



# Advanced Campus QoS Design

BRKCAM-3006



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**Cisco Networkers**  
**2007**

# HOUSEKEEPING

- We value your feedback, don't forget to complete your online session evaluations after each session and complete the Overall Conference Evaluation which will be available online from Friday.
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- Please remember this is a 'No Smoking' venue!
- Please switch off your mobile phones!
- Please remember to wear your badge at all times including the Party!
- Do you have a question? Feel free to ask them during the Q&A section or write your question on the Question form given to you and hand it to the Room Monitor when you see them holding up the Q&A sign.

# Agenda

- QoS Best Practices (6-Slide Review)
- Campus QoS Design Considerations
- Catalyst 2960/3560/3750 & 3650-E/3750-E QoS Design
- Catalyst 4500 & 4948 QoS Design
- Catalyst 6500 QoS Design
- Summary (At-A-Glance Summaries)
- Appendix A: Catalyst 2950 QoS Design
- Appendix B: Catalyst 3550 QoS Design

# QoS Best Practices

## 6-Slide Review



# General QoS Design Principles

## *Start with the Objectives: Not the Tools*

- Clearly define the organizational objectives
  - Protect voice? video? data? DoS/worm mitigation?
- Assign as few applications as possible to be treated as “mission-critical”
- Seek executive endorsement of the QoS objectives prior to design and deployment
- Determine how many classes of traffic are required to meet the organizational objectives
  - More classes = more granular service-guarantees

# Classification and Marking Design

## *Where and How Should Marking Be Done?*

- QoS policies (in general) should always be performed in hardware, rather than software, whenever a choice exists
- Classify and mark applications as close to their sources as technically and administratively feasible
- Use DSCP markings whenever possible
- Follow standards-based DSCP PHBs to ensure interoperation and future expansion

[RFC 2474 Class Selector Code Points](#)

[RFC 2597 Assured Forwarding Classes](#)

[RFC 3246 Expedited Forwarding](#)

[RFC 3662 A Lower Effort PDP \(Scavenger\)](#)

[RFC 4594 Configuration Guidelines for DiffServ Classes](#)

# Classification and Marking Design

## QoS Baseline Marking Recommendations

Application	L3 Classification			L2
	IPP	PHB	DSCP	CoS
Routing	6	CS6	48	6
Voice	5	EF	46	5
Video Conferencing	4	AF41	34	4
Streaming Video	4	CS4	32	4
Mission-Critical Data	3	AF31*	26	3
Call Signaling	3	CS3*	24	3
Transactional Data	2	AF21	18	2
Network Management	2	CS2	16	2
Bulk Data	1	AF11	10	1
Best Effort	0	0	0	0
Scavenger	1	CS1	8	1

# Classification and Marking Design

## *RFC 4594 Configuration Guidelines for DiffServ Service Classes*

Application	L3 Classification		IETF
	PHB	DSCP	RFC
Network Control	CS6	48	RFC 2474
VoIP Telephony	EF	46	RFC 3246
Call Signaling	CS5	40	RFC 2474
Multimedia Conferencing	AF41	34	RFC 2597
Real-Time Interactive	CS4	32	RFC 2474
Multimedia Streaming	AF31	26	RFC 2597
Broadcast Video	CS3	24	RFC 2474
Low-Latency Data	AF21	18	RFC 2597
OAM	CS2	16	RFC 2474
High-Throughput Data	AF11	10	RFC 2597
Best Effort	DF	0	RFC 2474
Low-Priority Data	CS1	8	RFC 3662



# Policing Design Principles

## *Where and How Should Policing Be Done?*

- Police traffic flows as close to their sources as possible
- Perform markdown according to standards-based rules, whenever supported

RFC 2597 specifies how assured forwarding traffic classes should be marked down (AF11 → AF12 → AF13) which should be done whenever DSCP-based WRED is supported on egress queues

Cisco Catalyst platforms currently do not support DSCP-based WRED, so Scavenger-class remarking is a viable alternative

Additionally, non-AF classes do not have a standards-based markdown scheme, so Scavenger-class remarking is a viable option

# Queuing Design Principles

## *Where and How Should Queuing Be Done?*

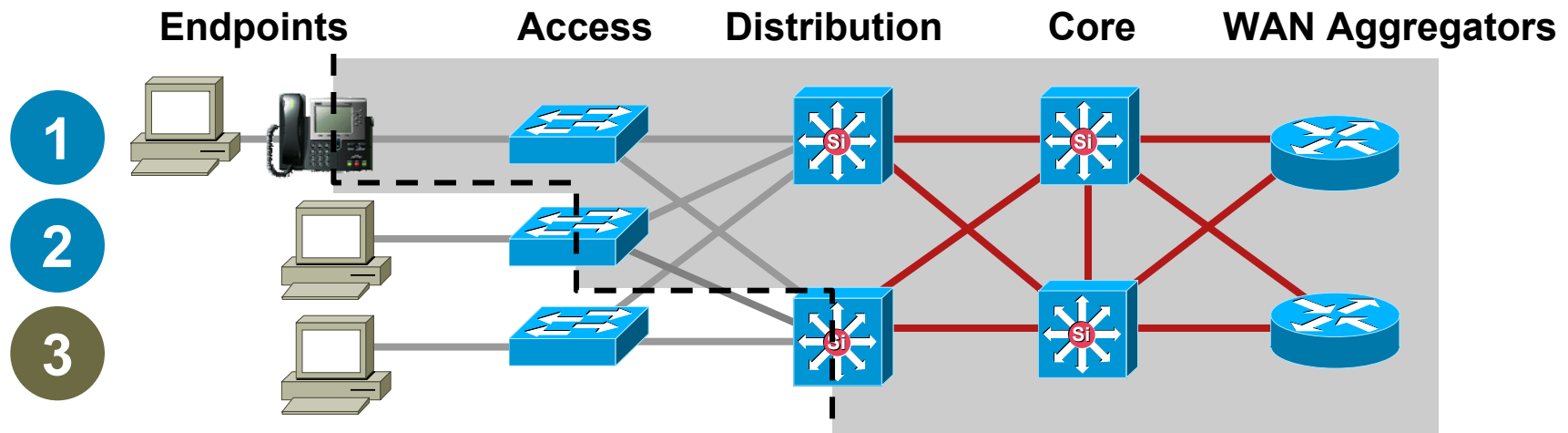
- The only way to provide service **guarantees** is to enable queuing at any node that has the potential for congestion
  - Regardless of how rarely—in fact—this may occur
- At least 25 percent of a link's bandwidth should be reserved for the default Best Effort class
- Limit the amount of strict-priority queuing to 33 percent of a link's capacity
- Whenever a Scavenger queuing class is enabled, it should be assigned a minimal amount of bandwidth
- To ensure consistent PHBs, configure consistent queuing policies in the Campus + WAN + VPN, according to platform capabilities
- Enable WRED on all TCP flows, whenever supported
  - Preferably DSCP-based WRED

# Campus QoS Design Considerations



# Campus QoS Considerations

## *Establishing Trust Boundaries*



**Trust Boundary**

- 1** Optimal Trust Boundary: Trusted Endpoint
- 2** Optimal Trust Boundary: Untrusted Endpoint
- 3** Suboptimal Trust Boundary

# Campus QoS Considerations

## *Endpoints and Endpoint Trust-Categories*

### Endpoints

- Analog gateways
- IP-conferencing stations
- Videoconferencing gateways and systems
- Video surveillance units
- Wireless access points
- Wireless IP phones
- Servers
- Client PCs

### Endpoint Trust-Categories

- Trusted endpoints
- Untrusted endpoints
- Conditionally-trusted endpoints

# Campus QoS Considerations

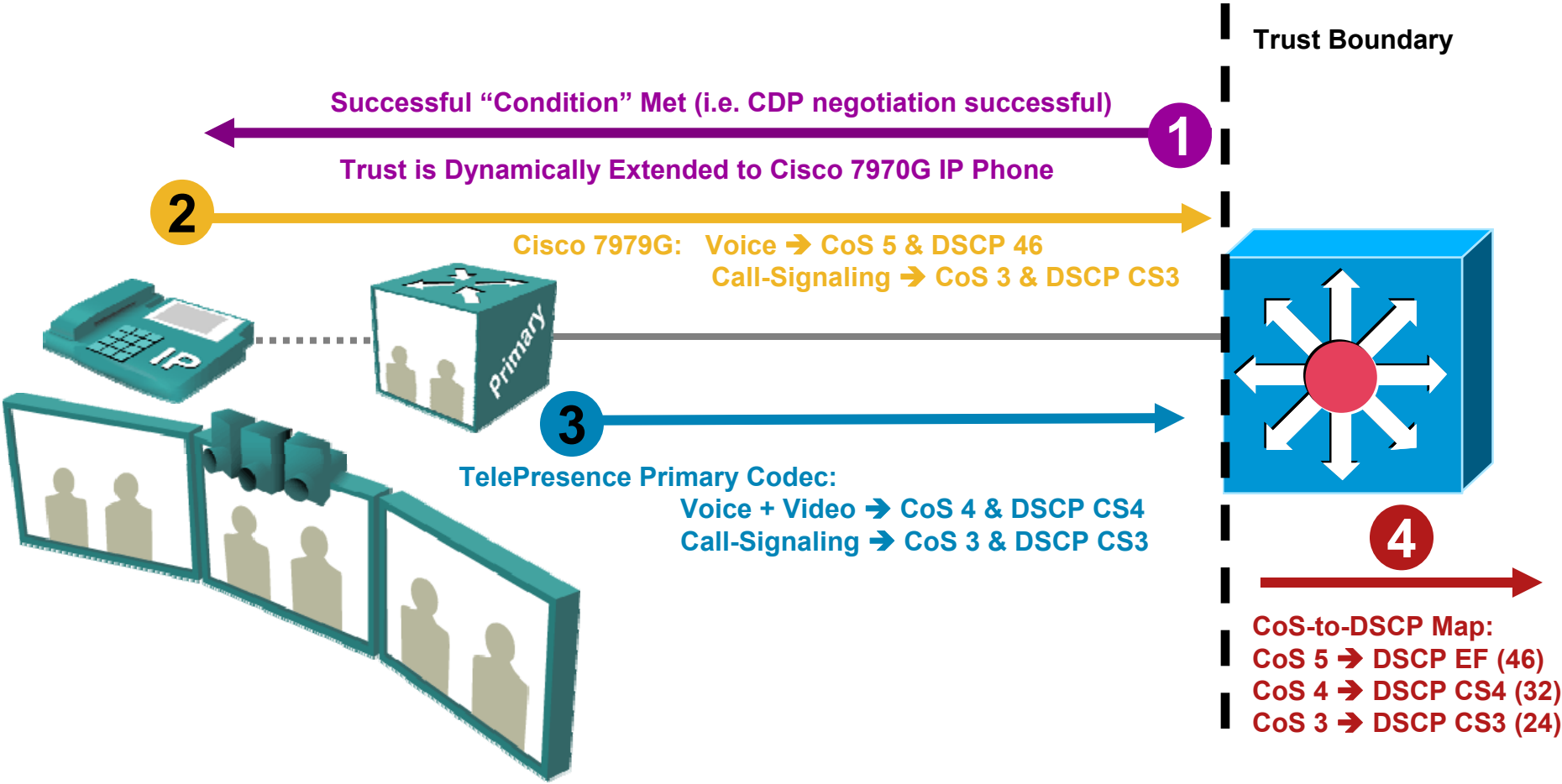
## Conditional-Trust Boundary Extension and Operation



- 1** Switch and Phone Exchange CDP; Trust Boundary Is Extended to IP Phone
- 2** Phone Sets CoS 5 for VoIP and CoS 3 for Call-Signaling Traffic
- 3** Phone Rewrites CoS from PC Port to 0
- 4** Switch Trusts CoS from Phone and Maps CoS → DSCP for Output Queuing

# Campus QoS Considerations

## Conditional-Trust Boundary for Cisco TelePresence



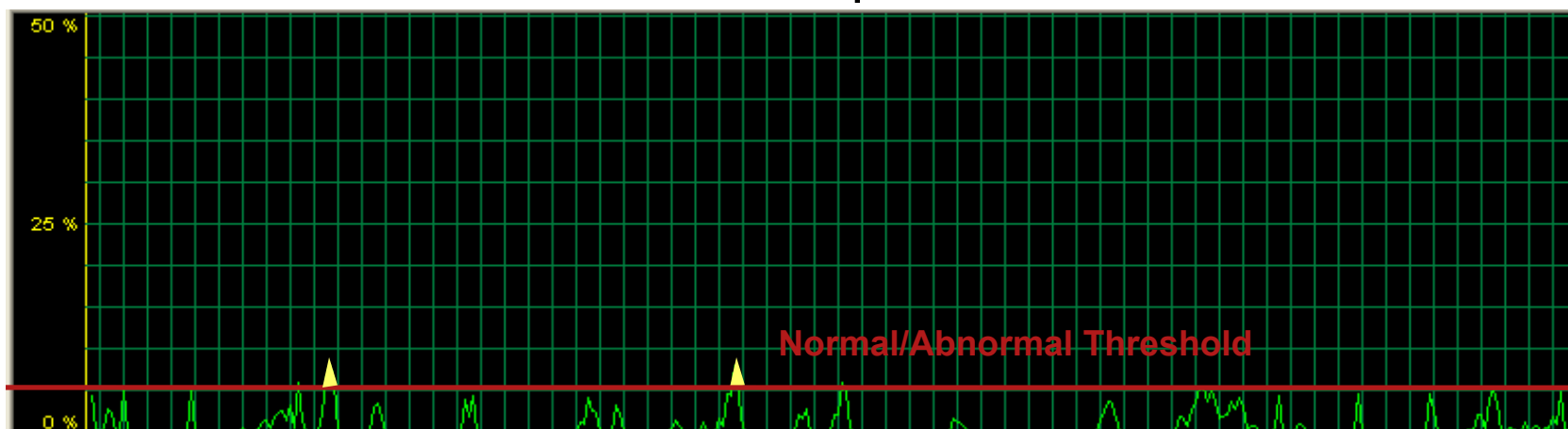
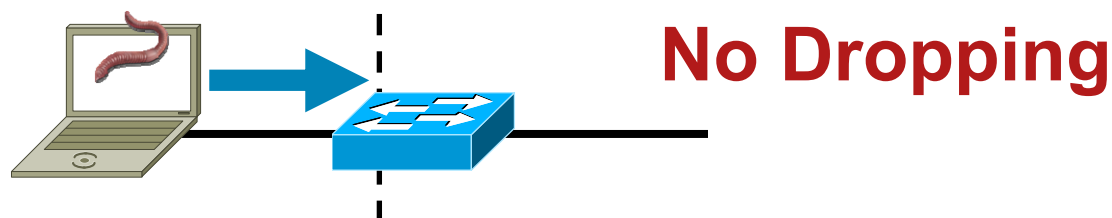
**Note:** As 2-6 data ports are available for PC connections (as part of the TelePresence tables), it is recommended to disable the PC port in the back of the Cisco Unified 7970G IP Phone (from within CallManager)

# Campus QoS Considerations

## Scavenger-Class QoS Operation – Part One

- All end systems generate traffic spikes, but worms create sustained spikes
- Normal/abnormal threshold set at approximately 95% confidence
- **No dropping at campus access-edge**; only remarking

