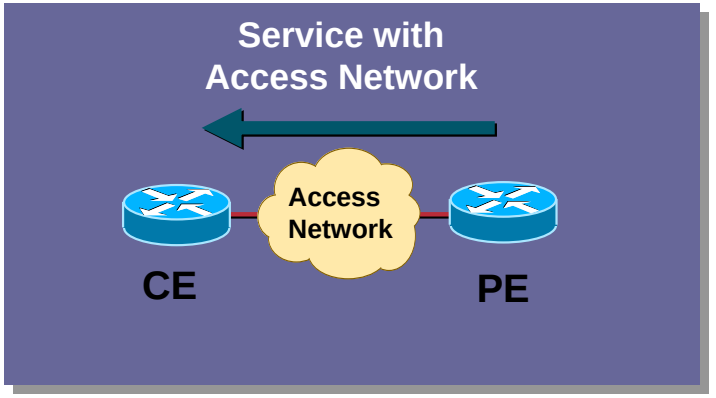
# Traffic Leaving Service Provider Network






**CE**
**Input Policy**

<irrelevant>

**Access**
**Network**
**Output Policy**

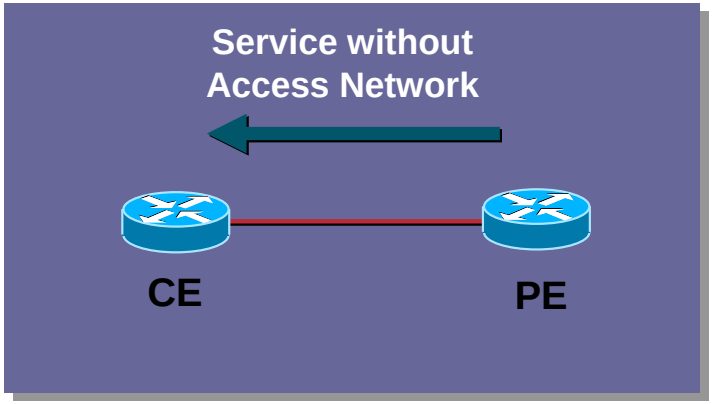
Queuing (LLQ)

Dropping (WRED)

[Shaping]

**PE**
**Output Policy**

<optional>




**CE**
**Input Policy**

<irrelevant>

**PE**
**Input Policy**

Queuing (LLQ)

WRED

[shaping]

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# Agenda



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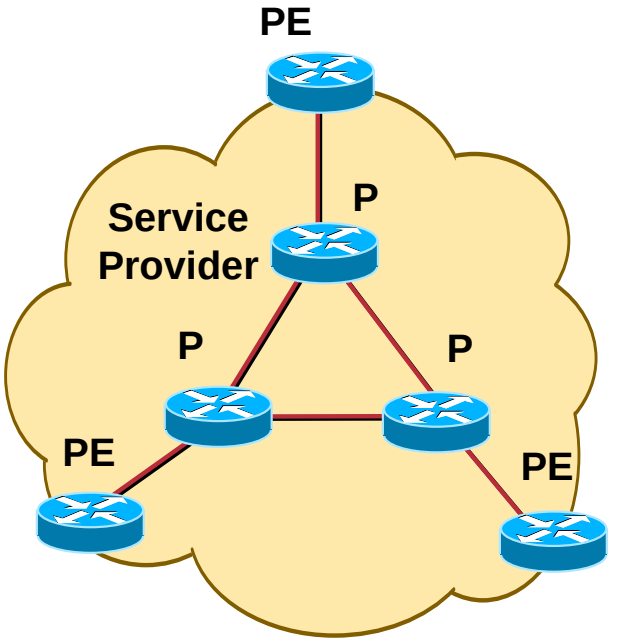
# Now the Easy Part…



- QoS complexity resides at the edge
- Backbone is service agnostic
- Backbone is customer agnostic
- Backbone only deals with classes
- Over-provisioning sometimes touted as best alternative

