Optimizing the Service Provider Network for Voice, Video, and Data

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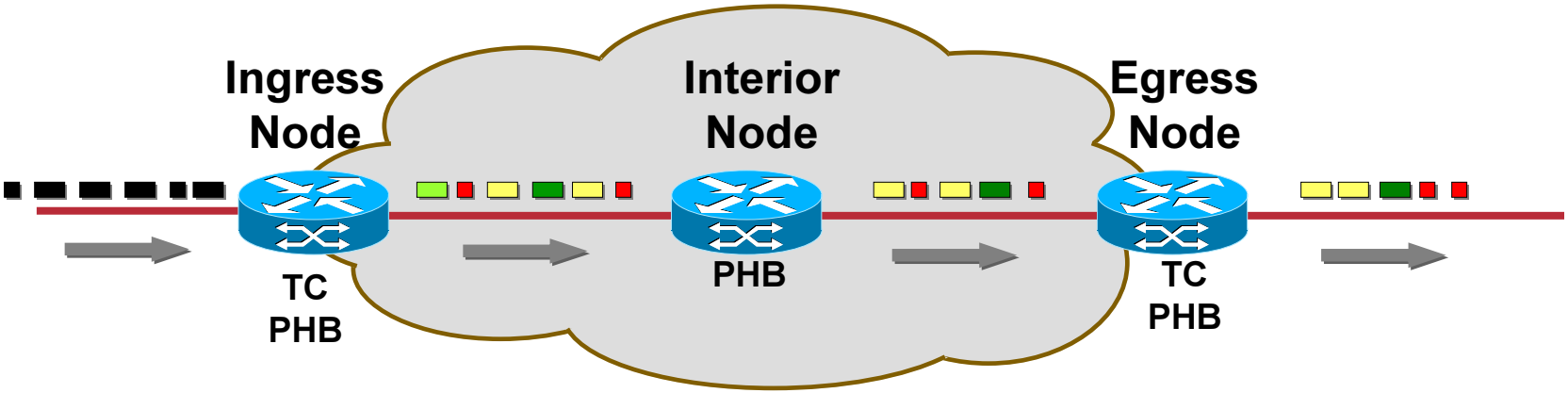
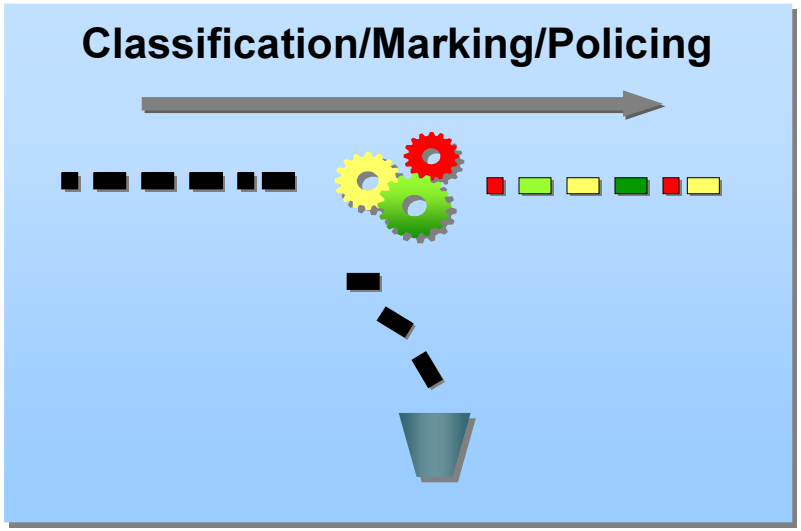
Agenda

- **Introduction**
- **Designing the edge**
- **Designing the backbone**
- **Summary and references**

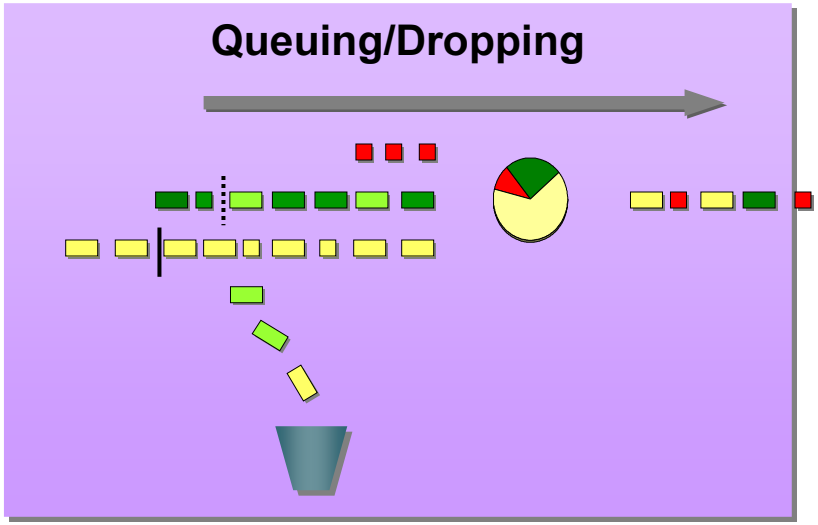
Differentiated Services Architecture



Traffic Classification and Conditioning



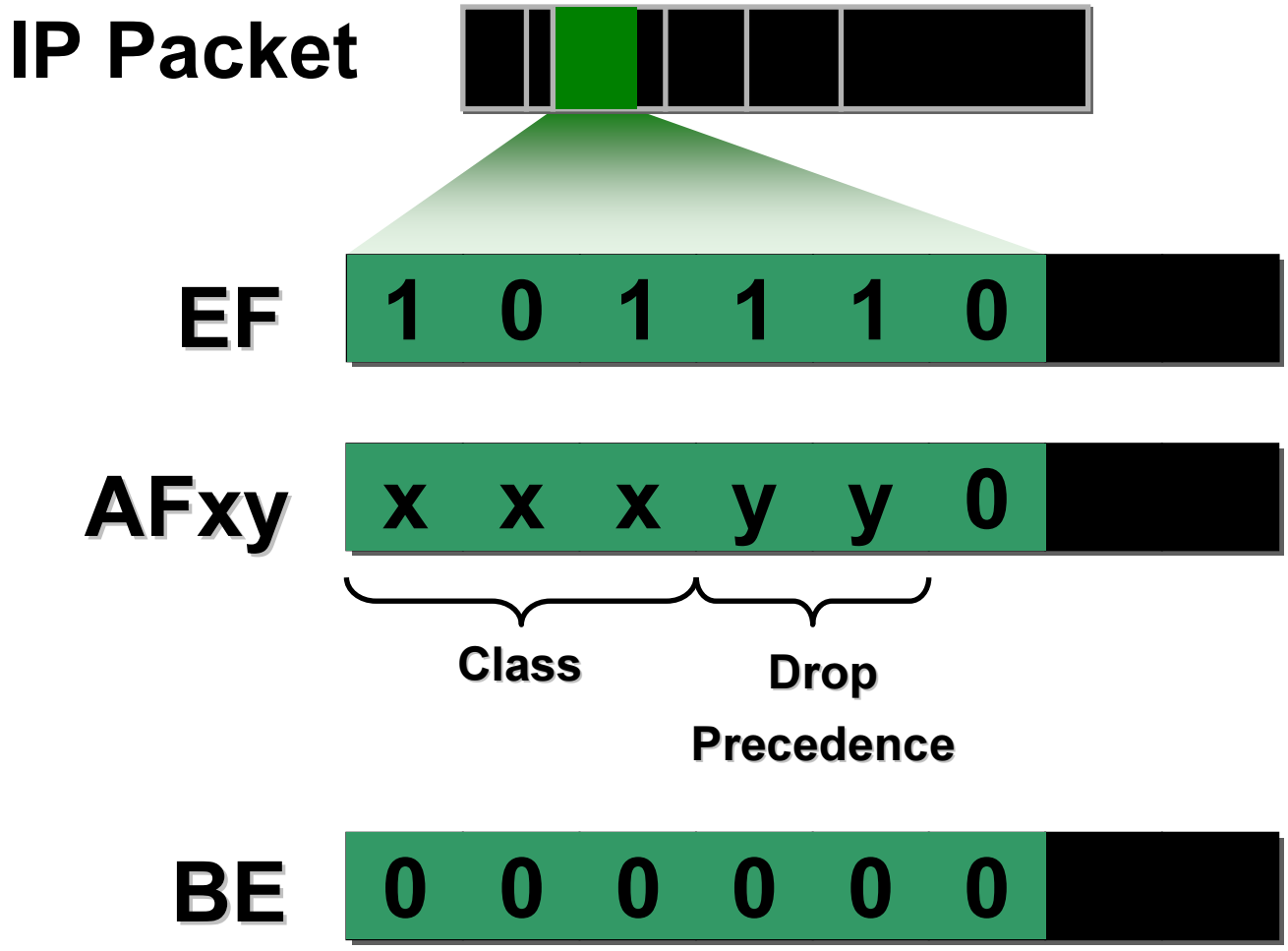
Per-Hop Behavior (PHB)