### Policing and Remarking (If Necessary)

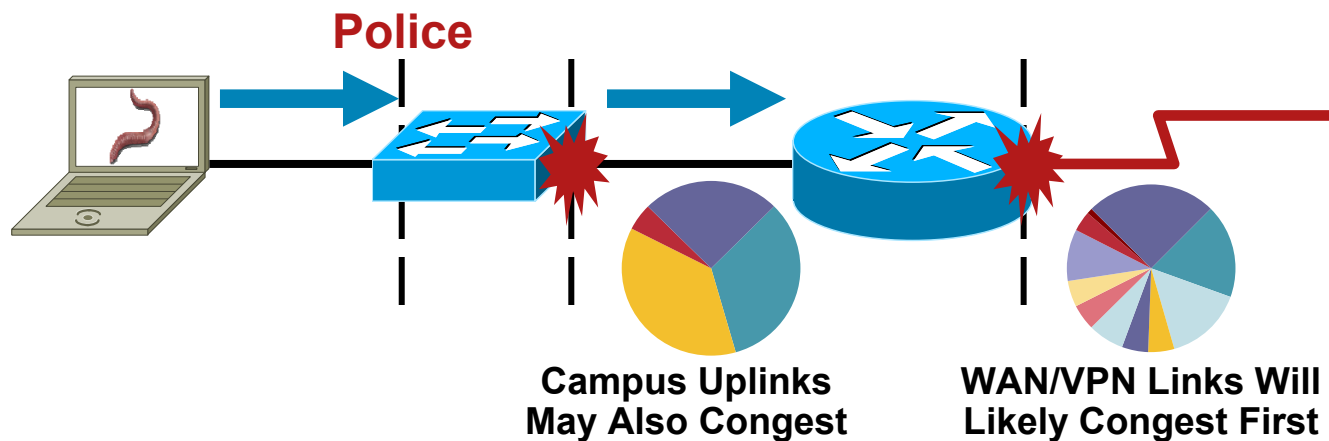




# Campus QoS Considerations

## Scavenger-Class QoS Operation – Part Two

- Queuing only engages if links become congested
  - When congestion occurs, drops will also occur
- Scavenger class QoS allows for increased intelligence in the dropping decision
  - 'Abnormal' traffic flows will be dropped aggressively
  - 'Normal' traffic flows will continue to receive network service



**Queuing Will Engage When Links Become Congested and Traffic Previously Marked as Scavenger Is Dropped Aggressively**

# Campus QoS Considerations

## *Access Edge Trust Models*

- Trusted endpoint model
- AutoQoS—VoIP model
- IP Phone + PC + Scavenger model

# Campus QoS Considerations

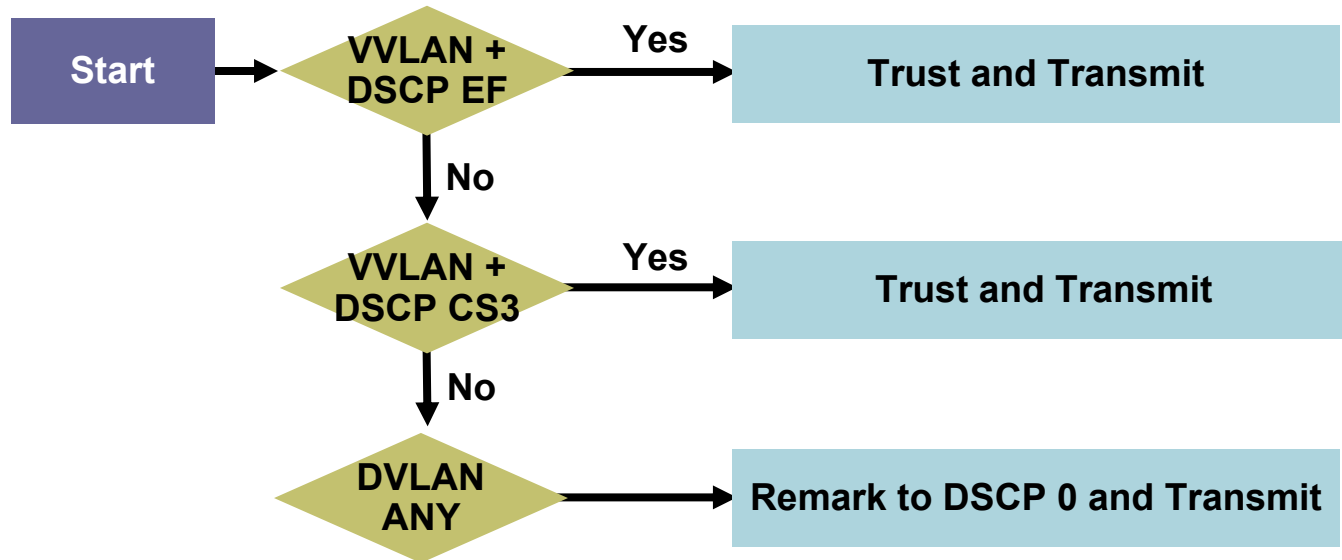
## *Access-Edge Trusted-Endpoint Model*

- DSCP from endpoint is accepted and admitted onto the network unaltered
- Policing is optional



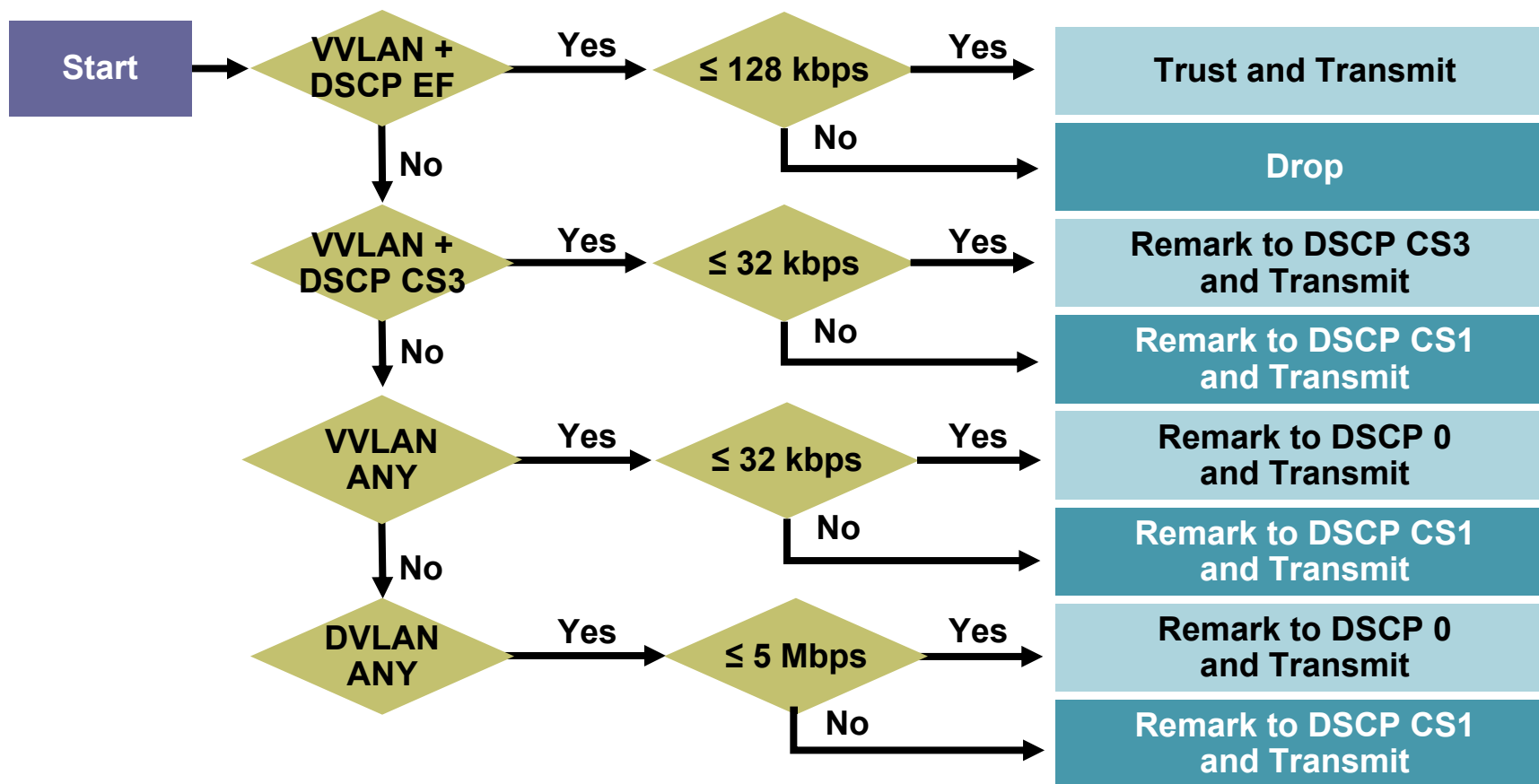
# Campus QoS Considerations

## *Access-Edge AutoQoS—VoIP Model*



# Campus QoS Design Considerations

## Access-Edge IP Phone + PC + Scavenger Model



# Campus QoS Design Considerations

## Catalyst Hardware Queuing

- All Catalyst switches perform queuing in hardware
- The number of queues are fixed, but have some configurable parameters
- All Catalyst queuing structures are expressed as:

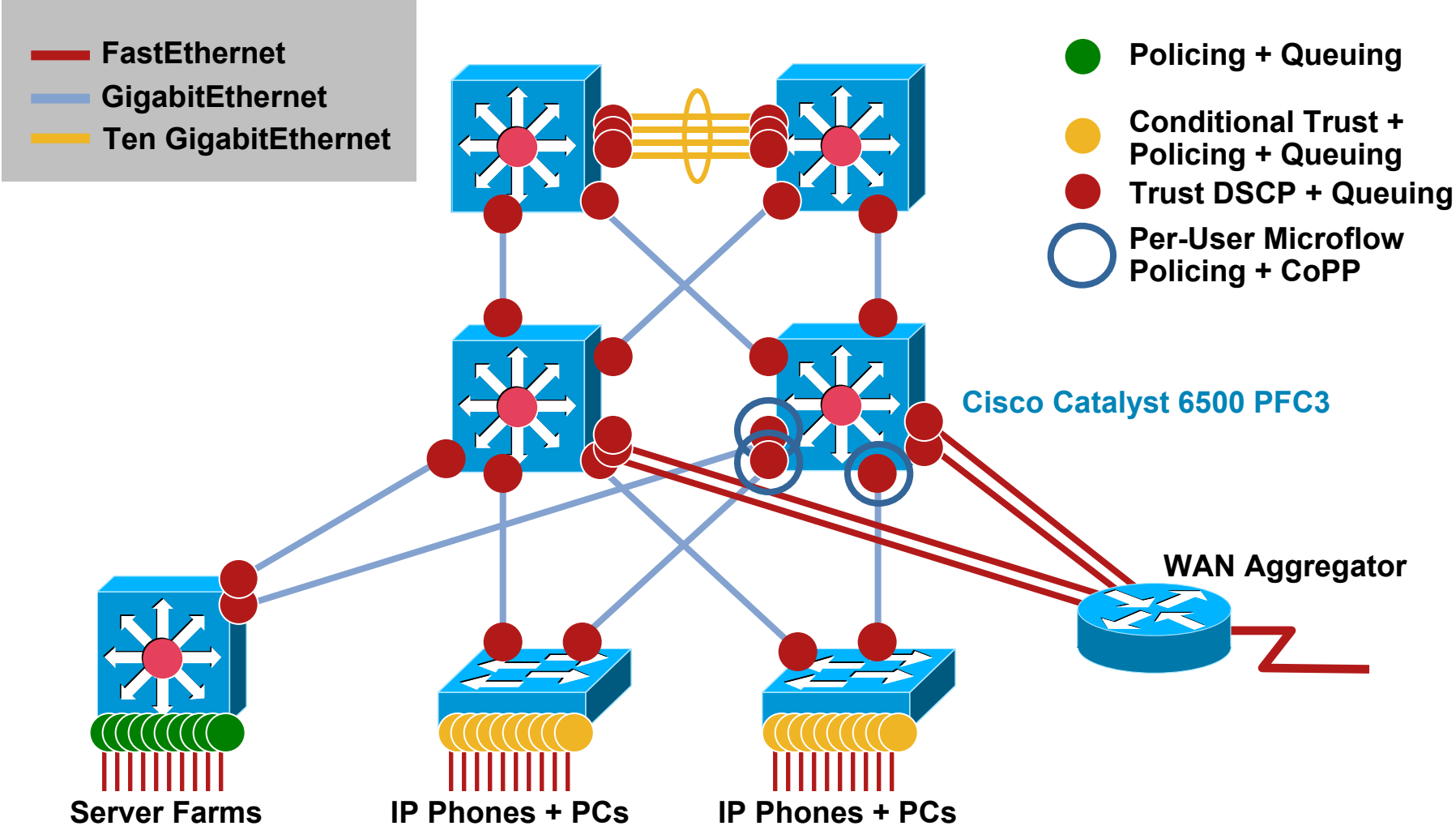
**1PxQyT**

**1P3Q8T (example)**

**1P** represents **1** strict priority queue  
**3Q** represents **3** non-priority queues  
**8T** represents **8** thresholds per queue