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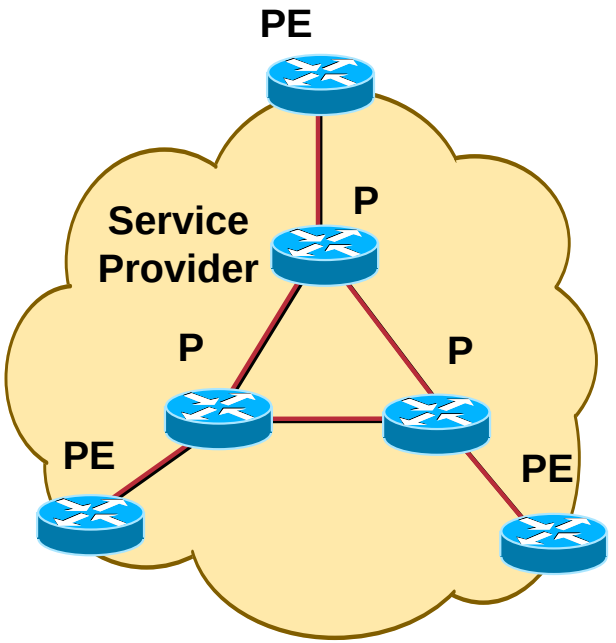
# Limitations of Over-Provisioning






- Expensive
- DOS attacks
- Failures conditions
- Planning mistakes
- Unexpected traffic demand

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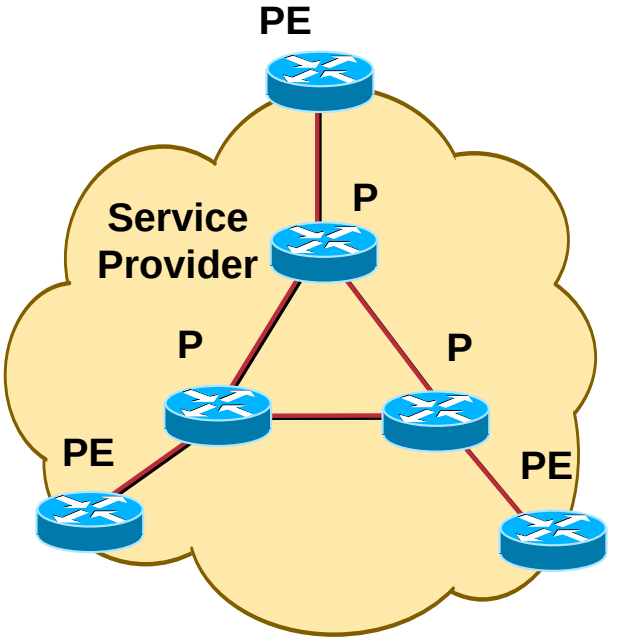
# Benefits of DiffServ in the Backbone



- Less bandwidth required
- Over-provisioning control per class
- Low maintenance design
- Low complexity design
- Can be tied to advanced traffic mgmt in control plane (MPLS TE)

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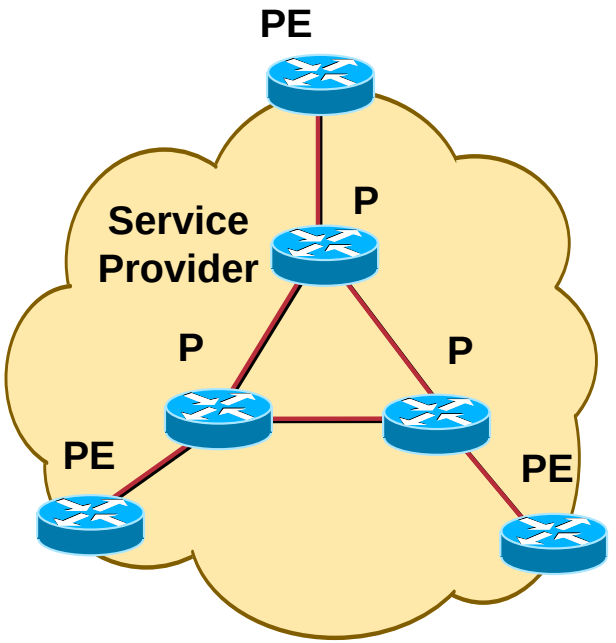
# Backbone QoS Design Recommendations






- Subset of classes may be used
- Typically, 2 or 3 classes (real time, business, BE)