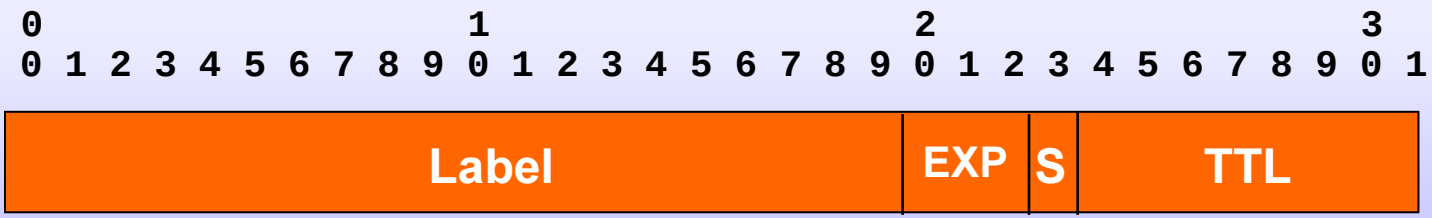
Per–Hop Behaviors

- **Expedited Forwarding (EF)**
  - **Building block for low delay/ jitter/loss**
  - **Served at a certain rate with short/empty 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)**

PHB Recommended Codepoints for IP



MPLS Label Header for Packet Media

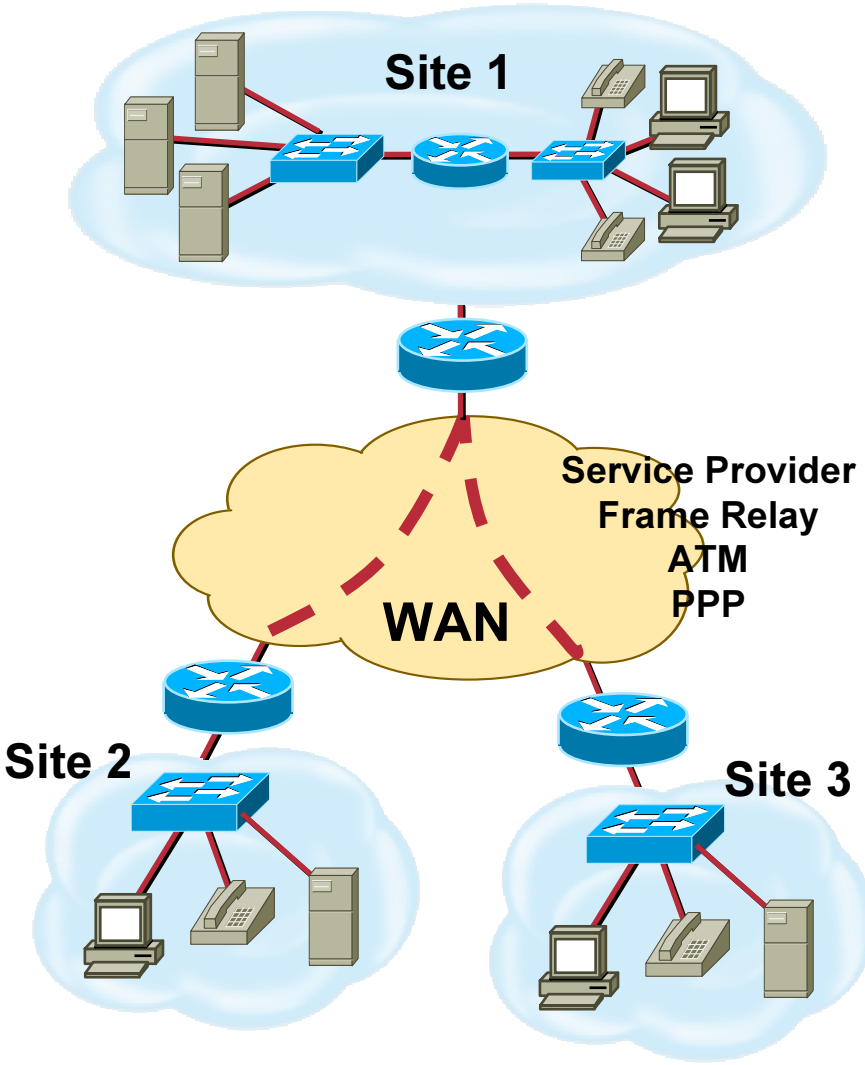


Label	**20 bits**
EXP	**Experimental Field, 3 bits**
S	**Bottom of Stack, 1 Bit**
TTL	**Time to Live, 8 Bits**