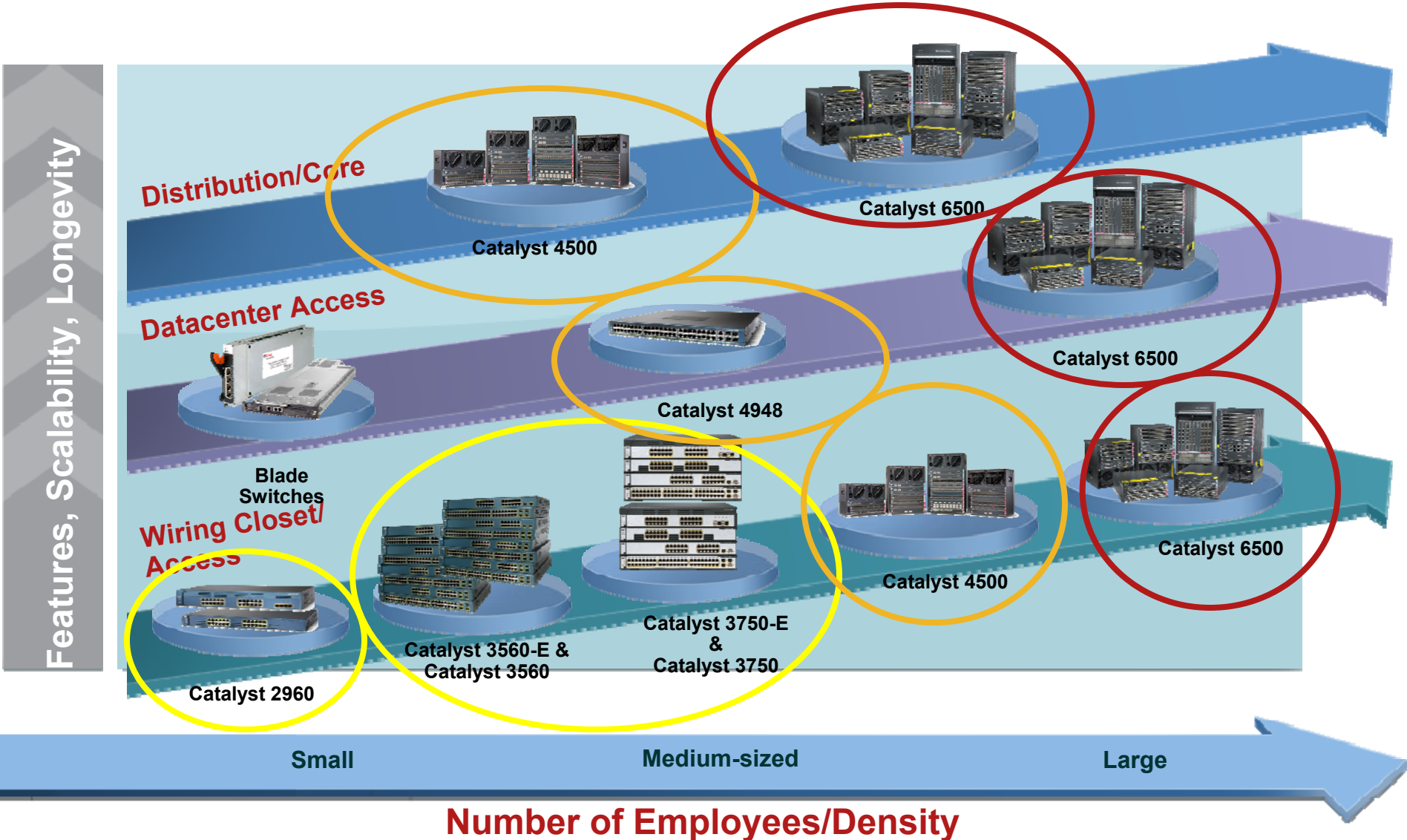
# Campus QoS Considerations

## Where Is QoS Required Within the Campus?



# Campus QoS Considerations

## Catalyst Switch-Family Platforms





# Cisco Catalyst 2960/3560/3750 & 3560-E/3750-E QoS Design



**Discover the C3750-E and C3560-E at the World of Solutions**

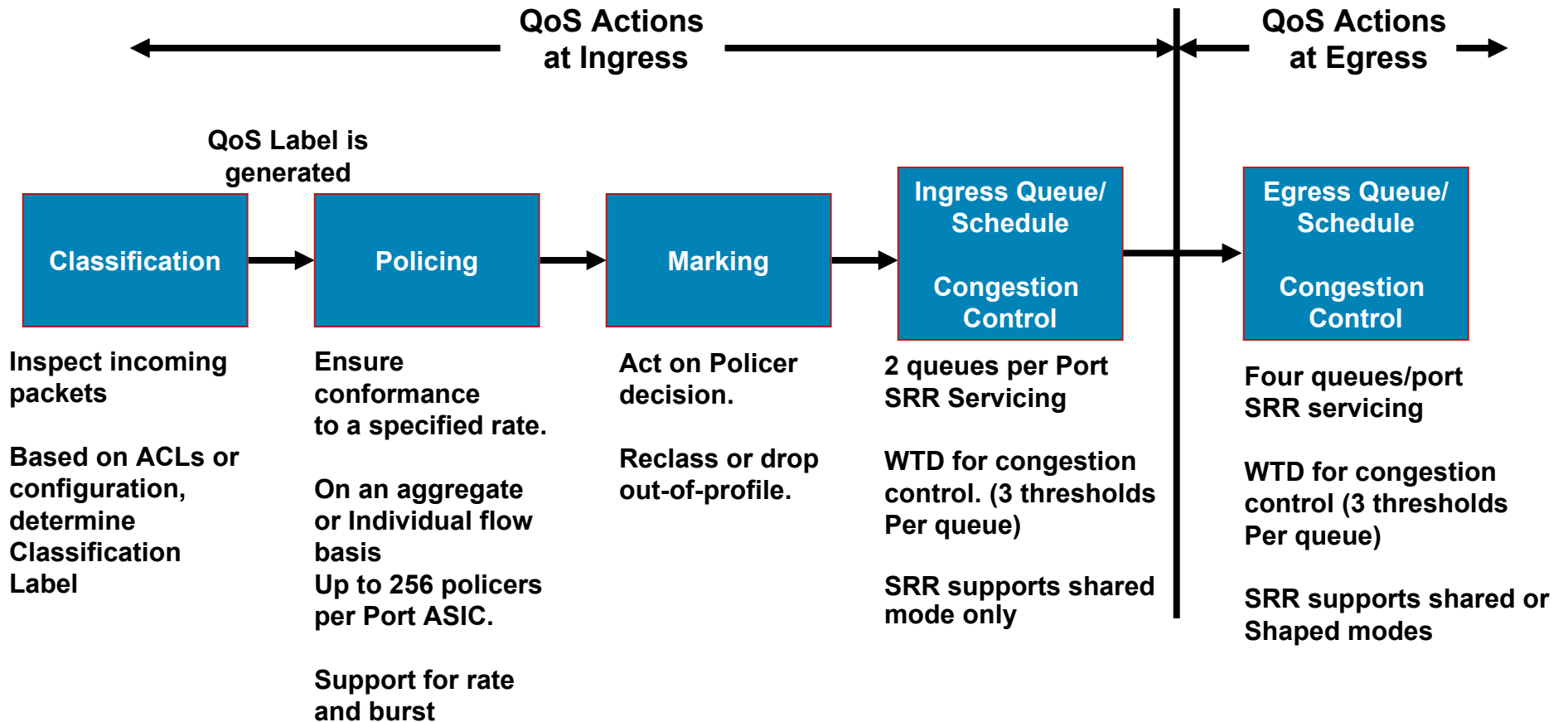
# Catalyst 2960/3560/3750 + 3560-E & 3750-E

## *Platform-Specific QoS Design Considerations*

- QoS disabled by default
- Full DSCP-range is supported
- Classification can be done by trust states, standard and advanced IP ACLs, or MAC ACLs
- Supports classification, marking, and policing by port or by Switched Virtual Interface (SVI) via hierarchical class maps on Cisco Catalyst 2970, 3650, and 3750 (not yet on Cisco Catalyst 2960)
- Minimum policing granularity is 8 kbps
- Supports 4Q3T queuing or 1P3Q3T queuing (Egress)
  - Q1 can be configured as a priority queue
  - Queues can operate in shaped or sharing modes
  - Each interface can be assigned to one of two queue-sets
  - Congestion avoidance algorithm is Weighted Tail Drop (WTD)
- Catalyst 3550, 2950G, 2950T, 2950 LRE are End-of-Life.

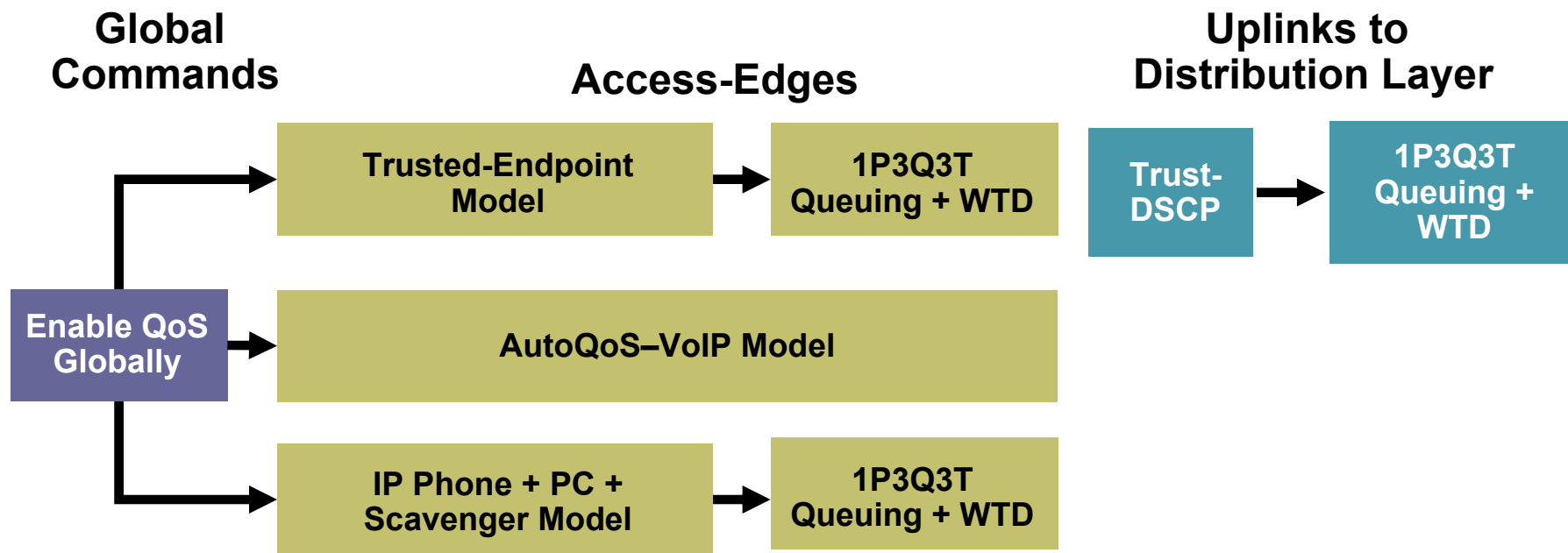
# Catalyst 2960/3560/3750 + 3560-E & 3750-E

## QoS Model



# Catalyst 2960/3560/3750 + 3560-E & 3750-E

## Access-Layer QoS Design



# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## Enabling QoS + Trusted Endpoint Example

```
CAT2970#show mls qos
QoS is disabled                                ! By default QoS is disabled

CAT2970#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
CAT3550(config)#mls qos                        ! Enables QoS globally
CAT3550(config)#exit
CAT3550#

CAT2970#show mls qos
QoS is enabled                                ! Verifies that QoS is enabled globally
CAT3550#

CAT2970(config)#interface range FastEthernet0/1 - 48
CAT2970(config-if)#mls qos trust dscp        ! Trusted Endpoint Example
```

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## AutoQoS VoIP Model Example



CAT2970(config-if)#auto qos voip cisco-phone

### Options:

auto qos voip cisco-phone

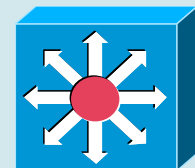
auto qos voip cisco-software

auto qos voip trust

```

mls qos srr-queue output cos-map queue 1 threshold 3 5
mls qos srr-queue output cos-map queue 2 threshold 3 3 6 7
mls qos srr-queue output cos-map queue 3 threshold 3 2 4
mls qos srr-queue output cos-map queue 4 threshold 2 1
mls qos srr-queue output cos-map queue 4 threshold 3 0
mls qos srr-queue output dscp-map queue 1 threshold 3 40 41 42 43 44 45 46 47
mls qos srr-queue output dscp-map queue 2 threshold 3 24 25 26 27 28 29 30 31
mls qos srr-queue output dscp-map queue 2 threshold 3 48 49 50 51 52 53 54 55
mls qos srr-queue output dscp-map queue 2 threshold 3 56 57 58 59 60 61 62 63
mls qos srr-queue output dscp-map queue 3 threshold 3 16 17 18 19 20 21 22 23
mls qos srr-queue output dscp-map queue 3 threshold 3 32 33 34 35 36 37 38 39
mls qos srr-queue output dscp-map queue 4 threshold 1 8
mls qos srr-queue output dscp-map queue 4 threshold 2 9 10 11 12 13 14 15
mls qos srr-queue output dscp-map queue 4 threshold 3 0 1 2 3 4 5 6 7
mls qos queue-set output 1 threshold 1 138 138 92 138
mls qos queue-set output 1 threshold 1 138 138 92 400
mls qos queue-set output 1 threshold 2 36 77 100 318
mls qos queue-set output 1 threshold 4 20 50 67 400
mls qos queue-set output 2 threshold 1 149 149 100 149
mls qos queue-set output 2 threshold 2 118 118 100 235
mls qos queue-set output 2 threshold 3 41 68 100 272
mls qos queue-set output 2 threshold 4 42 72 100 242
mls qos queue-set output 1 buffers 10 10 26 54
mls qos queue-set output 2 buffers 16 6 17 61
mls qos
!
!
interface GigabitEthernet0/1
srr-queue bandwidth share 10 10 60 20
srr-queue bandwidth shape 10 0 0 0
queue-set 2
mls qos trust device cisco-phone
mls qos trust cos
auto qos voip cisco-phone
!
!

```



Note: AutoQoS-VoIP on this family of switches does not automatically provision "priority-queue out"

It is highly recommended to manually include this interface-command after you have enabled AutoQoS-VoIP.

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## IP Phone + PC + Scavenger Model Example: Part One



```
CAT3750(config)#mls qos map cos-dscp 0 8 16 24 32 46 48 56
! Modifies CoS-to-DSCP mapping to map CoS 5 to DSCP EF
CAT3750(config)#mls qos map policed-dscp 0 24 to 8
! Excess VVLAN & DVLAN traffic will be remarked to Scavenger (CS1)

CAT3750(config)#
CAT3750(config)#
CAT3750(config)#class-map match-all VVLAN-VOICE
CAT3750(config-cmap)# match access-group name VVLAN-VOICE
CAT3750(config-cmap)#
CAT3750(config-cmap)#class-map match-all VVLAN-CALL-SIGNALING
CAT3750(config-cmap)# match access-group name VVLAN-CALL-SIGNALING
CAT3750(config-cmap)#
CAT3750(config-cmap)#class-map match-all VVLAN-ANY
CAT3750(config-cmap)# match access-group name VVLAN-ANY
CAT3750(config-cmap)#
CAT3750(config-cmap)#
```

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## IP Phone + PC + Scavenger Model Example: Part Two



```
CAT3750(config-cmap)#policy-map IPPHONE+PC-BASIC
CAT3750(config-pmap)#class VVLAN-VOICE
CAT3750(config-pmap-c)# set ip dscp 46                ! DSCP EF (Voice)
CAT3750(config-pmap-c)# police 128000 8000 exceed-action drop
                    ! Only one voice call is permitted per switchport VVLAN
CAT3750(config-pmap-c)#class VVLAN-CALL-SIGNALING
CAT3750(config-pmap-c)# set ip dscp 24                ! DSCP CS3 (Call-Signaling)
CAT3750(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
                    ! Out-of-profile Call-Signaling is marked down to Scavenger (CS1)
CAT3750(config-pmap-c)#class VVLAN-ANY
CAT3750(config-pmap-c)# set ip dscp 0
CAT3750(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
                    ! Unauthorized VVLAN traffic is marked down to Scavenger (CS1)
CAT3750(config-pmap-c)#class class-default
CAT3750(config-pmap-c)# set ip dscp 0
CAT3750(config-pmap-c)# police 5000000 8000 exceed-action policed-dscp-transmit
                    ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT3750(config-pmap-c)# exit
CAT3750(config-pmap)#exit
CAT3750(config)#
```