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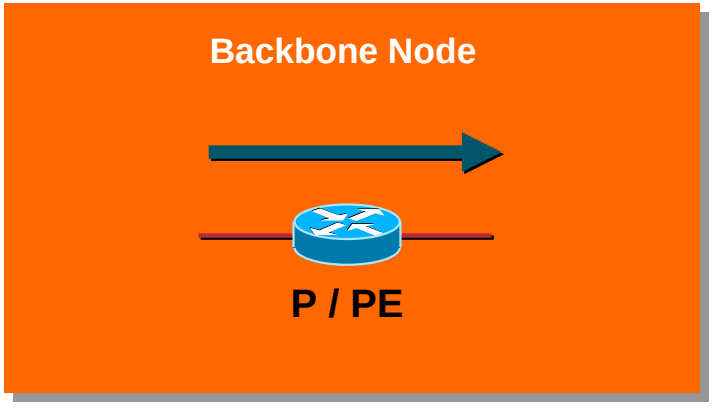
# Traffic through Backbone Node






- SP implements SLA using output QoS policy
- Output policy uses queuing and dropping

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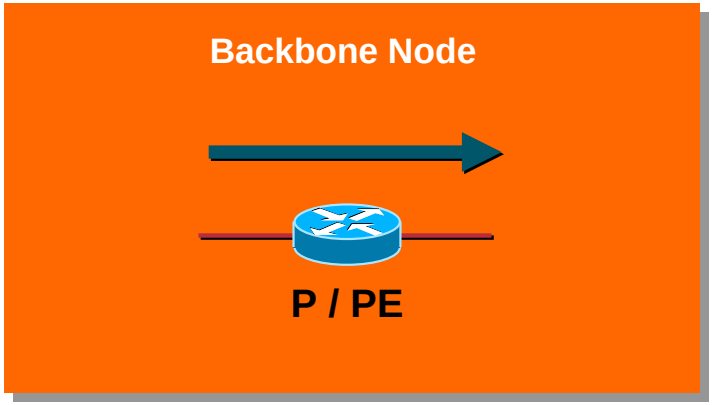
# Traffic through Backbone Node






**PE**
**Output Policy**

**LLQ**

**WRED**

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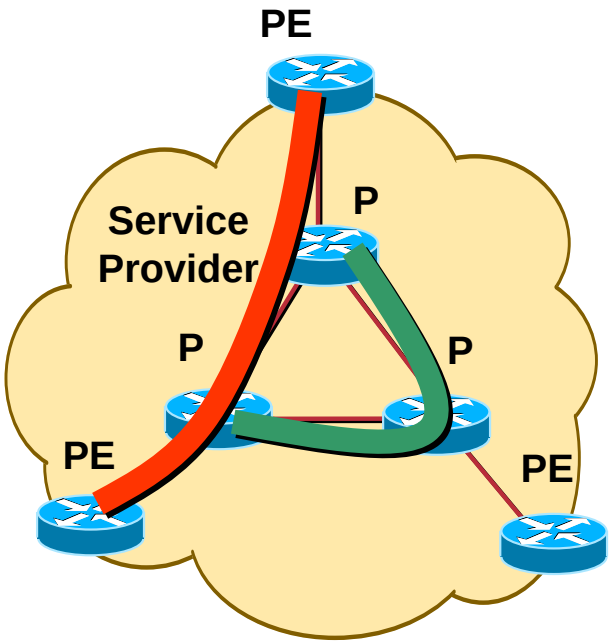
# Further Enhancing the SLA with MPLS TE






- Bandwidth optimization
- Stronger point-to-point guarantees
- Quick restoration (FRR)
- Bandwidth protection during failures

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# Summary



- IP QoS can provide more sophisticated SLAs than traditional layer-2 services
- Service Providers can use converged network to implement layer-3 and layer-2 services with QoS
- MPLS TE can be used for enhanced SLAs
- Edge QoS design much more elaborate
- Multiple options for edge design (e.g. classes, managed vs. unmanaged, sub-rate)
- Backbone QoS design simple