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

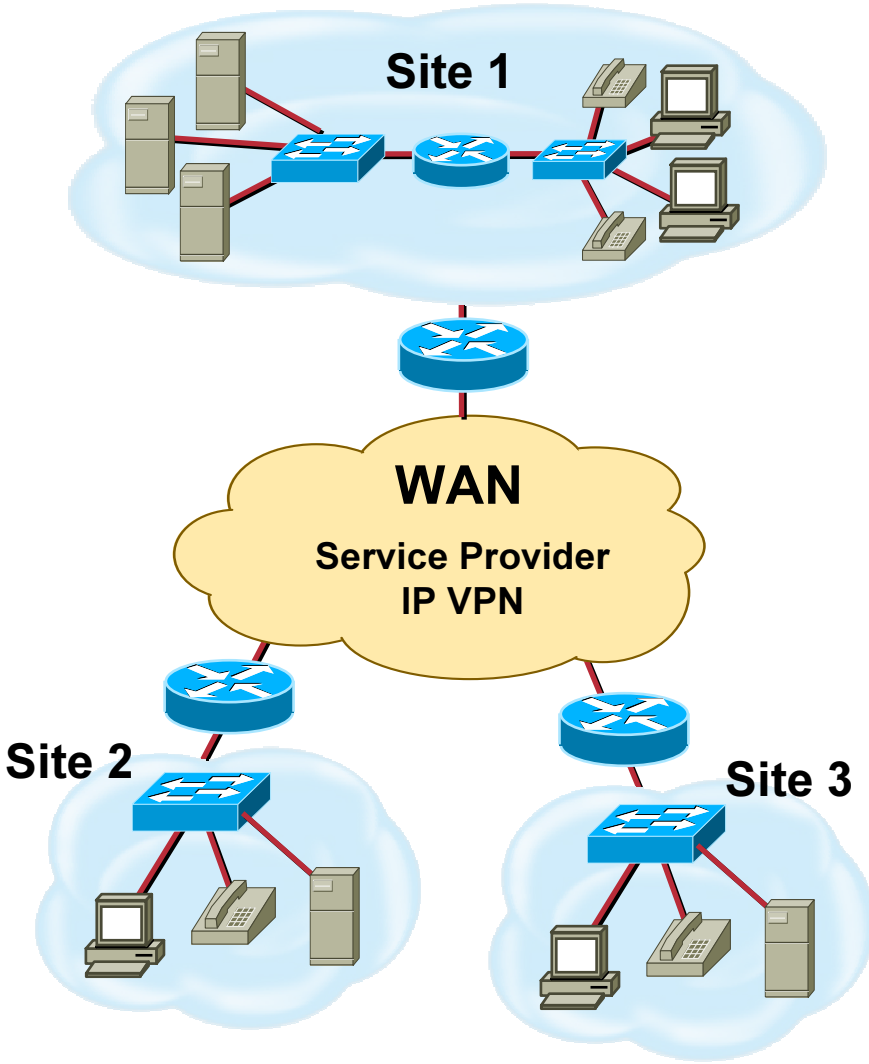
Traditional Enterprise Network

- 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



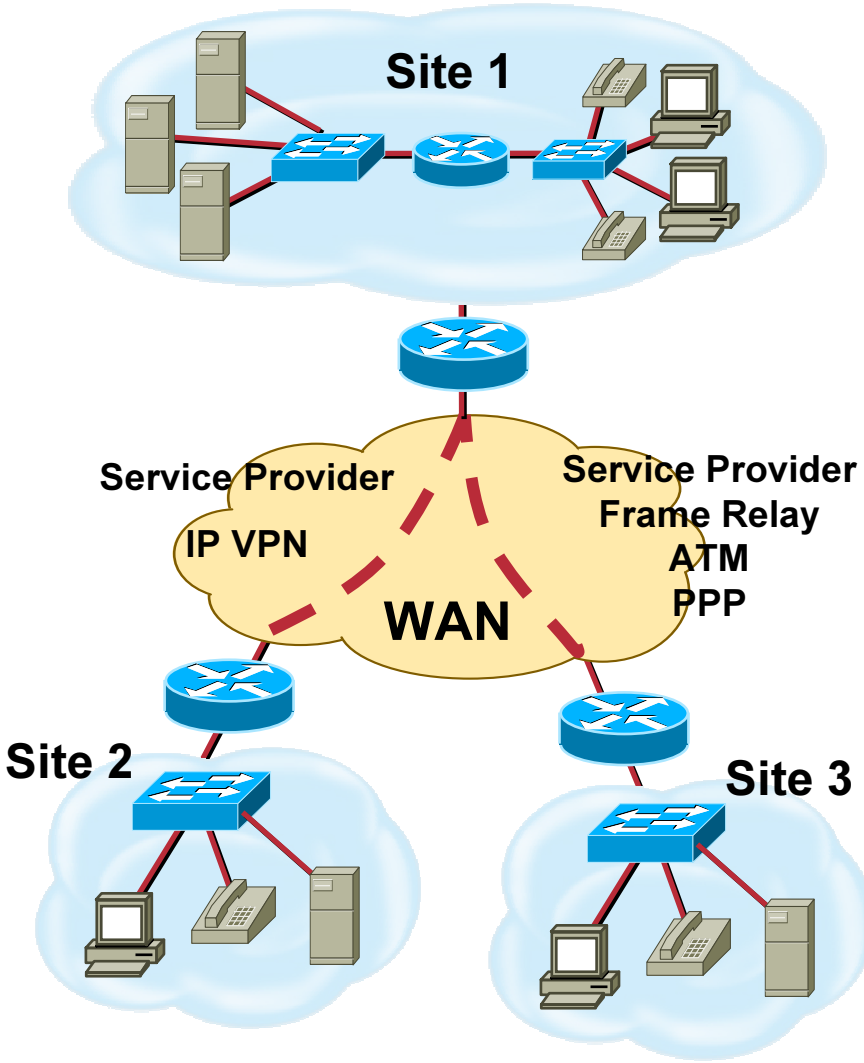
Enterprise Network with IP Service

- 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



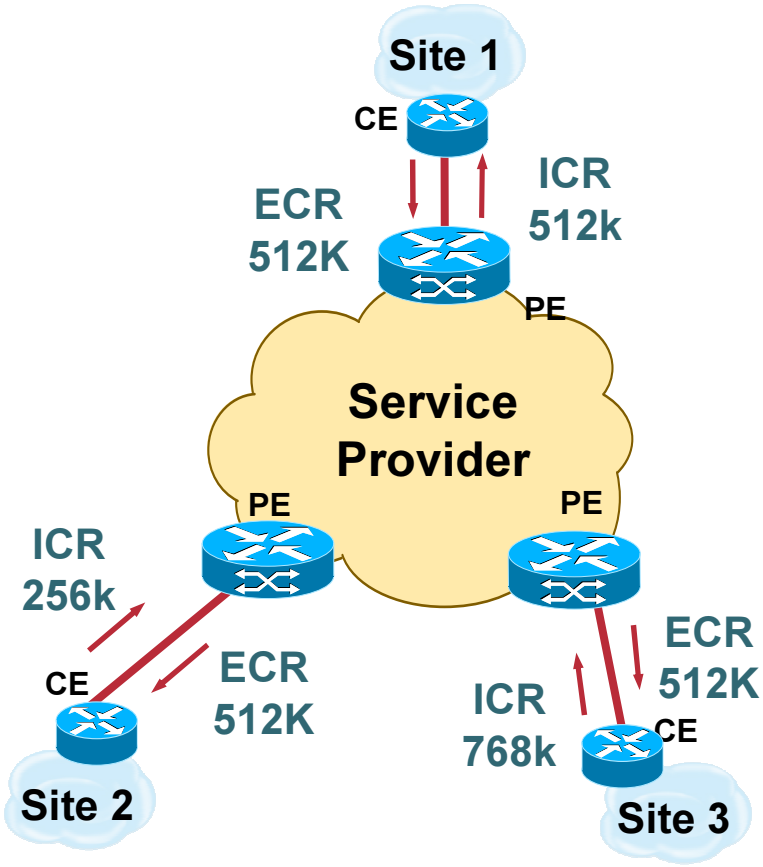
Enterprise Network with Layer-2 Service

- 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



Cisco IOS IP SLAs

- **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**

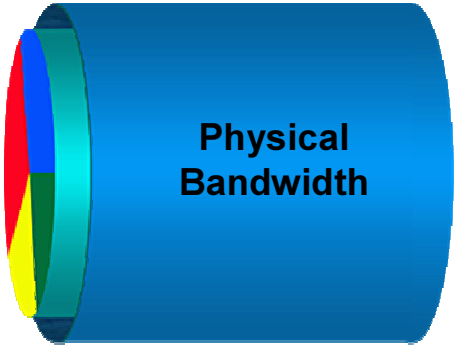


ECR – Egress Committed Rate
ICR – Ingress Committed Rate

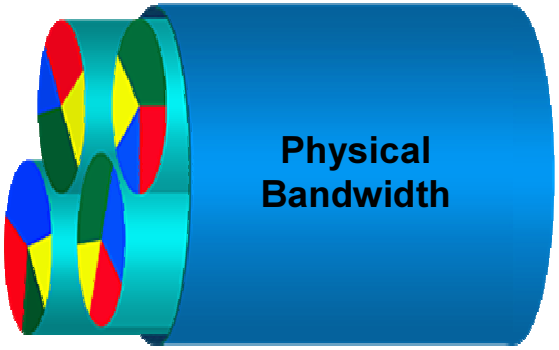
Cisco IOS IP SLAs (Cont'd.)

- 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)

SLA per interface (possibly sub-rate)