# Catalyst 2960/3560/3750 + 3650-E & 3750-E

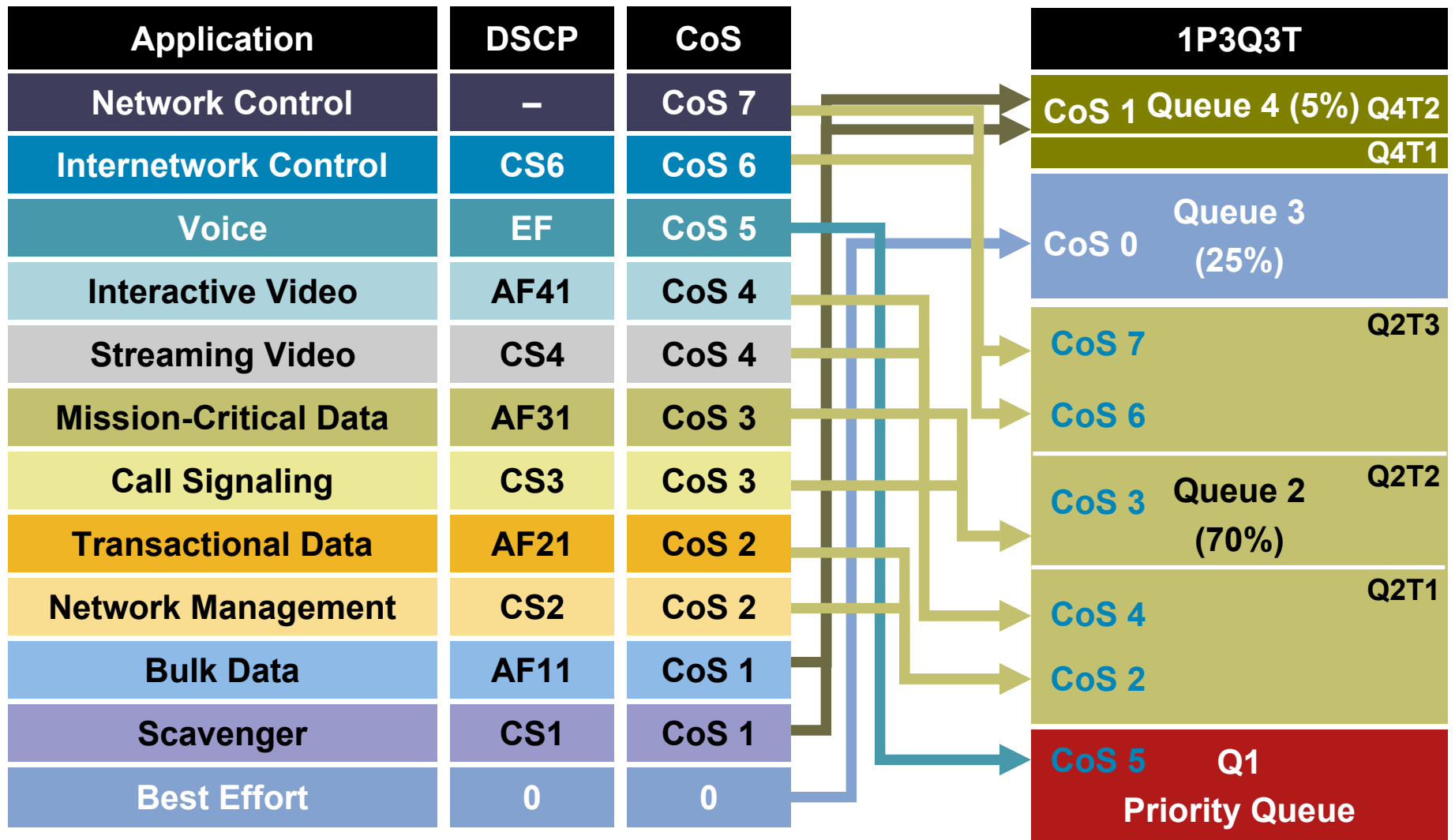
## IP Phone + PC + Scavenger Model Example: Part Three



```
CAT3750(config)#interface GigabitEthernet0/1
CAT3750(config-if)# switchport access vlan 10                ! DVLAN
CAT3750(config-if)# switchport voice vlan 110               ! VVLAN
CAT3750(config-if)# service-policy input IPPHONE+PC-BASIC
CAT3750(config-if)#exit
CAT3750(config)#
CAT3750(config)#
CAT3750(config)#ip access-list extended VVLAN-VOICE
CAT3750(config-ext-nacl)#permit udp 10.1.110.0 0.0.0.255 any
                        range 16384 32767
                        ! Voice is matched by VVLAN subnet and VoIP UDP port-range
CAT3750(config-ext-nacl)#exit
CAT3750(config)#
CAT3750(config)#ip access-list extended VVLAN-CALL-SIGNALING
CAT3750(config-ext-nacl)#permit tcp 10.1.110.0 0.0.0.255 any
                        range 2000 2002
                        ! Call-Signaling is matched by VVLAN subnet and TCP port-range
CAT3750(config-ext-nacl)#exit
CAT3750(config)#
CAT3750(config)#ip access-list extended VVLAN-ANY
CAT3750(config-ext-nacl)# permit ip 10.1.110.0 0.0.0.255 any
                        ! Matches all other traffic sourced from the VVLAN subnet
CAT3750(config-ext-nacl)#end
CAT3750#
```

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## Queuing Design: 1P3Q3T



# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## Queuing Design: 1P3Q3T – Part One

```
CAT3750(config)#mls qos srr-queue output cos-map queue 1 threshold 3 5
! Maps CoS 5 to Queue 1 Threshold 3 (Voice gets all of Queue 1)
CAT3750(config)#mls qos srr-queue output cos-map queue 2 threshold 1 2 4
! Maps CoS 2 and CoS 4 to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output cos-map queue 2 threshold 2 3
! Maps CoS 3 to Queue 2 Threshold 2
CAT3750(config)#mls qos srr-queue output cos-map queue 2 threshold 3 6 7
! Maps CoS 6 and CoS 7 to Queue 2 Threshold 3
CAT3750(config)#mls qos srr-queue output cos-map queue 3 threshold 3 0
! Maps CoS 0 to Queue 3 Threshold 3 (Best Efforts gets all of Q3)
CAT3750(config)#mls qos srr-queue output cos-map queue 4 threshold 3 1
! Maps CoS1 to Queue 4 Threshold 3 (Scavenger/Bulk gets all of Q4)
CAT3750(config)#
```

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## Queuing Design: 1P3Q3T – Part Two

```
CAT3750(config)#mls qos srr-queue output dscp-map queue 1 threshold 3 46
! Maps DSCP EF (Voice) to Queue 1 Threshold 3
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 1 16
! Maps DSCP CS2 (Network Management) to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 1 18 20 22
! Maps DSCP AF21, AF22, AF23 (Transactional Data) to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 1 26
! Maps DSCP AF31 (Mission-Critical Data) to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 1 32
! Maps DSCP CS4 (Streaming Video) to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 1 34 36 38
! Maps DSCP AF41, AF42, AF43 (Interactive-Video) to Queue 2 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 2 24
! Maps DSCP CS3 (Call-Signaling) to Queue 2 Threshold 2
CAT3750(config)#mls qos srr-queue output dscp-map queue 2 threshold 3 48 56
! Maps DSCP CS6 and CS7 (Network/Internetwork) to Queue 2 Threshold 3
CAT3750(config)#mls qos srr-queue output dscp-map queue 3 threshold 3 0
! Maps DSCP 0 (Best Effort) to Queue 3 Threshold 3
CAT3750(config)#mls qos srr-queue output dscp-map queue 4 threshold 1 8
! Maps DSCP CS1 (Scavenger) to Queue 4 Threshold 1
CAT3750(config)#mls qos srr-queue output dscp-map queue 4 threshold 3 10 12 14
! Maps DSCP AF11, AF12, AF13 (Bulk Data) to Queue 4 Threshold 3
CAT3750(config)#
```

# Catalyst 2960/3560/3750 + 3650-E & 3750-E

## Queuing Design: 1P3Q3T – Part Three

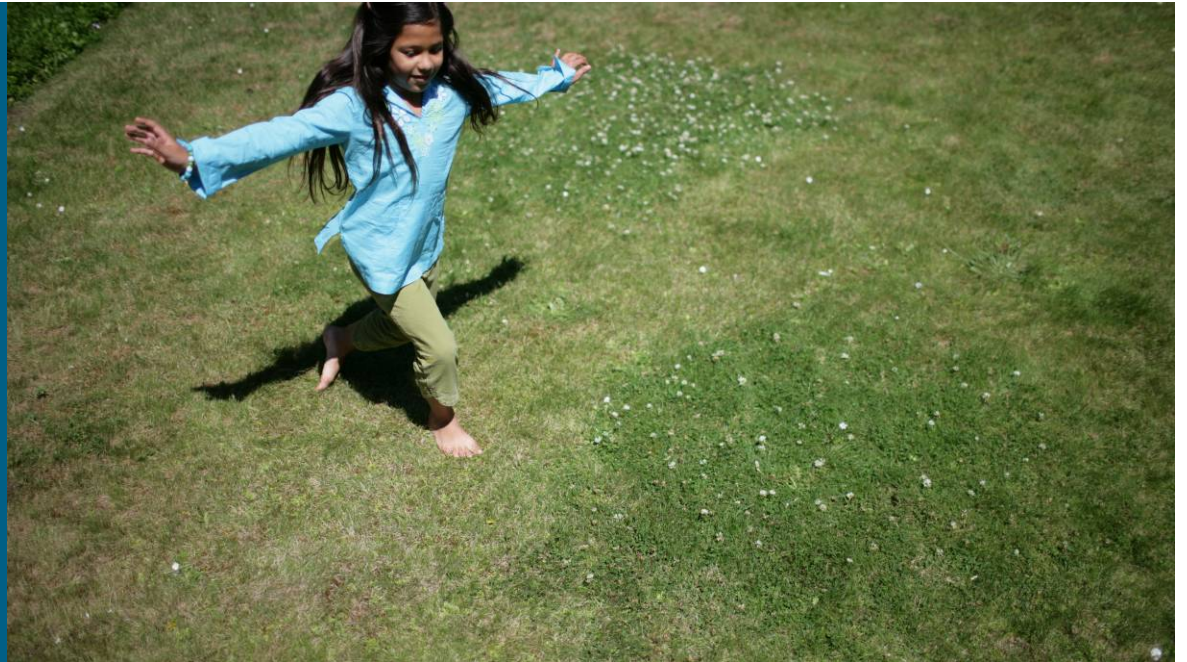
```
CAT3750(config)#mls qos queue-set output 1 threshold 2 70 80 100 100
! Sets Q2 Threshold 1 to 70% and Q2 Threshold 2 to 80%
CAT3750(config)#mls qos queue-set output 1 threshold 4 40 100 100 100
! Sets Q4 Threshold 1 to 40% and Q4 Threshold 2 to 100%
CAT3750(config)#

CAT3750(config)#interface range GigabitEthernet0/1 - 28
CAT3750(config-if-range)# queue-set 1
! Assigns interface to Queue-Set 1 (default)
CAT3750(config-if-range)# srr-queue bandwidth share 1 70 25 5
! Q2 gets 70% of remaining BW; Q3 gets 25% and Q4 gets 5%
CAT3750(config-if-range)# srr-queue bandwidth shape 3 0 0 0
! Q1 is limited to 30% of the total available BW
CAT3750(config-if-range)# priority-queue out
! Q1 is enabled as a PQ
CAT3750(config-if-range)#end
CAT3750#
```

# Catalyst 4500

(Sup II+ through Sup V-10GE)

# and 4948 QoS Design



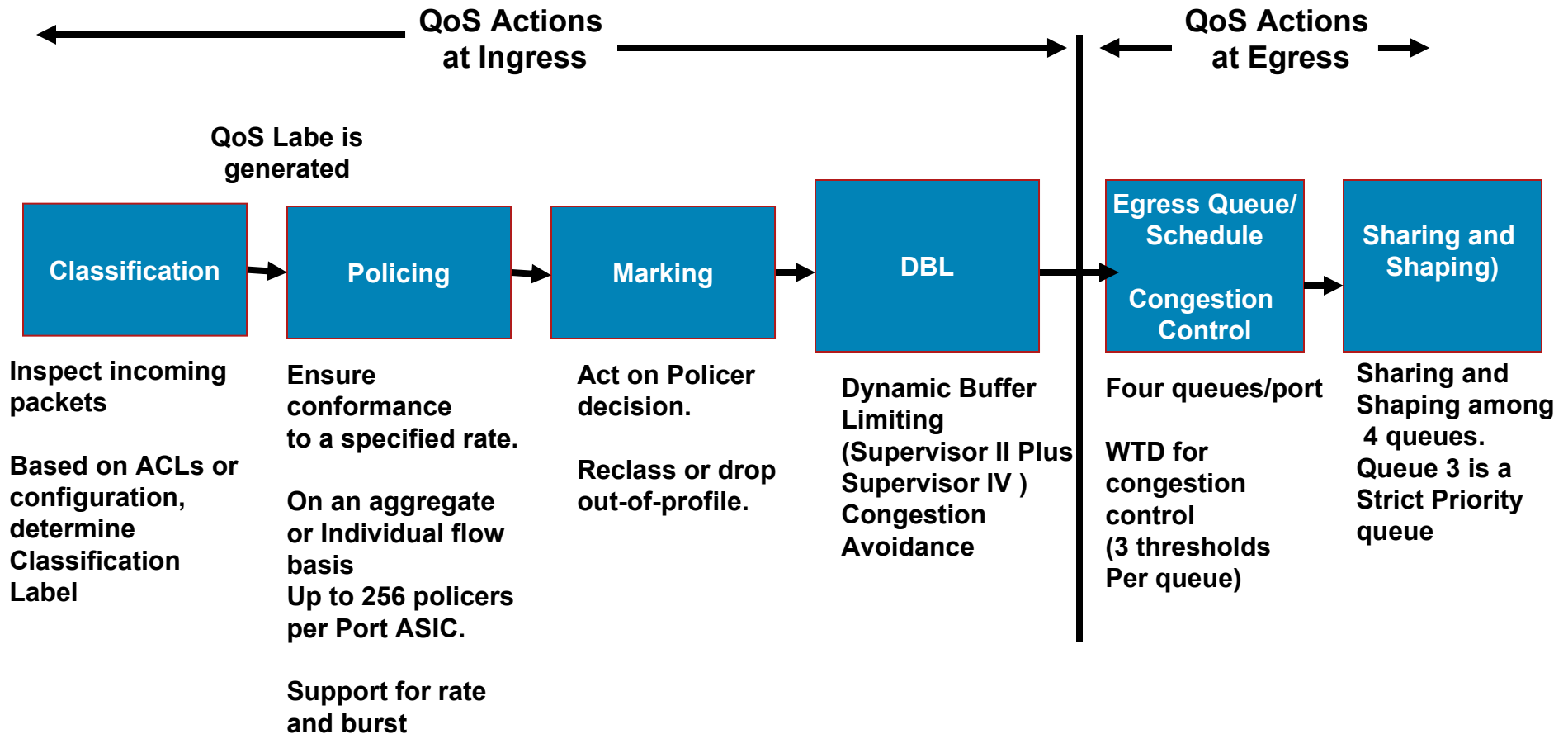
# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## *Platform-Specific QoS Design Considerations*

- QoS disabled by default
- Full DSCP-range is supported
- Classification can be done by trust states, standard and advanced IP ACLs, or MAC ACLs
- No “mls” prefix in command syntax
- Policing rates can use ‘k’, ‘m,’ or ‘g’ for kbps, mbps, or gbps
- Supports per-port/per-VLAN policing
- SupV-10GE supports User-Based Rate Limiting (UBRL)
- Minimum policing granularity is 8 kbps
- Supports 4Q1T queuing or 1P3Q1T queuing
  - Q3 can be configured as a priority queue
  - DSCP values can be mapped to queues
  - Supports bandwidth allocation and shaping on certain linecards  
(However shaping is not hierarchical)
  - Congestion avoidance algorithm is Dynamic Buffer Limiting (DBL)