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# References



- QoS Page on CCO

  http://www.cisco.com/go/qos
- MPLS Page on CCO

  http://www.cisco.com/go/mpls
- Cisco IOS 12.2 QoS Configuration Guide and Command Reference

  http://www.cisco.com/
- Cisco IOS 12.2T New Feature Documentation

  http://www.cisco.com/
- **Plus, lots of internal test results and detailed designs available through your account team**

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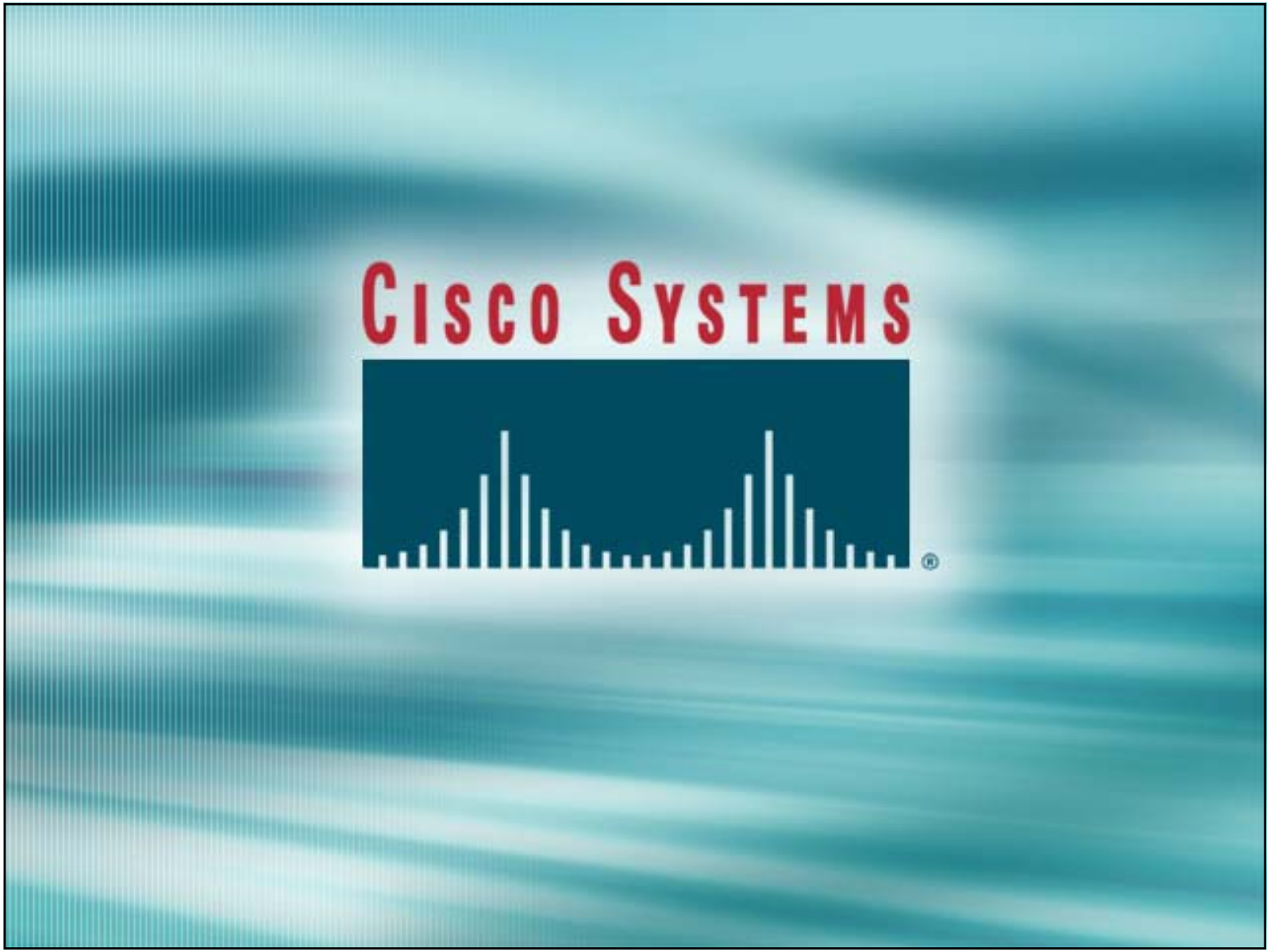
CISCO SYSTEMS