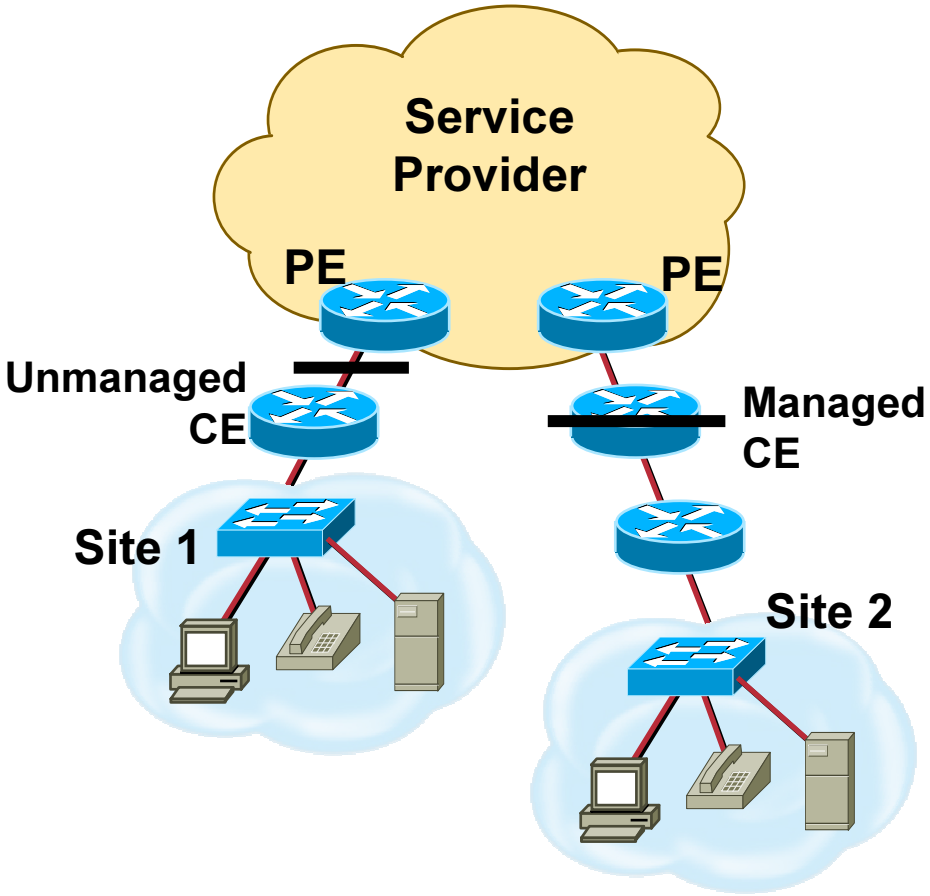


SLA per PVC / VLAN

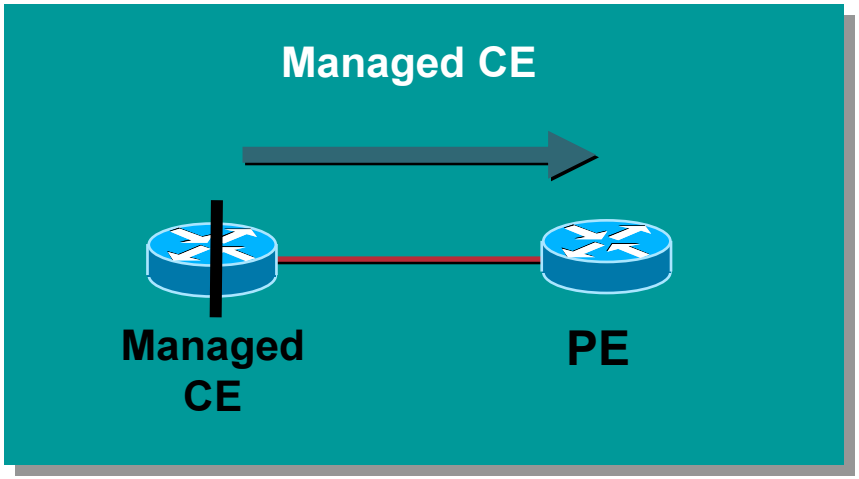


Where is the SP Edge?

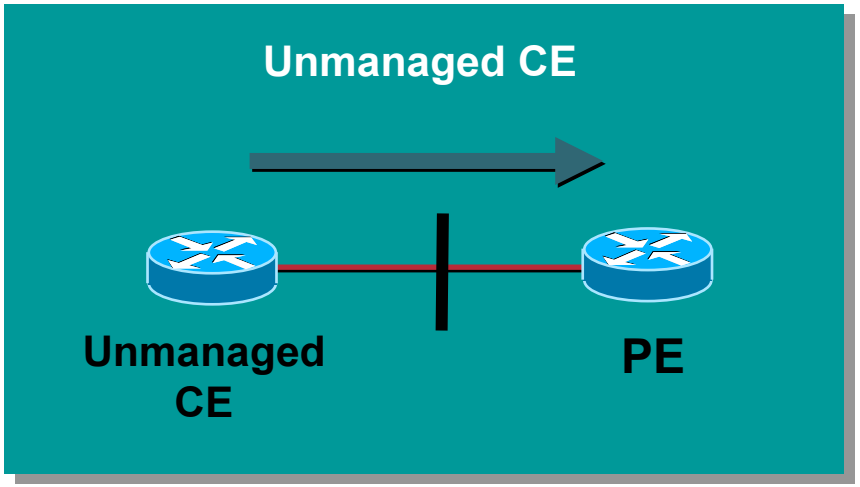
- Managed vs. unmanaged IP service
- Trust boundary implications
- Different QoS design options
- Edge QoS policies offloaded to CE for managed IP



Traffic Leaving Enterprise Network

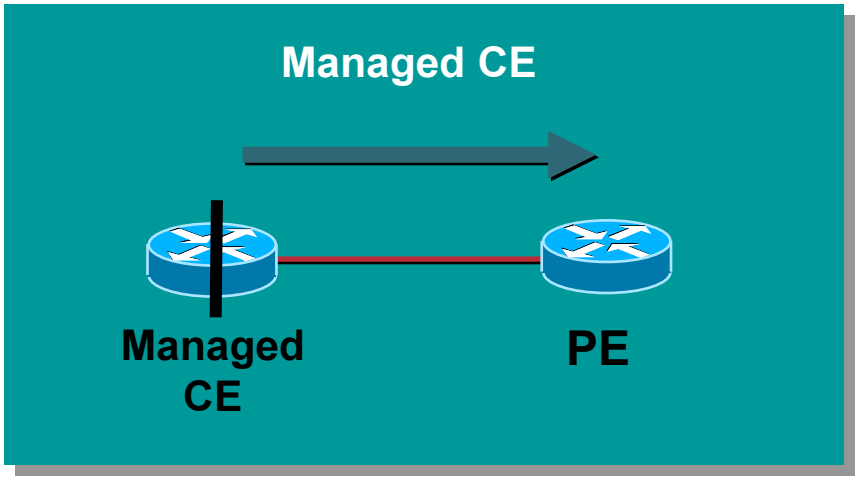


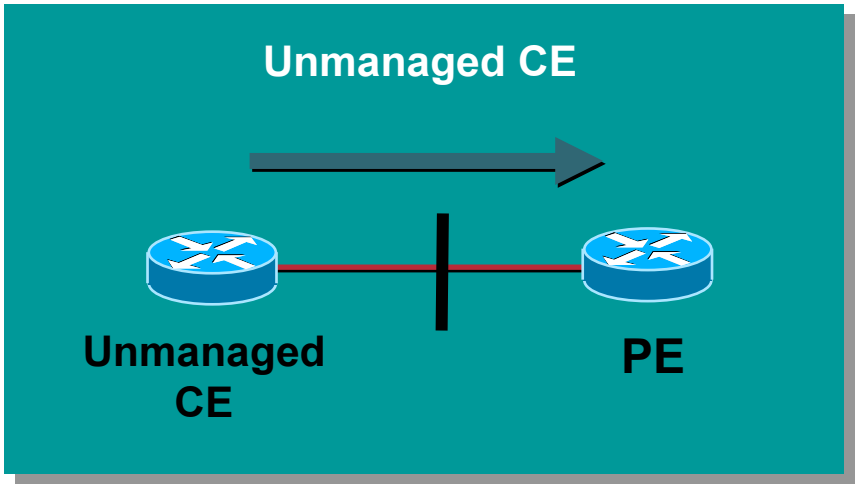
- Output QoS policy on CE controlled by SP
- SP enforces SLA using the output QoS policy on CE
- Output policy uses queuing, dropping and optionally, shaping
- Elaborate traffic classification or mapping of existing markings
- Slow links require LFI / cRTP