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

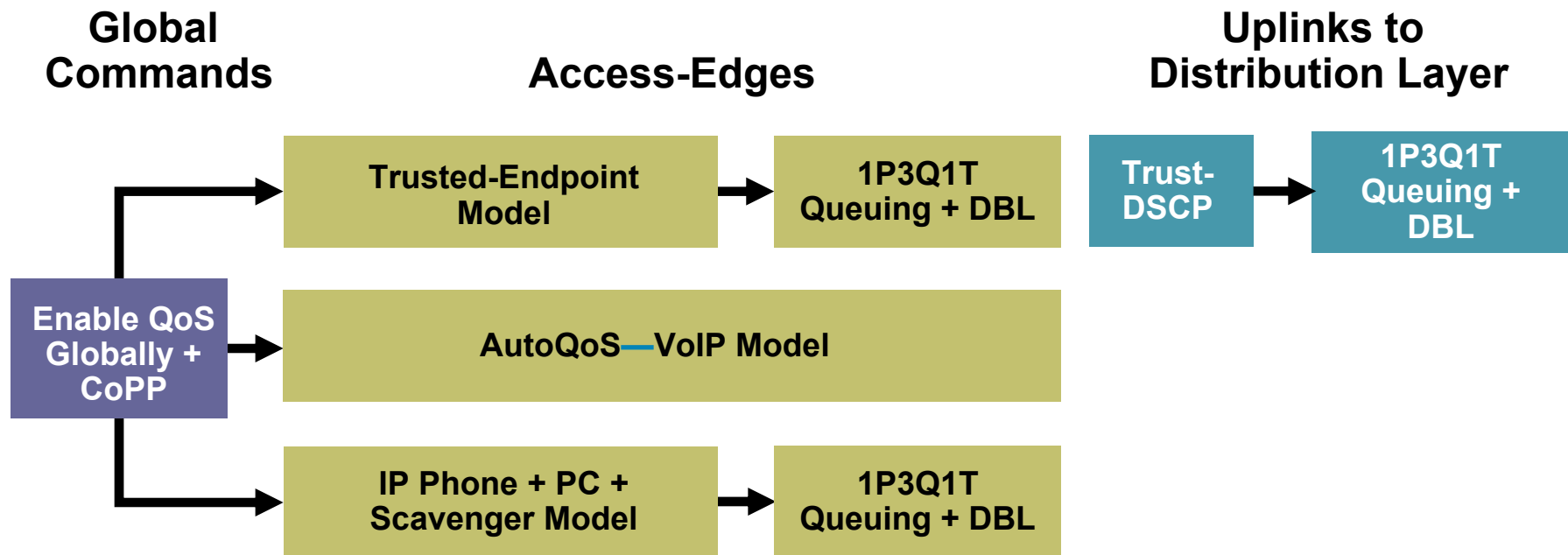
## QoS Model





# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Access-Layer QoS Design



# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Enabling QoS + Trusted Endpoint Example

```
CAT4500#show qos
QoS is disabled globally                ! By default QoS is disabled
IP header DSCP rewrite is enabled

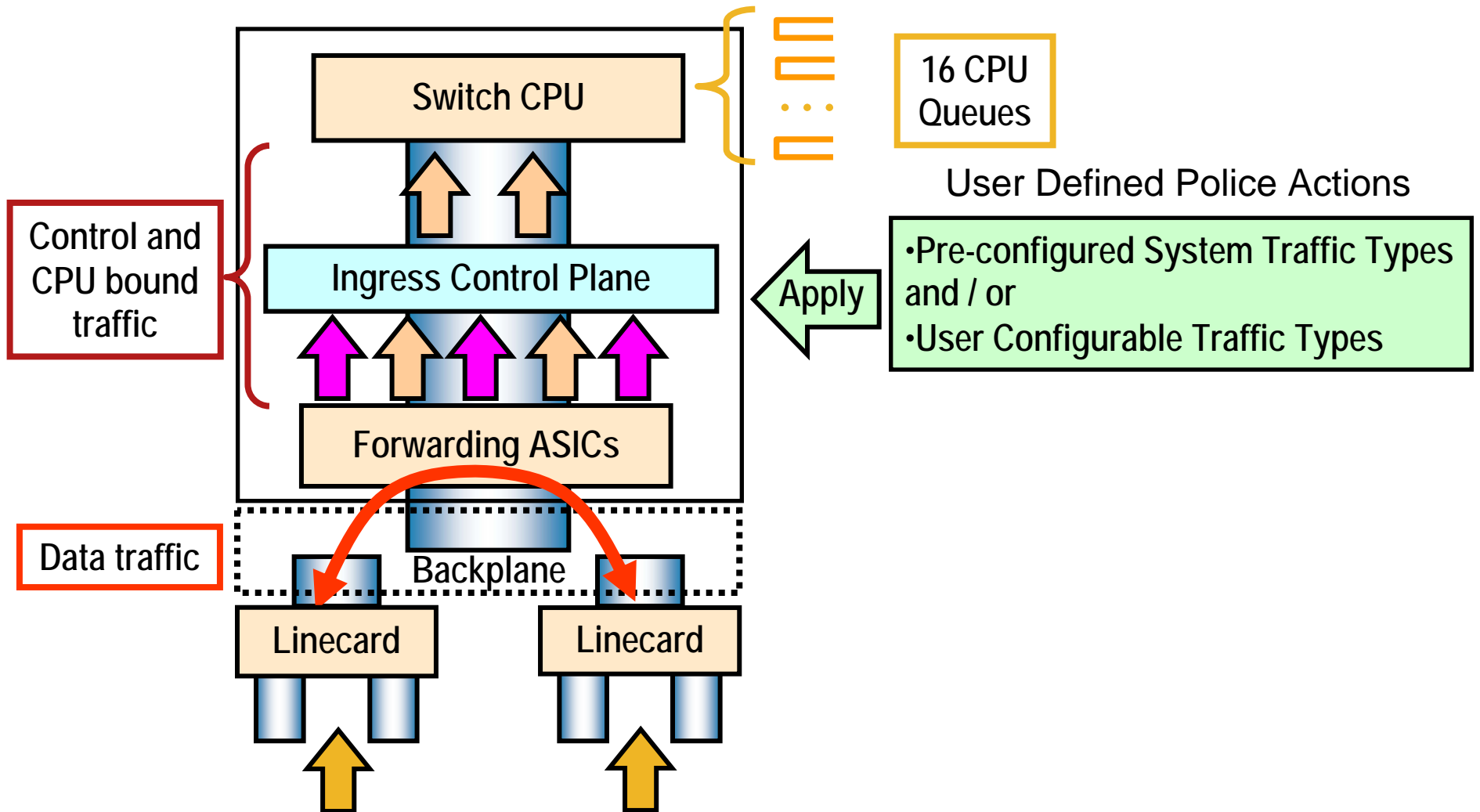
CAT4500#conf term
Enter configuration commands, one per line.  End with CNTL/Z.
CAT4500(config)#qos                    ! Enables QoS globally for the Cat4500
CAT4500(config)#end
CAT4500#

CAT4500#show qos
QoS is enabled globally                ! Verifies that QoS is enabled globally
IP header DSCP rewrite is enabled
CAT4500#

CAT4500(config)#interface FastEthernet2/1
CAT4500(config-if)# qos trust dscp    ! Trusted Endpoint Example
CAT4500(config-if)#end
CAT4500#
```

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Control Plane Policing (CPP)



# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## *Pre-Configured CPP System Traffic Types*

Pre-defined Named ACL	Description
system-cpp-dot1x	MacDA = 0180.C200.0003
system-cpp-bpdu-range	MacDA = 0180.C200.0000 - 0180.C200.000F
system-cpp-cdp	MacDA = 0100.0CCC.CCCC (UDLD/DTP/VTP/Pagp)
system-cpp-garp-range	MacDA = 0180.C200.0020 - 0180.C200.002F
system-cpp-sstp	MacDA = 0100.0CCC.CCCD
system-cpp-cgmp	Mac DA = 01-00-0C-DD-DD-DD
system-cpp-ospf	IP Protocol = OSPF, IPDA matches 224.0.0.0/24
system-cpp-igmp	IP Protocol = IGMP, IPDA matches 224.0.0.0/3
system-cpp-pim	IP Protocol = PIM, IPDA matches 224.0.0.0/24
system-cpp-all-systems-on-subnet	IPDA = 224.0.0.1
system-cpp-all-routers-on-subnet	IPDA = 224.0.0.2
system-cpp-ripv2	IPDA = 224.0.0.9
system-cpp-ip-mcast-linklocal	IP DA = 224.0.0.0/24
system-cpp-dhcp-cs	IP Protocol = UDP, L4SrcPort = 68, L4DstPort = 67
system-cpp-dhcp-sc	IP Protocol = UDP, L4SrcPort = 67, L4DstPort = 68
system-cpp-dhcp-ss	IP Protocol = UDP, L4SrcPort = 67, L4DstPort = 67

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Config Option 1: Pre-Configured System Traffic Types

1. Create the system-cpp-policy policy-map and attach it to the control-plane.

```
C4500(config)# macro global apply system-cpp
```

2. Specify a discrete policing level per (pre-configured) class

```
C4500(config-pmap)# policy-map system-cpp-policy
```

```
C4500(config-pmap-c)# class system-cpp-<cpp_class_name>
```

```
C4500(config-pmap-c)# police rate burst
```

```
conform-action transmit exceed-action drop
```

3. Verify CPP QoS policy

```
C4500# show policy-map system-cpp-policy
```

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Config Option 2: User-Defined Traffic Types

1. Create the system-cpp-policy policy-map and attach it to the control-plane.

```
C4500(config)# macro global apply system-cpp
```

2. Define a packet classification criteria

```
C4500(config)# class-map <traffic_class_name>
```

```
C4500(config-cmap)# match access-group <access-list-number>
```

3. Specify a discrete policing level for the user-configured class

```
C4500(config-pmap)# policy-map system-cpp-policy
```

```
C4500(config-pmap-c)# class <traffic_class_name>
```

```
C4500(config-pmap-c)# police rate burst
```

```
conform-action transmit exceed-action drop
```

4. Verify CPP QoS policy

```
C4500# show policy-map system-cpp-policy
```

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## AutoQoS – VoIP Model Example



```
CAT4500(config-if)#auto qos voip cisco-phone
```

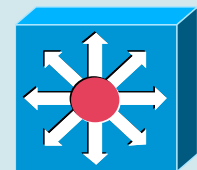
Options:

`auto qos voip cisco-phone`

`auto qos voip trust`

Note: AutoQoS-VoIP on this family of switches does not support the “cisco-softphone” model.

```
!  
qos  
qos dbl  
qos map cos 3 to 26  
qos map cos 5 to 46  
qos map dscp 24 25 26 27 28 29 30 31 to tx-queue 4  
qos map dscp 32 33 34 35 36 37 38 39 to tx-queue 4  
!  
policy-map autoqos-voip-policy  
  class class-default  
    dbl  
!  
Interface GigabitEthernet0/1  
  qos trust device cisco-phone  
  qos trust cos  
  tx-queue 3  
  priority high  
  shape percent 33  
  bandwidth percent 33  
!
```



# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## IP Phone + PC + Scavenger Model Example: Part One



```
CAT4500-SUP4(config)#qos map cos 5 to dscp 46
! Modifies CoS-to-DSCP mapping to map CoS 5 to DSCP EF
CAT4500-SUP4(config)#qos map dscp policed 0 24 to dscp 8
! Excess DVLAN & VVLAN traffic will be marked down to Scavenger (CS1)

CAT4500-SUP4(config)#class-map match-all VVLAN-VOICE
CAT4500-SUP4(config-cmap)# match ip dscp ef
CAT4500-SUP4(config-cmap)#
CAT4500-SUP4(config-cmap)#class-map match-all VVLAN-CALL-SIGNALING
CAT4500-SUP4(config-cmap)# match ip dscp cs3

CAT4500-SUP4(config-cmap)#policy-map IPPHONE+PC-BASIC-VVLAN
CAT4500-SUP4(config-pmap)#class VVLAN-VOICE
CAT4500-SUP4(config-pmap-c)# police 128 kbps 8000 byte exceed-action drop
! Only one voice call is permitted per switchport VVLAN
CAT4500-SUP4(config-pmap-c)#class VVLAN-CALL-SIGNALING
CAT4500-SUP4(config-pmap-c)# police 32 kbps 8000 byte exceed-action
policed-dscp-transmit
! Out-of-profile Call-Signaling is marked down to Scavenger (CS1)
CAT4500-SUP4(config-pmap-c)#class class-default
CAT4500-SUP4(config-pmap-c)# set ip dscp 0
CAT4500-SUP4(config-pmap-c)# police 32 kbps 8000 byte exceed-action
policed-dscp-transmit
! Unauthorized VVLAN traffic is marked down to Scavenger (CS1)
```



# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## IP Phone + PC + Scavenger Model Example: Part Two



```
CAT4500-SUP4(config-cmap)#policy-map IPPHONE+PC-BASIC-DVLAN
CAT4500-SUP4(config-pmap-c)#class class-default
CAT4500-SUP4(config-pmap-c)# set ip dscp 0
CAT4500-SUP4(config-pmap-c)# police 5 mbps 8000 byte exceed-action
    policed-dscp-transmit
    ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT4500-SUP4(config-pmap-c)# exit
CAT4500-SUP4(config-pmap)#exit
CAT4500-SUP4(config)#

CAT4500-SUP4(config)#interface FastEthernet2/1
CAT4500-SUP4(config-if)# switchport voice vlan 110           ! VVLAN
CAT4500-SUP4(config-if)# switchport access vlan 10          ! DVLAN
CAT4500-SUP4(config-if)# qos trust device cisco-phone       ! Conditional Trust

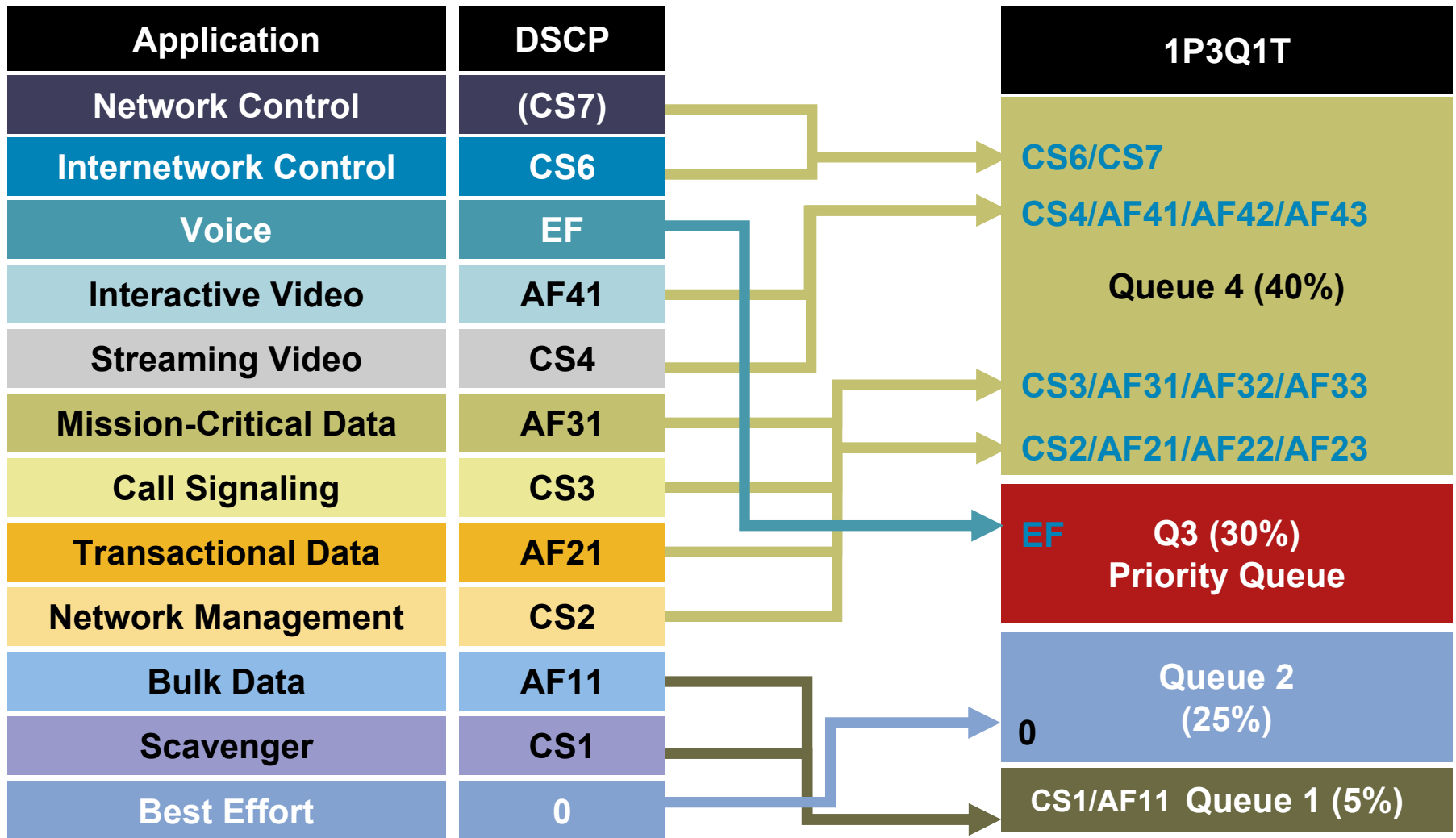
CAT4500-SUP4(config-if)# vlan-range 110
CAT4500-SUP4(config-if-vlan-range)# service-policy input IPPHONE+PC-BASIC-VVLAN
    ! Applies VVLAN policers to VVLAN (110) via Per-Port/Per-VLAN policing

CAT4500-SUP4(config-if)# vlan-range 10
CAT4500-SUP4(config-if-vlan-range)# service-policy input IPPHONE+PC-BASIC-DVLAN
    ! Applies DVLAN policer to DVLAN (10) via Per-Port/Per-VLAN policing

CAT4500-SUP4(config-if)#end
CAT4500-SUP4#
```

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Queuing Design: 1P3Q1T + DBL



# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Queuing Design: 1P3Q1T + DBL – Part One

```
CAT4500-SUP4(config)#qos dbl
    ! Globally enables DBL
CAT4500-SUP4(config)#qos dbl exceed-action ecn
    ! Optional: Enables DBL to mark RFC 3168 ECN bits in the IP ToS Byte
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#qos map dscp 0 to tx-queue 2
    ! Maps DSCP 0 (Best Effort) to Q2
CAT4500-SUP4(config)#qos map dscp 8 10 12 14 to tx-queue 1
    ! Maps DSCP CS1 (Scavenger) and AF11/AF12/AF13 (Bulk) to Q1
CAT4500-SUP4(config)#qos map dscp 16 18 20 22 to tx-queue 4
    ! Maps DSCP CS2 (Net-Mgmt) and AF21/AF22/AF23 (Transactional) to Q4
CAT4500-SUP4(config)#qos map dscp 24 26 28 30 to tx-queue 4
    ! Maps DSCP CS3 (Call-Signaling) and AF31/AF32/AF33 (MC Data) to Q4
CAT4500-SUP4(config)#qos map dscp 32 34 36 38 to tx-queue 4
    ! Maps DSCP CS4 (Str-Video) and AF41/AF42/AF43 (Int-Video) to Q4
CAT4500-SUP4(config)#qos map dscp 46 to tx-queue 3
    ! Maps DSCP EF (VoIP) to Q3 (PQ)
CAT4500-SUP4(config)#qos map dscp 48 56 to tx-queue 4
    ! Maps DSCP CS6 (Internetwork) and CS7 (Network) Control to Q4
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#policy-map DBL
CAT4500-SUP4(config-pmap)#class class-default
CAT4500-SUP4(config-pmap-c)# dbl          ! Enables DBL on all traffic flows
CAT4500-SUP4(config-pmap-c)# end
CAT4500-SUP4#
```

# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## Queuing Design: 1P3Q1T + DBL – Part Two (FE + GE)

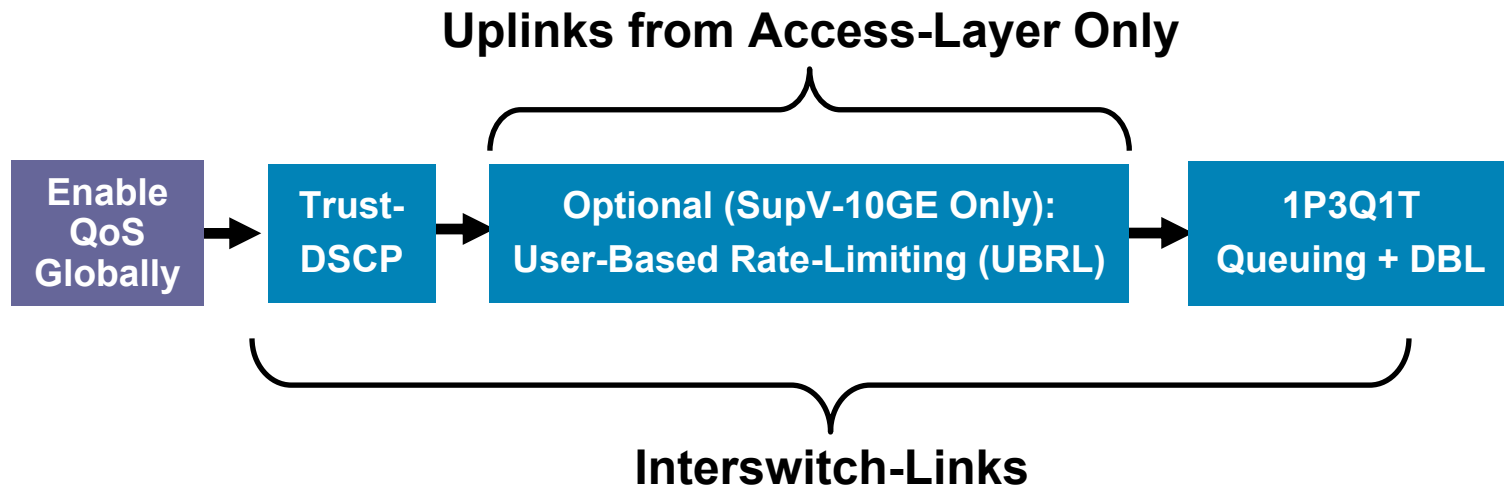
```
CAT4500-SUP4(config)#interface range FastEthernet2/1 - 48
CAT4500-SUP4(config-if-range)# service-policy output DBL
CAT4500-SUP4(config-if-range)# tx-queue 3
CAT4500-SUP4(config-if-tx-queue)# priority high           ! Enables Q3 as PQ
CAT4500-SUP4(config-if-tx-queue)# shape percent 30       ! Shapes PQ to 30%
CAT4500-SUP4(config-if-tx-queue)# exit
CAT4500-SUP4(config-if-range)#exit
CAT4500-SUP4(config)#

CAT4500-SUP4(config)#interface range GigabitEthernet1/1 - 2
CAT4500-SUP4(config-if-range)# service-policy output DBL
CAT4500-SUP4(config-if-range)# tx-queue 1
CAT4500-SUP4(config-if-tx-queue)# bandwidth percent 5    ! Q1 gets 5%
CAT4500-SUP4(config-if-tx-queue)# tx-queue 2
CAT4500-SUP4(config-if-tx-queue)# bandwidth percent 25  ! Q2 gets 25%
CAT4500-SUP4(config-if-tx-queue)# tx-queue 3
CAT4500-SUP4(config-if-tx-queue)# priority high         ! Enables Q3 as PQ
CAT4500-SUP4(config-if-tx-queue)# bandwidth percent 30  ! PQ gets 30%
CAT4500-SUP4(config-if-tx-queue)# shape percent 30      ! Shapes PQ to 30%
CAT4500-SUP4(config-if-tx-queue)# tx-queue 4
CAT4500-SUP4(config-if-tx-queue)# bandwidth percent 40  ! Q4 gets 40%
CAT4500-SUP4(config-if-tx-queue)#end
CAT4500-SUP4#
```

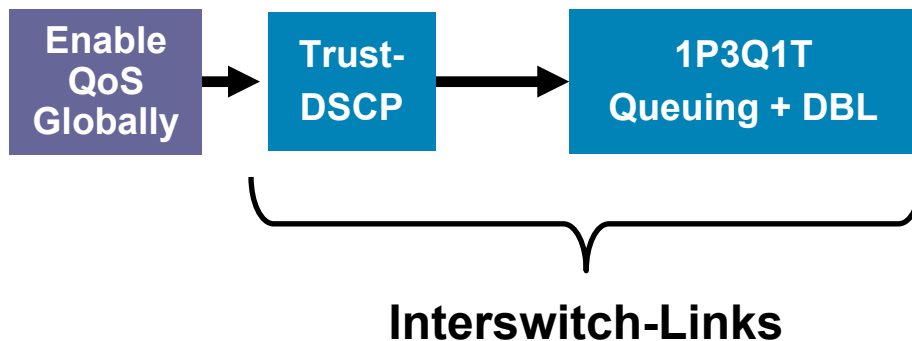
# Catalyst 4500 (Sup II+ to Sup V-10GE) & 4948

## *Distribution and/or Core-Layer QoS Design*

### Distribution Layer



### Core Layer



# Catalyst 4500 (Sup V-10GE)

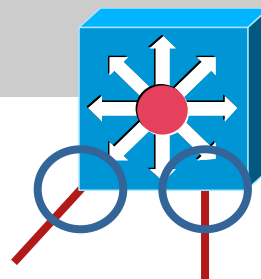
## User-Based Rate Limiting (UBRL)

```
CAT4500-SUPV-10GE(config)#qos map dscp policed 0 24 46 to dscp 8
    ! Excess DVLAN & VVLAN traffic will be marked down to Scavenger (CS1)

CAT4500-SUPV-10GE(config)#class-map match-all UBRL-BY-SOURCE-IP
CAT4500-SUPV-10GE(config-cmap)#match flow ip source-address

CAT4500-SUPV-10GE(config)#policy-map UBRL-TO-5MBPS-SCAVENGER
CAT4500-SUPV-10GE(config-pmap)#class UBRL-BY-SOURCE-IP
CAT4500-SUPV-10GE(config-pmap-c)# police 5 mbps 8000 byte exceed-action
    policed-dscp-transmit
    ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT4500-SUPV-10GE(config-pmap-c)# exit
CAT4500-SUPV-10GE(config-pmap)#exit
CAT4500-SUPV-10GE(config)#

CAT4500-SUPV-10GE(config)#interface GigabitEthernet2/1
CAT4500-SUPV-10GE(config-if)# service-policy input UBRL-TO-5MPBS-SCAVENGER
    ! Applies the UBRL policy to the uplink from the Access-Layer
CAT4500-SUPV-10GE(config-if)# end
CAT4500-SUPV-10GE#
```

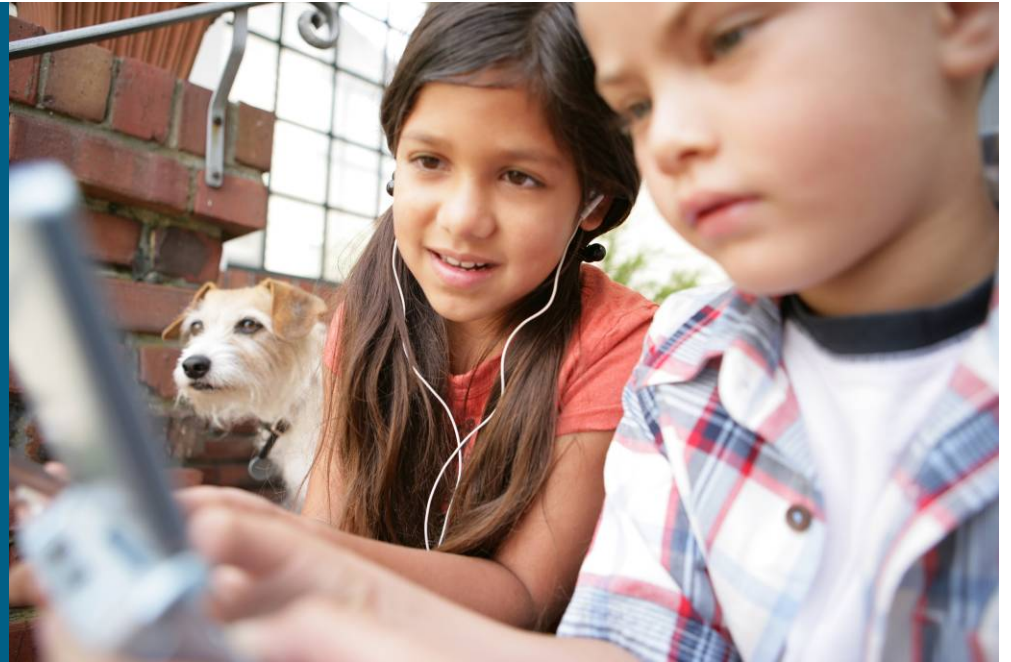


Distribution-Layer  
Cisco Catalyst 4500  
SupV-10GE

# Catalyst 6500

(PFC2 & PFC3)

## QoS Design



# Catalyst 6500 (PFC 2 & PFC 3)

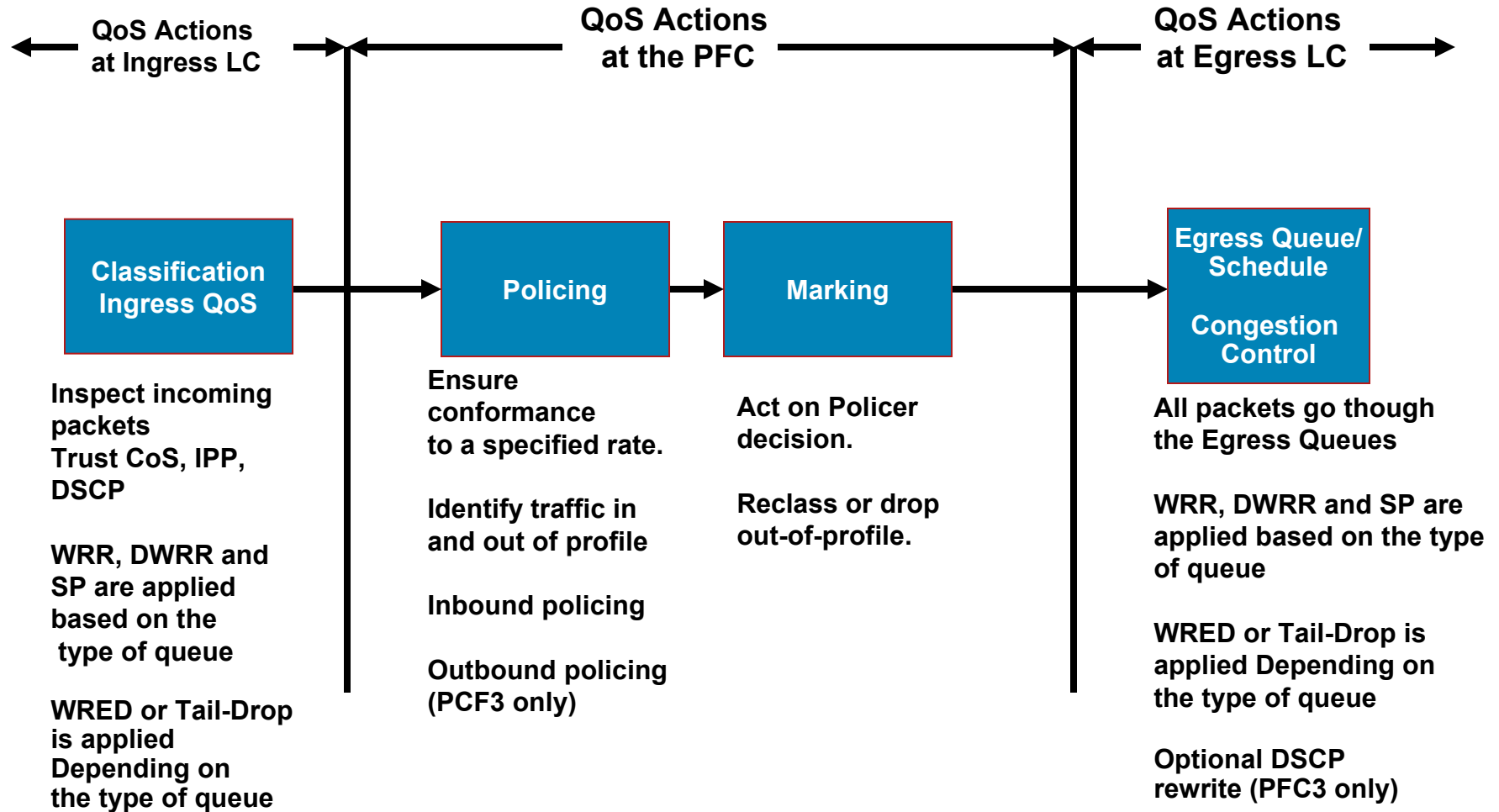
## Platform-Specific QoS Design Considerations

- QoS disabled by default
- Configuration may be CatOS or Cisco IOS
  - Cisco IOS does not (yet) support conditional trust (“`mls qos trust device`”) nor AutoQoS-VoIP
- Classification can be done by trust states, standard and advanced IP ACLs, or MAC ACLs
- PFC3 supports Per-User Microflow Policing and Control Plane Policing (CoPP on Sup720 and Sup32)
- SRR is supported on Sup32 GE/10GE uplinks only
  - Hierarchical QoS is not supported on Ethernet ports
- Linecards determine queuing structure
  - 2Q2T
    - 1P2Q1T                      1P2Q2T
    - 1P3Q1T                      1P3Q8T
    - 1P7Q4T                      1P7Q8T