- 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

Traffic Leaving Enterprise Network

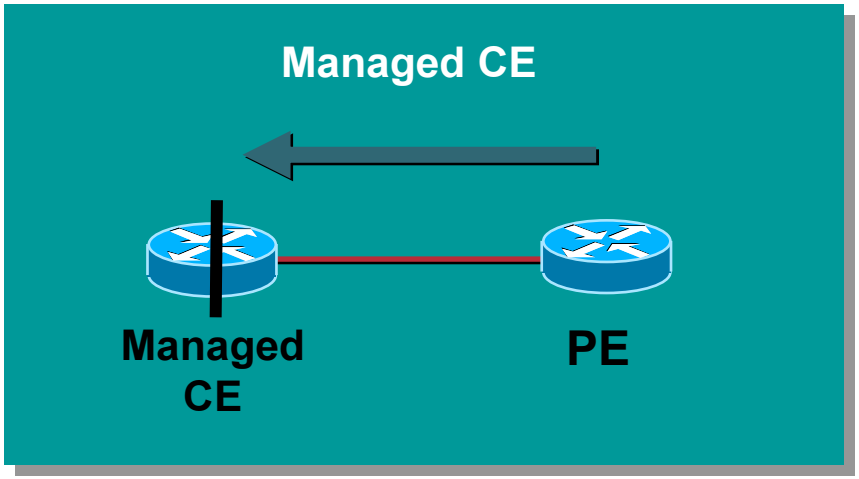




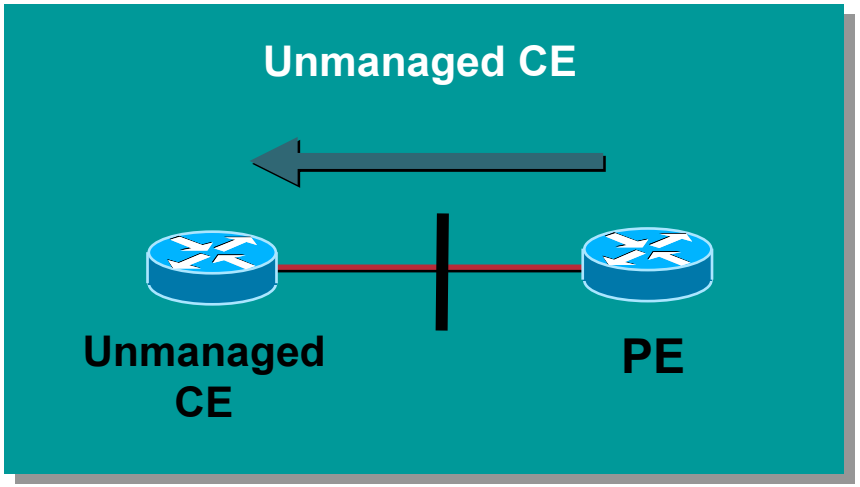
CE	PE
Output Policy	Input Policy
Classification / Marking / Mapping	<Not required>
LLQ	
WRED	
[Shaping]	
[LFI / cRTP]	

CE	PE
Output Policy	Input Policy
<irrelevant>	Classification / Marking / Mapping
	Policing

Traffic Leaving Service Provider Network

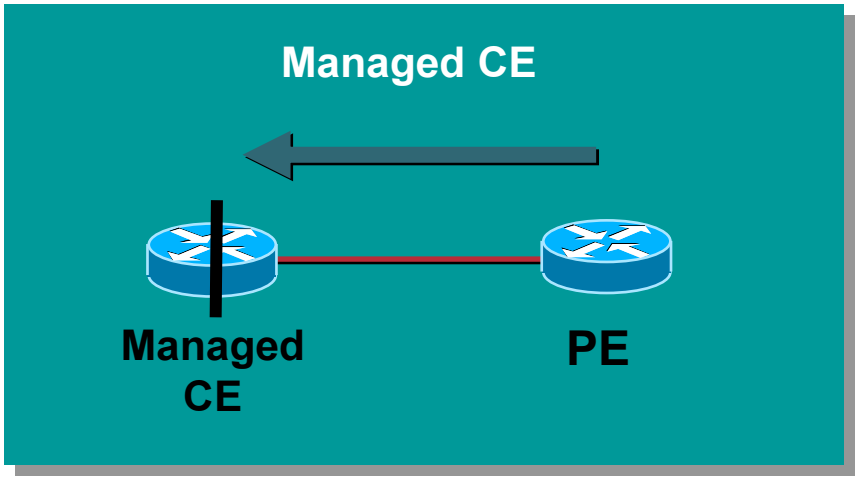


- SP enforces SLA using the output QoS policy on PE
- Output policy uses queuing, dropping and optionally, shaping
- Slow links require LFI / cRTP
- No input QoS policy on CE needed

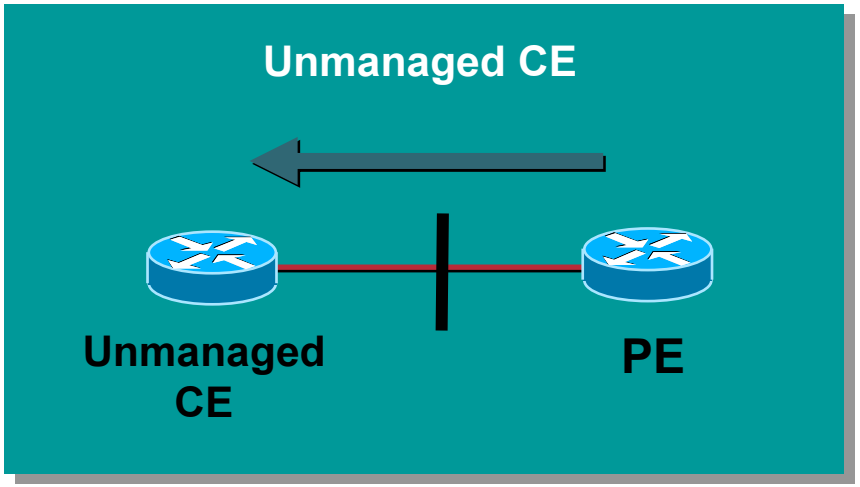


- SP enforces SLA using the output QoS policy on PE
- Output policy uses queuing, dropping and optionally, shaping
- Slow links require LFI / cRTP
- Input QoS policy on CE irrelevant

Traffic Leaving Service Provider Network



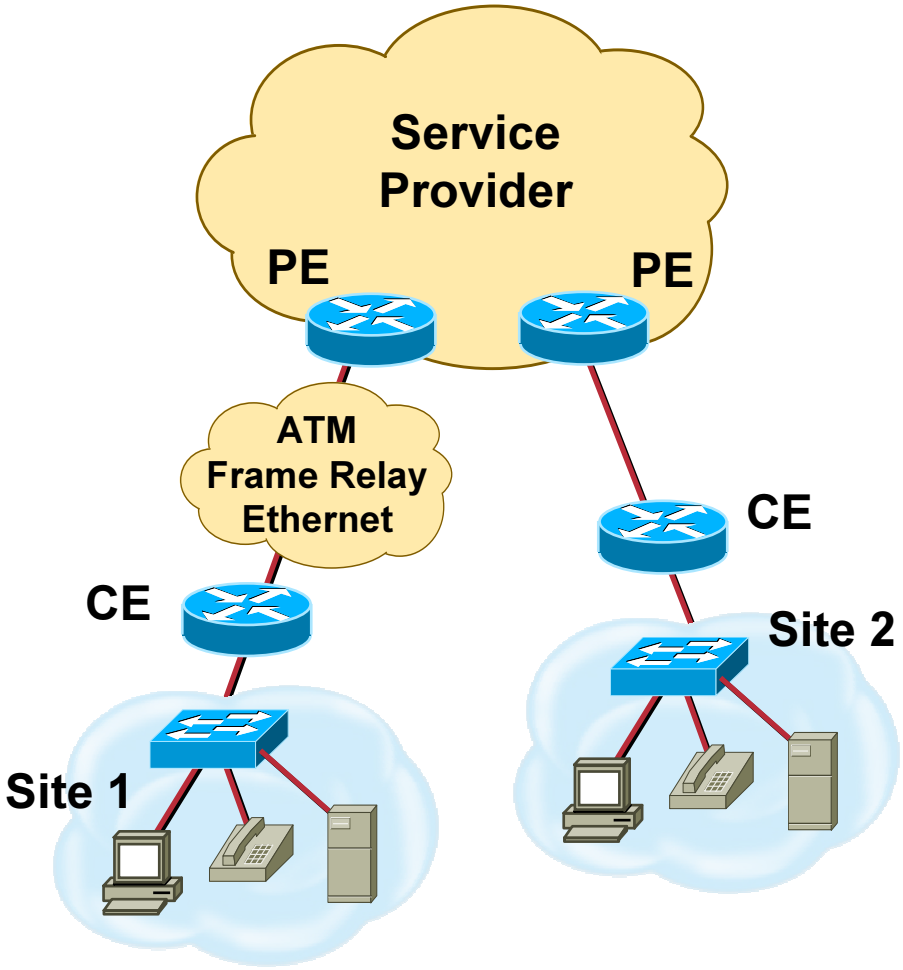
CE Input Policy	PE Output Policy
<Not needed>	LLQ
	WRED
	[Shaping]
	[LFI / cRTP]



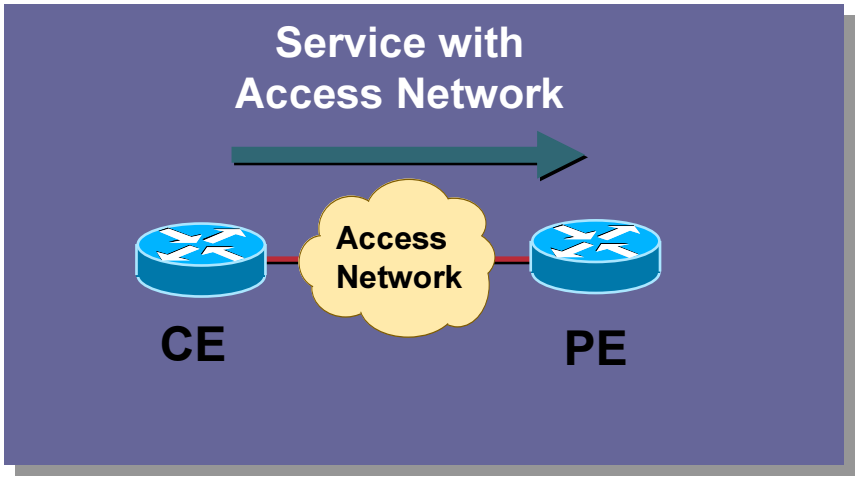
CE Input Policy	PE Output Policy
<Irrelevant>	LLQ
	WRED
	[Shaping]
	[LFI / cRTP]

Layer 2 SLAs

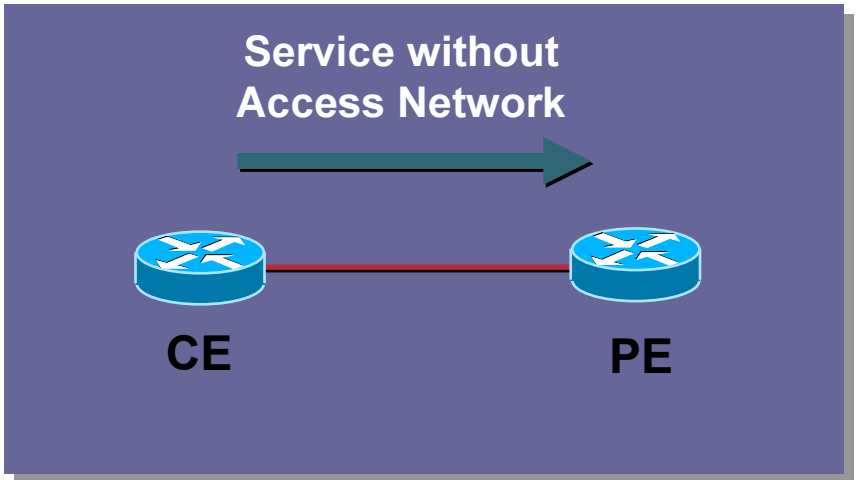
- FR / ATM customers receive traditional SLA
- FR / ATM / Ethernet access network may enforce SLA
- Pay-as-you-grow services can be implemented for PPP / HDLC
- Service is typically unmanaged



Traffic Leaving Enterprise Network

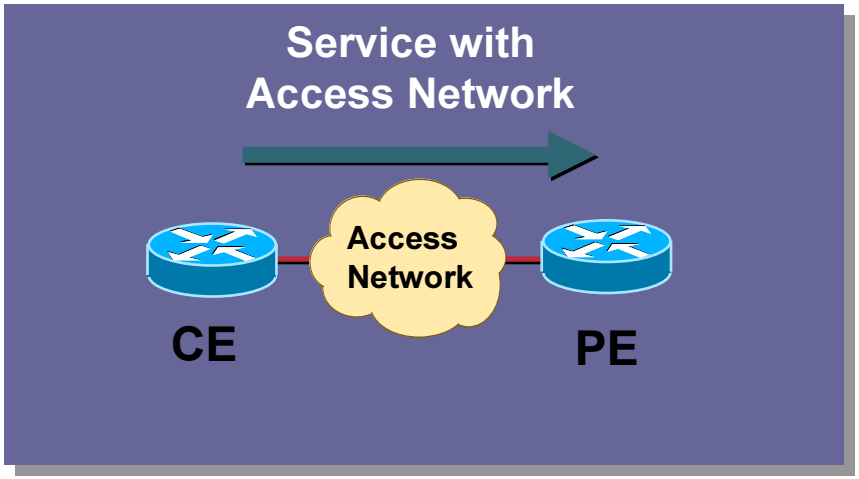


- SP enforces SLA on access network preferably
- Drop precedence may be marked for FR / ATM / Ethernet
- Ethernet may support multiple classes
- PE may mark traffic after encapsulation
- No elaborate traffic classification or mapping of existing IP markings



- 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

Traffic Leaving Enterprise Network



CE
Output Policy

<irrelevant>

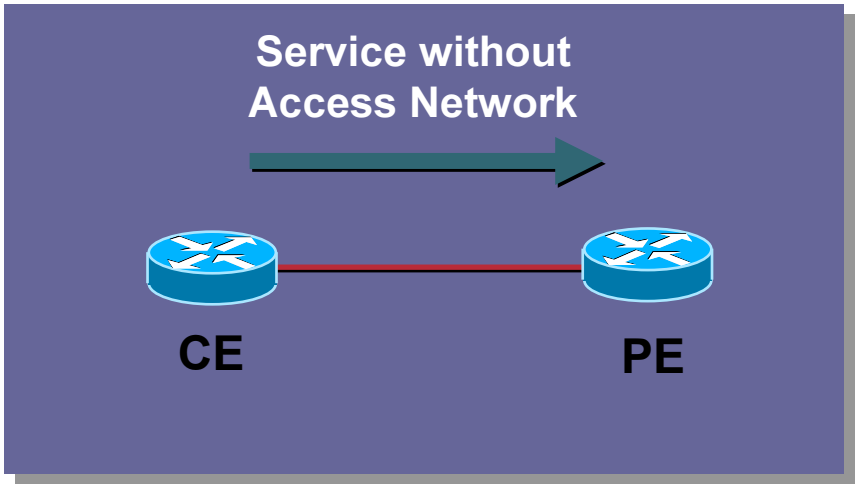
Access
Network
Input Policy

Policing

[Marking]

PE
Input Policy

[Marking]



CE
Output Policy

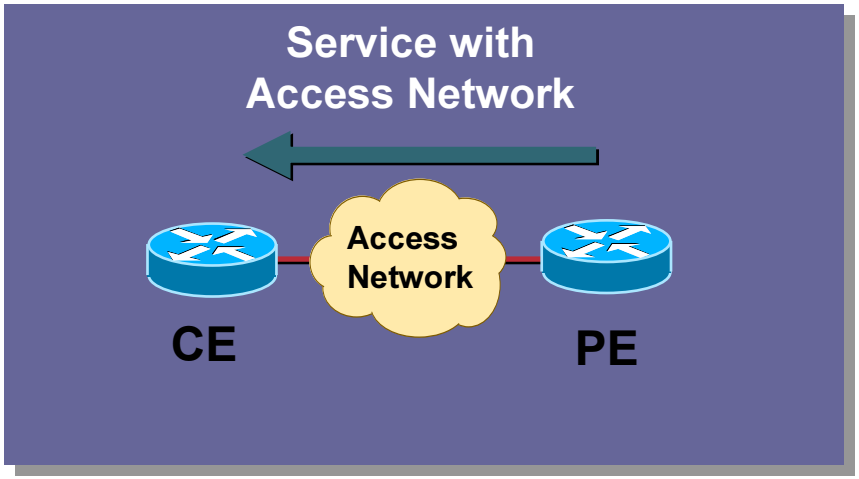
<irrelevant>

PE
Input Policy

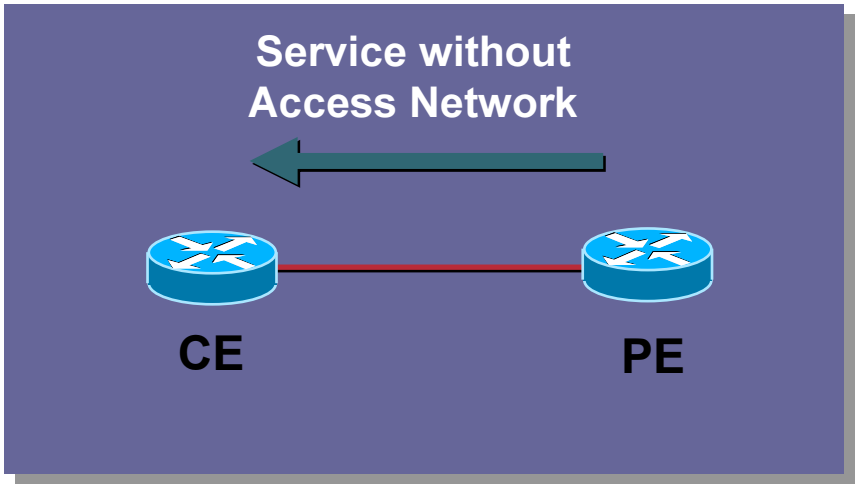
Policing

[Marking]