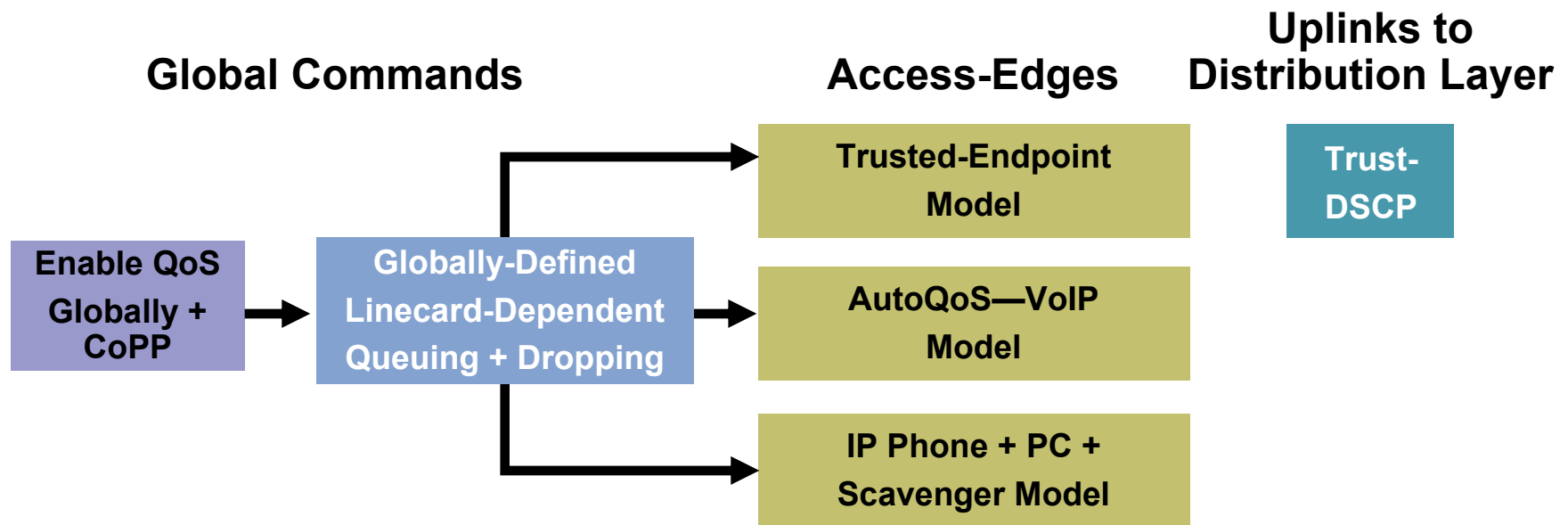
# Catalyst 6500 (PFC 2 & PFC 3)

## QoS Model



# Catalyst 6500 (PFC 2 & PFC 3)

## Access-Layer QoS Design



# Catalyst 6500 (PFC 2 & PFC 3)

## *Trusted-Endpoint Model Examples*

### **CatOS Trust:**

```
CAT6500-PFC2-CATOS> (enable) set port qos 3/1 trust trust-dscp
Port 3/1 qos set to trust-dscp.
CAT6500-PFC2-CATOS> (enable)
```

### **Trust Workaround for 2Q2T non-GigabitEthernet Linecards:**

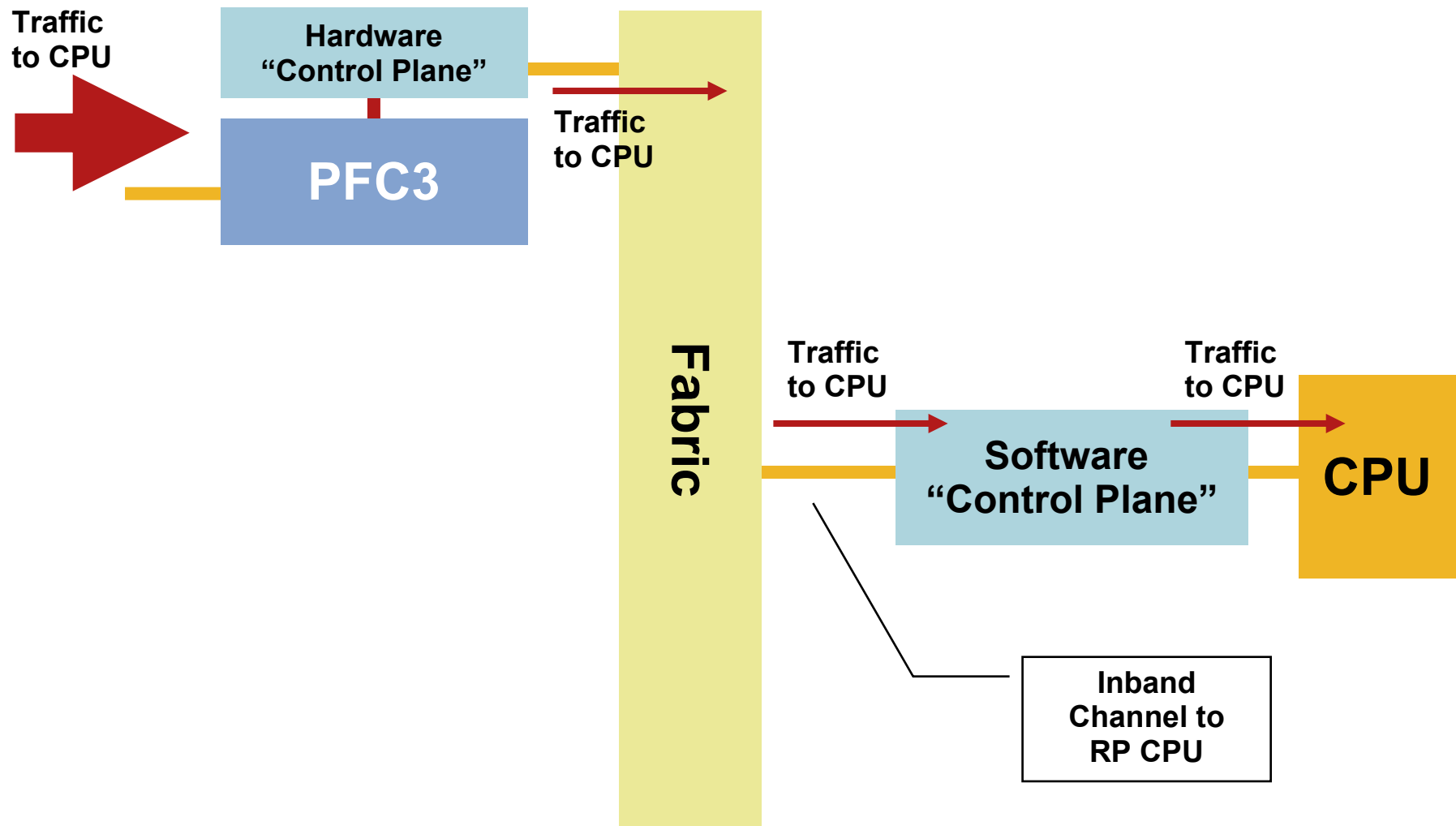
```
CAT6500-PFC2-CATOS> (enable) set qos acl ip TRUST-DSCP trust-dscp any
TRUST-DSCP editbuffer modified. Use 'commit' command to apply changes.
CAT6500-PFC2-CATOS> (enable) commit qos acl TRUST-DSCP
QoS ACL 'TRUST-DSCP' successfully committed.
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) set qos acl map TRUST-DSCP 4/1
```

### **Cisco IOS Trust:**

```
CAT6500-PFC2-IOS(config)#interface FastEthernet3/1
CAT6500-PFC2-IOS(config-if)#mls qos trust dscp
```

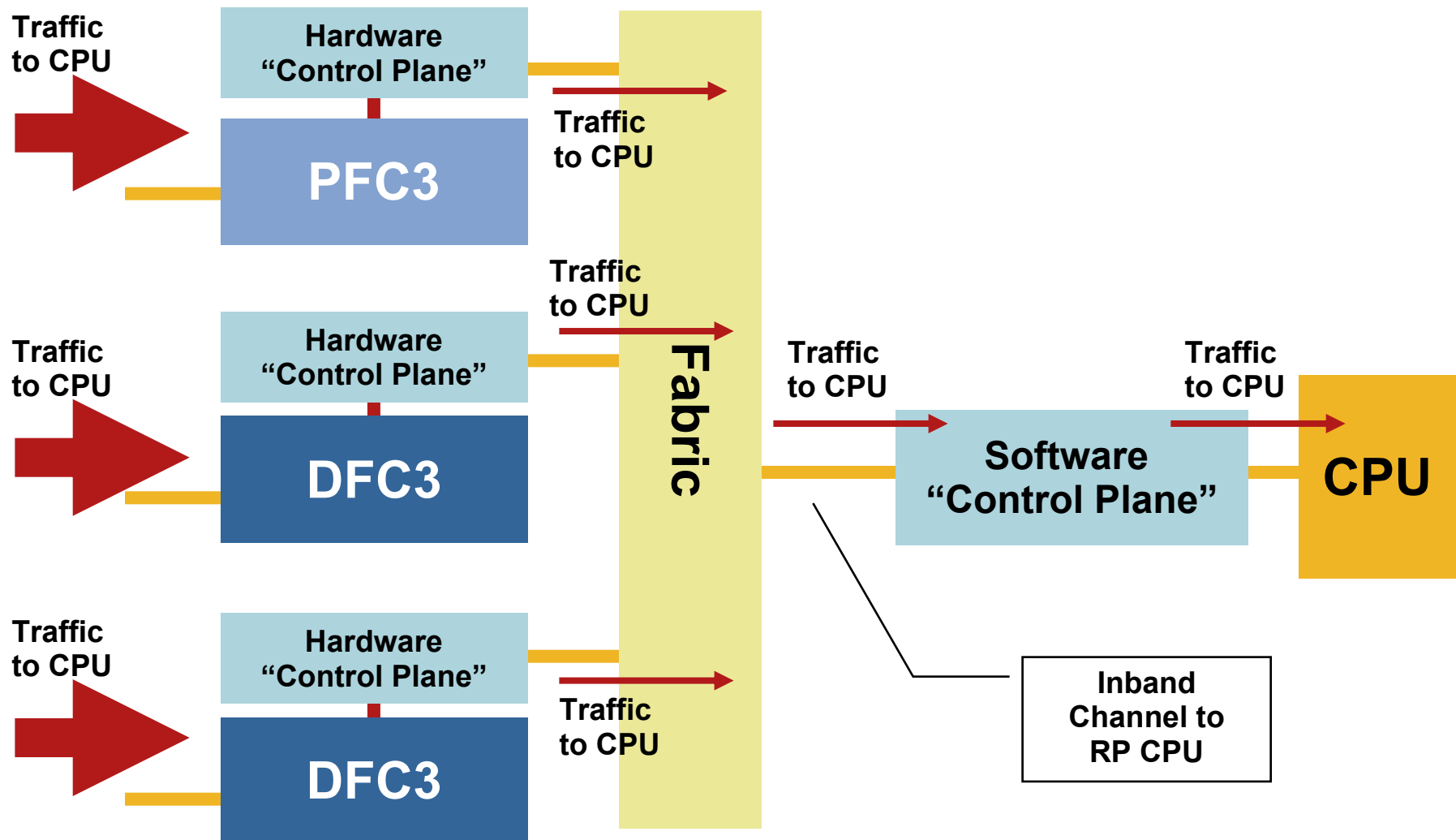
# Cisco Catalyst 6500 (PFC 3)

## Control Plane Policing (CoPP) Implementation: Part One



# Cisco Catalyst 6500 (PFC 3)

## Control Plane Policing (CoPP) Implementation: Part Two



# Cisco Catalyst 6500 (PFC 3)

## What CPU Rate Limiters Are Available?

### Unicast Rate Limiters

CEF Receive	Traffic Destined to the Router
CEF Glean	ARP Packets
CEF No Route	Packets with No Route in the FIB
IP Errors	Packets with IP Checksum or Length Errors
ICMP Redirect	Packets That Require ICMP Redirects
ICMP No Route	ICMP Unreachables for Unroutable Packets
ICMP ACL Drop	ICMP Unreachables for Admin Deny Packets
RPF Failure	Packets That Fail uRPF Check
L3 Security	CBAC, Auth-Proxy, and IPSec Traffic
ACL Input	NAT, TCP Int, Reflexive ACLs, Log on ACLs
ACL Output	NAT, TCP Int, Reflexive ACLs, Log on ACLs
VACL Logging	CLI Notification of VACL Denied Packets
IP Options	Unicast Traffic with IP Options Set
Capture	Used with Optimized ACL Logging

### Layer 2 Rate Limiters

L2PT	L2PT Encapsulation/Decapsulation
PDU	Layer 2 PDUs

### Multicast Rate Limiters

Multicast FIB-Miss	Packets with No Mroute in the FIB
IGMP	IGMP Packets
Partial Shortcut	Partial Shortcut Entries
Directly Connected	Local Multicast on Connected Interface
IP Options	Multicast Traffic with IP Options Set
V6 Directly Connect	Packets with No Mroute in the FIB
V6 *, G M Bridge	IGMP Packets
V6 *, G Bridge	Partial Shortcut Entries
V6 S, G Bridge	Partial Shortcut Entries
V6 Route Control	Partial Shortcut Entries
V6 Default Route	Multicast Traffic with IP Options Set
V6 Second Drop	Multicast Traffic with IP Options Set

### General Rate Limiters

MTU Failure	Packets Requiring Fragmentation
TTL Failure	Packets with TTL $\leftarrow$ 1

# Cisco Catalyst 6500 (PFC 3)

## Configuring Control Plane Policing (CoPP)

### 1. Define a Packet Classification Criteria

```
C6500(config)# class-map <traffic_class_name>  
C6500(config-cmap)# match <access-group>
```

### 2. Define a Policing Service-Policy

```
C6500(config-pmap)# policy-map <service_policy_name>  
C6500(config-pmap)# class <traffic_class_name>  
C6500(config-pmap)#     police <rate> conform-action transmit  
                          exceed-action drop
```

### 3. Enter Control-Plane Config-Mode and Apply CoPP policy

```
C6500(config)# control-plane  
C6500(config-cp)# service-policy input <service_policy_name>
```

### 4. Verify CoPP Policy

```
C6500# show policy-map control-plane
```

# Cisco Catalyst 6500 (PFC 3)

## Control Plane Policing (CoPP) Deployment Guide

- Explicitly allow needed, known critical protocols such as BGP and EIGRP
  - Conform and exceed action → **transmit**
- Define other required but not critical traffic such as ICMP, SNMP, SSH, telnet, and default
  - Conform action → **transmit**, exceed action → **drop**
- **Drop** all other **undesirable** traffic
- Depending on class defined, apply appropriate policy
  - Routing protocol traffic (BGP, IGP)—**no rate limit**
  - Management traffic (SNMP, SSH, NTP, etc.)—**conservative rate limit**
  - Reporting traffic (SAA combined with DSCP)—**conservative rate limit**
  - Monitoring traffic (ICMP, trace route)—**conservative rate limit**
  - Critical traffic (HSRP, SIP/VoIP, DLSw)—**conservative rate limit**
  - Default traffic—**low rate limit**
  - Undesirable traffic (DoS attacks)—**drop**



# Catalyst 6500 (PFC 2 & PFC 3)

## AutoQoS – VoIP (CatOS Only)

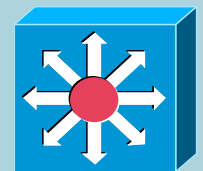


```
set qos autoqos
set port qos 3/1 autoqos voip ciscoipphone
```