Traffic Leaving Service Provider Network

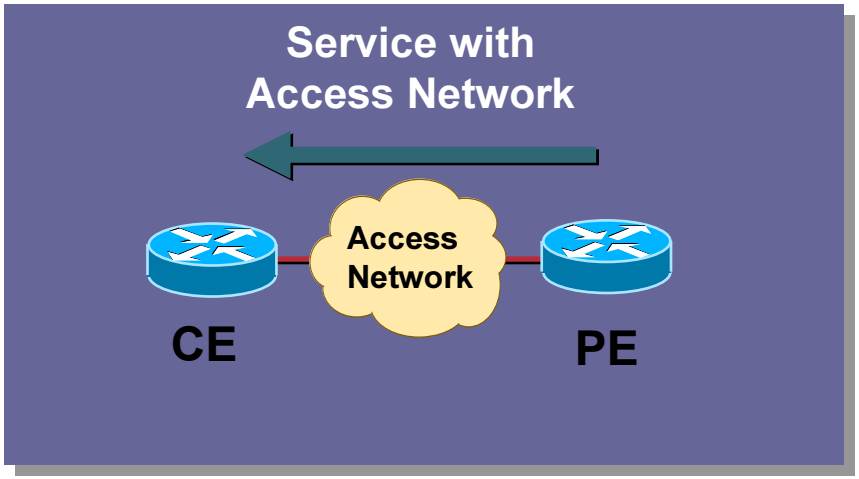


- SP enforces SLA on access network preferably
- Access network should serve packets according to their marking (class / drop precedence) where applicable



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

Traffic Leaving Service Provider Network



CE
Input Policy

<irrelevant>

Access
Network
Output Policy

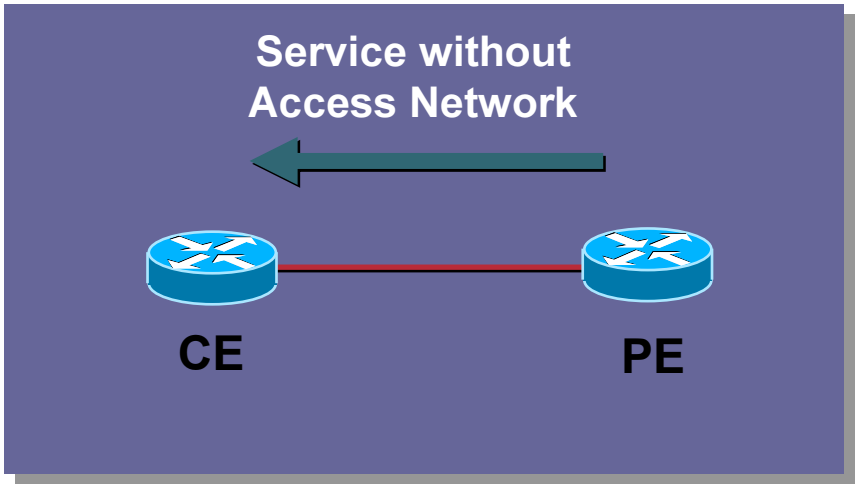
Queuing (LLQ)

Dropping (WRED)

[Shaping]

PE
Output Policy

<optional>



CE
Input Policy

<irrelevant>

PE
Input Policy

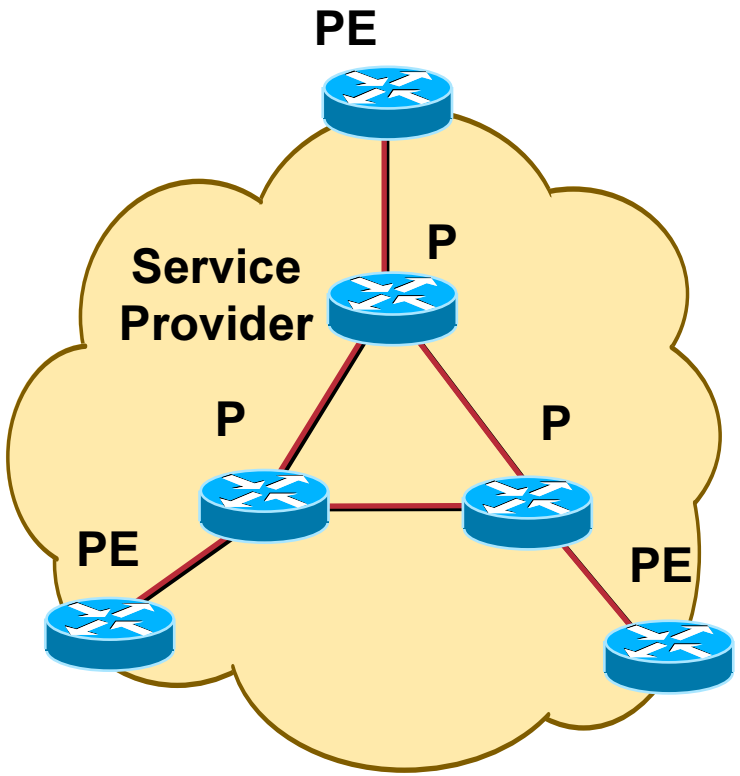
Queuing (LLQ)

WRED

[shaping]

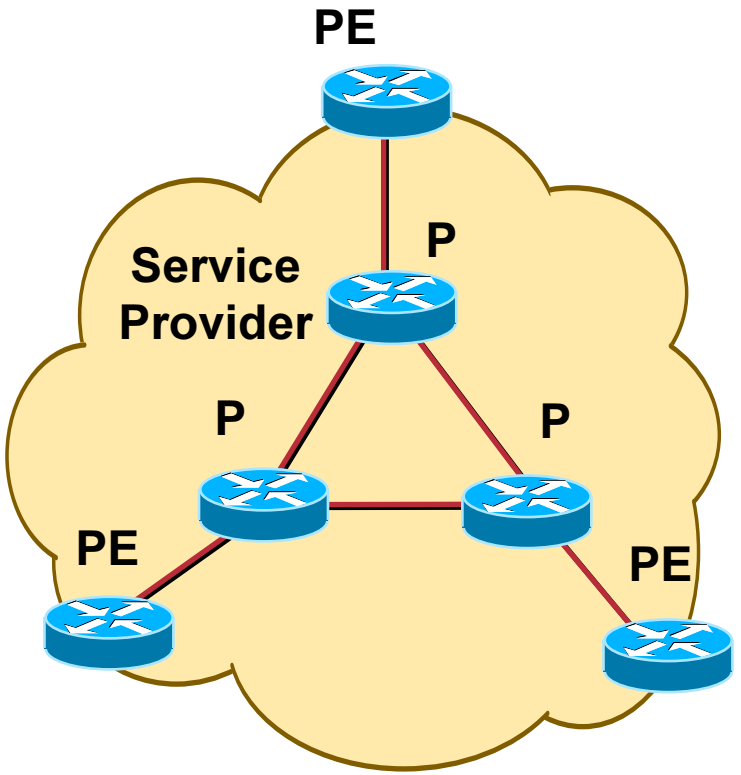
Now the Easy Part…

- 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



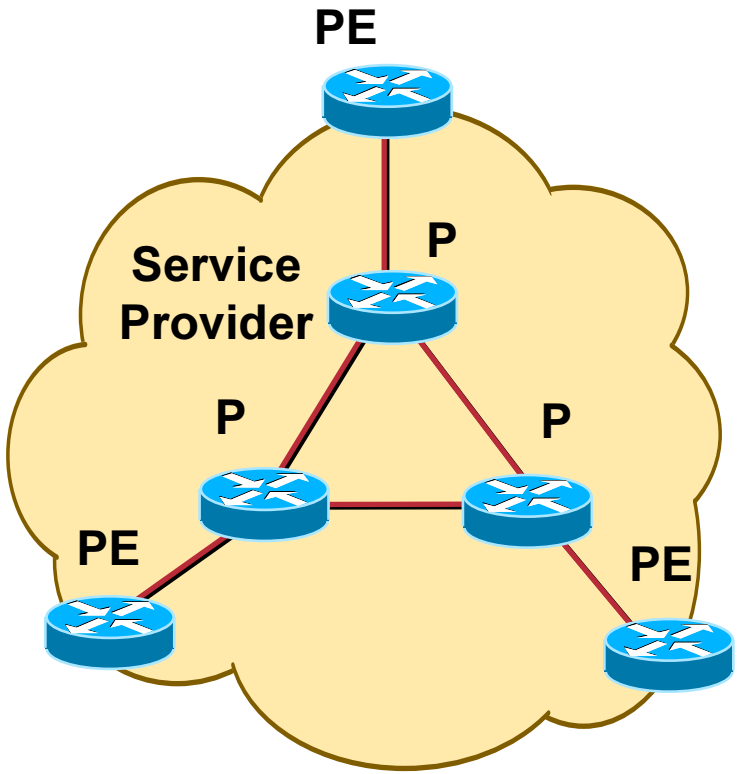
Limitations of Over-Provisioning

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



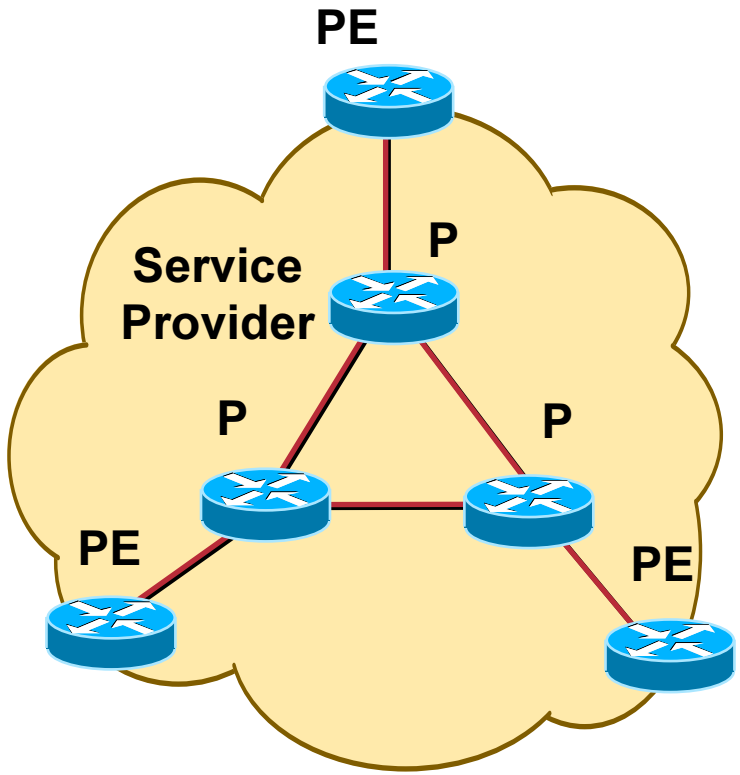
Benefits of DiffServ in the Backbone

- 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)

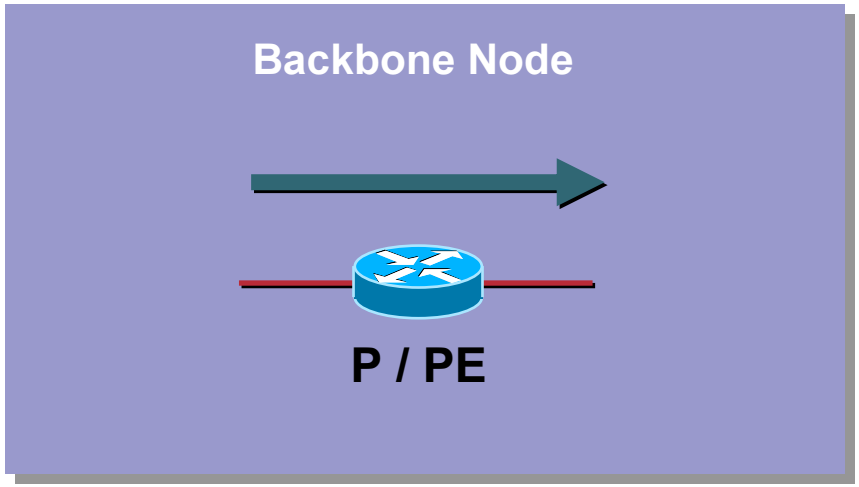


Backbone QoS Design Recommendations

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

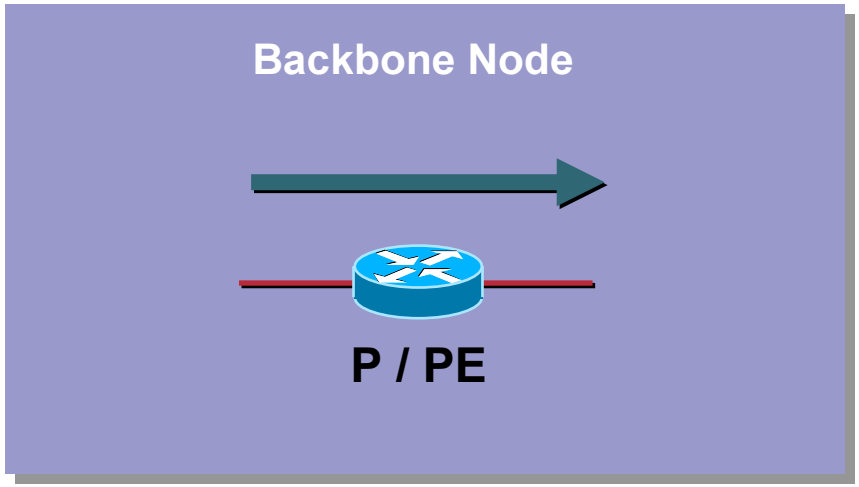


Traffic through Backbone Node



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

Traffic through Backbone Node



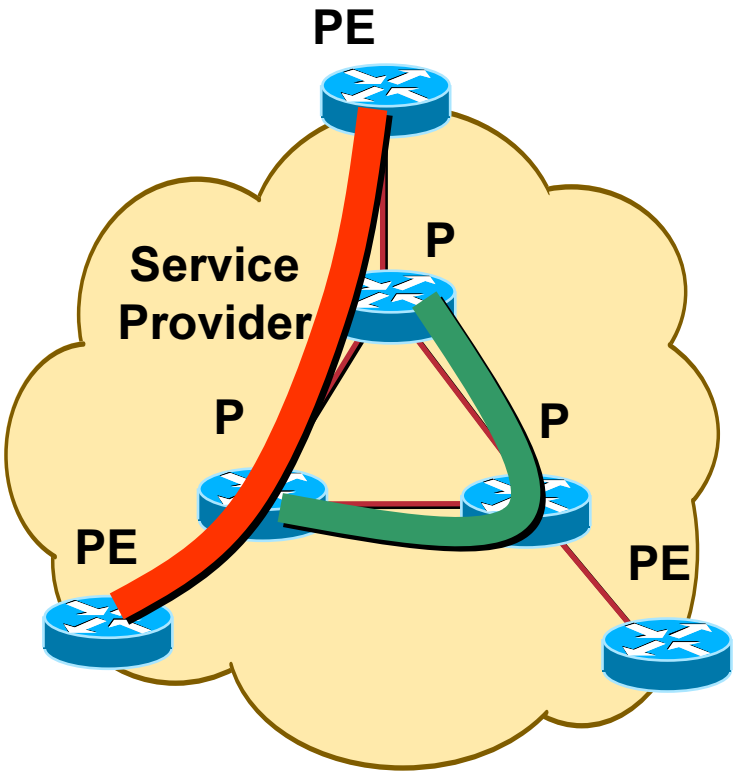
PE
Output Policy

LLQ

WRED

Further Enhancing the SLA with MPLS TE

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



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

References

- **QoS**

  http://www.cisco.com/go/qos

- **MPLS**

  http://www.cisco.com/go/mpls

- **Cisco IOS Software Release 12.4T New Feature Documentation**

  http://www.cisco.com/warp/public/732/releases/release124/124t/

- **Account teams have internal test result and detailed designs**