### Options:

autoqos voip cisco-phone  
autoqos voip ciscosoftphone  
auto qos voip trust

```
set qos enable
set qos map 2q2t tx 2 1 cos 1
set qos map 2q2t tx 2 1 cos 2
set qos map 2q2t tx 2 1 cos 3
set qos map 2q2t tx 2 2 cos 5
set qos drop-threshold 2q2t tx queue 1 100 100
...
set qos cos-dscp-map 0 10 18 26 34 46 48 56
set qos ipprec-dscp-map 0 10 18 26 34 46 48 56
set qos policed-dscp-map 0,26,46:0
set qos policed-dscp-map 1:1
...
set qos policed-dscp-map 63:63
clear qos acl all
#ACL_IP-PHONES
set qos acl ip ACL_IP-PHONES trust-cos ip any any
#
commit qos acl all
!
set vlan 100 3/1
set port qos 3/1 trust-device ciscoipphone
set trunk 3/1 off negotiate 1-1005,1025-4094
set spantree portfast 3/1 enable
set port qos 3/1 trust trust-cos
set qos acl map ACL_IP-PHONES 3/1
set port qos 3/1-48 policy-source local
set port channel 3/1 mode off
```



# Catalyst 6500 (PFC 2 & PFC 3)



## IP Phone + PC + Scavenger Model (CatOS) – Part One

```
CAT6500-PFC2-CATOS> (enable) set qos cos-dscp-map 0 8 16 24 32 46 48 56
! Modifies default CoS-DSCP mapping so that CoS 5 is mapped to DSCP EF
CAT6500-PFC2-CATOS> (enable) set qos policed-dscp-map 0,24:8
! Excess traffic marked DSCP 0 or CS3 is remarked to CS1
CAT6500-PFC2-CATOS> (enable)

CAT6500-PFC2-CATOS> (enable) set qos policer aggregate VVLAN-VOICE-3-1
rate 128 burst 8000 drop
! Defines the policer for IP Phone VoIP traffic
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate VVLAN-SIGNALING-3-1
rate 32 burst 8000 policed-dscp
! Defines the policer for IP Phone Call-Signaling traffic
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate VVLAN-ANY-3-1
rate 32 burst 8000 policed-dscp
! Defines the policer for any other traffic sourced from the VVLAN
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate PC-DATA-3-1
rate 5000 burst 8000 policed-dscp
! Defines the policer for PC Data traffic
CAT6500-PFC2-CATOS> (enable)
```

For C6500 IOS Voice Deployment Guide – see:

[http://www.cisco.com/application/pdf/en/us/guest/products/ps708/c1244/cdccont\\_0900aecd804dc7ae.pdf](http://www.cisco.com/application/pdf/en/us/guest/products/ps708/c1244/cdccont_0900aecd804dc7ae.pdf)

But keep in mind – C6500 IOS does not yet support conditional trust (i.e. “mls qos trust device ...”)

# Catalyst 6500 (PFC 2 & PFC 3)

## IP Phone + PC + Scavenger Model (CatOS) – Part Two



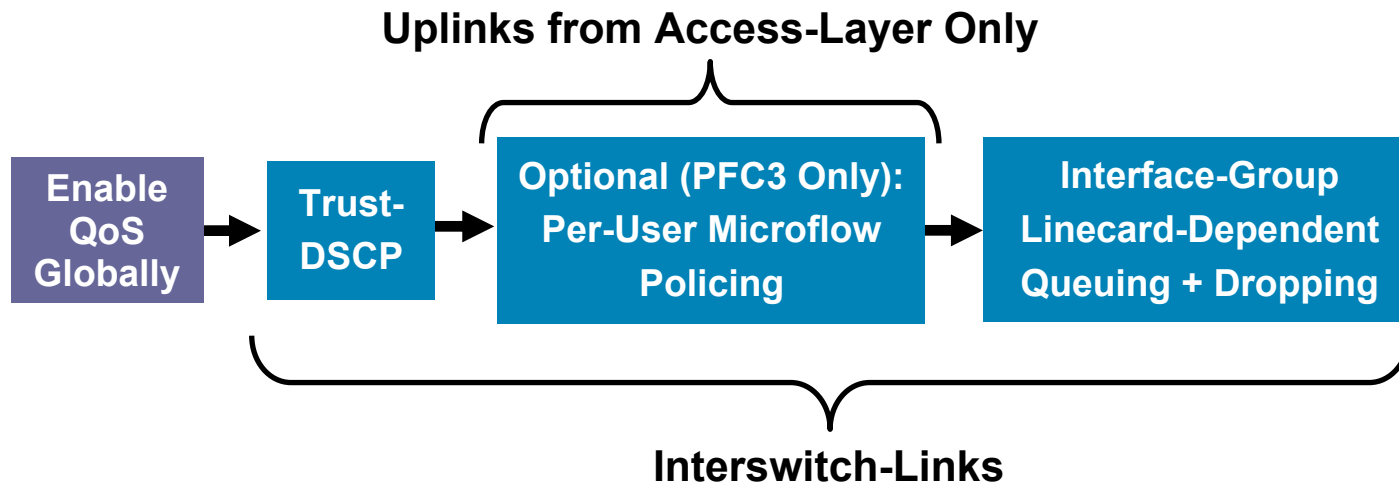
```
CAT6500-PFC2-CATOS> (enable) set qos acl ip IPPHONE-PC-BASIC-3-1 dscp 46
aggregate VVLAN-VOICE-3-1 udp 10.1.110.0 0.0.0.255 any range 16384 32767
! Binds ACL to policer and marks in-profile VVLAN VoIP to DSCP EF
CAT6500-PFC2-CATOS> (enable) set qos acl ip IPPHONE-PC-BASIC-3-1 dscp 24
aggregate VVLAN-SIGNALING-3-1 tcp 10.1.110.0 0.0.0.255 any range 2000 2002
! Binds ACL to policer marks in-profile VVLAN Call-Signaling to DSCP CS3
CAT6500-PFC2-CATOS> (enable) set qos acl ip IPPHONE-PC-BASIC-3-1 dscp 0
aggregate VVLAN-ANY-3-1 10.1.110.0 0.0.0.255
! Binds ACL to policer and marks all other VVLAN traffic to DSCP 0
CAT6500-PFC2-CATOS> (enable) set qos acl ip IPPHONE-PC-BASIC-3-1 dscp 0
aggregate PC-DATA-3-1 any
! Binds ACL to policer and marks in-profile PC Data traffic to DSCP 0
CAT6500-PFC2-CATOS> (enable) commit qos acl IPPHONE-PC-BASIC-3-1
! Commits ACL to PFC memory
CAT6500-PFC2-CATOS> (enable)

CAT6500-PFC2-CATOS> (enable) set port qos 3/1 cos 0
! Sets CoS to 0 for all untrusted packets (when there is no IP Phone)
CAT6500-PFC2-CATOS> (enable) set port qos 3/1 cos-ext 0
! Sets CoS to 0 for all untrusted PC-generated packets (behind an IP Phone)
CAT6500-PFC2-CATOS> (enable) set port qos 3/1 trust-ext untrusted
! Ignore any CoS values for all PC-generated packets (behind an IP Phone)
CAT6500-PFC2-CATOS> (enable) set port qos 3/1 trust-device ciscoipphone
! Conditional trust (for Cisco IP Phones only)
CAT6500-PFC2-CATOS> (enable) set qos acl map IPPHONE-PC-BASIC-3-1 3/1
! Attaches ACL to switch port
CAT6500-PFC2-CATOS> (enable)
```

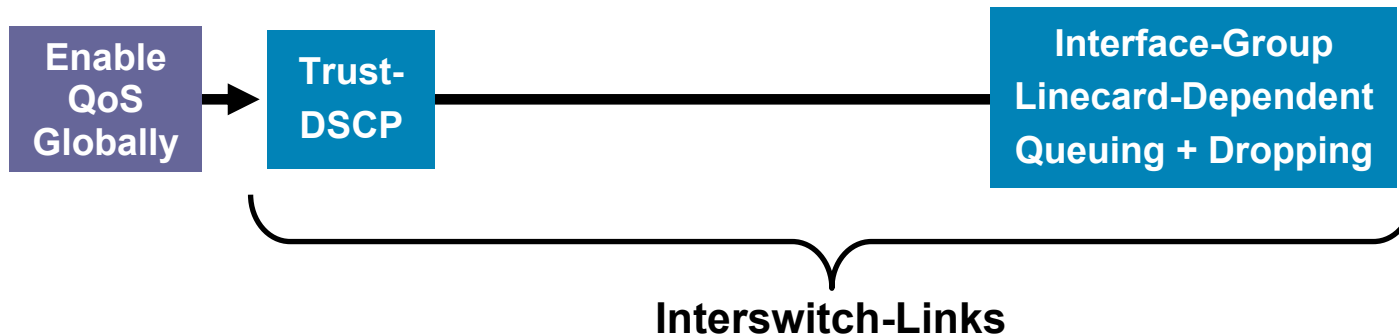
# Cisco Catalyst 6500 (PFC 3)

## Distribution- & Core-Layer QoS Design

### Distribution Layer



### Core Layer



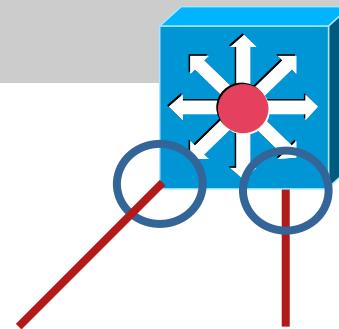
# C6500 (PFC3) QoS Design

## PFC3 Per-User Microflow Policing: Part One

```
CAT6500-IOS(config)#mls qos map policed-dscp normal 0 24 26 34 36 to 8
! Excess traffic marked 0,CS3,AF31,AF41 or AF42 will be remarked to CS1

CAT6500-IOS(config)#class-map match-any VVLAN-TRAFFIC
CAT6500-IOS(config-cmap)# match ip dscp ef
CAT6500-IOS(config-cmap)# match ip dscp cs3
CAT6500-IOS(config-cmap)#class-map match-all DLVAN-TRAFFIC
CAT6500-IOS(config-cmap)# match ip dscp 0

CAT6500-IOS(config-cmap)#policy-map PER-USER-POLICING
CAT6500-IOS(config-pmap)# class VLAN-TRAFFIC
CAT6500-IOS(config-pmap-c)# police flow mask src-only 160000 8000
conform-action transmit exceed-action drop
! Traffic from any VVLAN source (IP Phones) in excess of 160 kbps is dropped
CAT6500-IOS(config-pmap-c)# class BEST-EFFORT
CAT6500-IOS(config-pmap-c)# police flow mask src-only 5000000 8000
conform-action transmit exceed-action policed-dscp-transmit
! Traffic from any DVLAN source (PCs) in excess of 5 Mbps is remarked to CS1
CAT6500-IOS(config-pmap-c)# exit
```

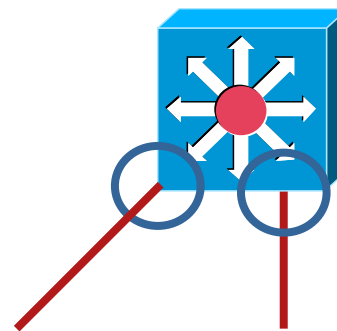


Distribution-Layer  
Cisco Catalyst 6500  
Sup720

# C6500 (PFC3) QoS Design

## PFC3 Per-User Microflow Policing: Part Two

```
CAT6500-IOS(config)#  
CAT6500-IOS(config)#interface range GigabitEthernet4/1 - 4  
CAT6500-IOS(config-if-range)# mls qos trust dscp  
CAT6500-IOS(config-if-range)# service-policy input PER-USER-POLICING  
    ! Attaches Per-User Microflow policing policy to Uplinks from Access  
CAT6500-IOS(config-if-range)#end  
CAT6500-IOS#
```



**Distribution-Layer  
Cisco Catalyst 6500  
Sup720**

# Catalyst 6500 Queuing Structures and Design by Supervisor and Linecard



# Cisco Catalyst 6500

## Queuing Structures by Supervisors

Supervisor Engines	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-SUP720	1p1q4t	WRR	1p2q2t	WRR	512 KB	73 KB	439 KB
WS-SUP720-3B							
WS-SUP720-3BXL							
WS-SUP32-10GE	2q8t	WRR	1p3q8t	SRR	1.3 MB	166 KB	1.2 MB
WS-SUP32-GE							
WS-X6K-S2U-MSFC2	1p1q4t	WRR	1p2q2t	WRR	512 KB	73 KB	439 KB
WS-X6K-S2-MSFC2							
WS-X6K-S2-PFC2							



# Cisco Catalyst 6500

## Queuing Structures by FE or 10/100 Linecards

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6524-100FX-MM	1p1q0t	WRR	1p3q1t	DWRR	1,116 KB	28 KB	1,088 KB
WS-X6548-RJ-21							
WS-X6548-RJ-45							
WS-X6324-100FX-MM	1q4t	WRR	2q2t	WRR	128 KB	16 KB	112 KB
WS-X6324-100FX-SM							
WS-X6348-RJ-45							
WS-X6348-RJ-45V							
WS-X6348-RJ-21V							

# Cisco Catalyst 6500

## Queuing Structures by FE or 10/100 Linecards (cont)

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6224-100FX-MT	1q4t	WRR	2q2t	WRR	64 KB	8 KB	56 KB
WS-X6248-RJ-45							
WS-X6248-TEL							
WS-X6248A-TEL					128 KB	16 KB	112 KB
WS-X6148-RJ-45							
WS-X6148-RJ-45V							
WS-X6148-45AF							
WS-X6148-RJ-21							
WS-X6148-RJ-21V							
WS-X6148-21AF							
WS-X6148A-RJ-45	1p1q4t	WRR	1p3q8t	WRR	5.3 MB	60 KB	5.3 MB
WS-X6148A-45AF							

# Cisco Catalyst 6500

## Queuing Structures by FE or 10/100 Linecards (cont)

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6148X2-RJ-45	1p1q0t	WRR	1p3q1t	DWRR	1,116 KB	28 KB	1088 KB
WS-X6148X2-45AF							
WS-X6024-10FL-MT	1q4t	WRR	2q2t	WRR	64 KB	8 KB	56 KB

# Cisco Catalyst 6500

## Queuing Structures by GE or 10/100/1000 Linecards

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6816-GBIC	1p1q4t	WRR	1p2q2t	WRR	512 KB	73 KB	439 KB
WS-X6748-GE-TX with DFC3	2q8t	WRR	1p3q8t	DWRR	1.3 MB	166 KB	1.2 MB
WS-X6748-GE-TX with CFC	1q8t	WRR					
WS-X6748-SFP with DFC3	2q8t	WRR					
WS-X6748-SFP with CFC	1q8t	WRR					
WS-X6724-SFP with DFC3	2q8t	WRR					
WS-X6724-SFP with CFC	1q8t	WRR					
WS-X6548-GE-TX	1q2t	WRR	1p2q2t	WRR	1.4 MB	185 KB	1.2 MB
WS-X6548V-GE-TX							
WS-X6548-GE-45AF							

# Cisco Catalyst 6500

## Queuing Structures by GE or 10/100/1000 Linecards (cont)

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6516-GBIC	1p1q4t	WRR	1p2q2t	WRR	512 KB	73 KB	439 KB
WS-X6516A-GBIC		WRR		WRR	1 MB	135 KB	946 KB
WS-X6516-GE-TX		WRR		WRR	512 KB	73 KB	439 KB
WS-X6408-GBIC	1q4t	WRR	2q2t	WRR		80 KB	432 KB
WS-X6408A-GBIC	1p1q4t	WRR	1p2q2t	WRR	512 KB	73 KB	439 KB
WS-X6416-GBIC		WRR					
WS-X6416-GE-MT		WRR					
WS-X6316-GE-TX		WRR					
WS-X6148-GE-TX	1q2t	WRR			1.4 MB	185 KB	1.2 MB
WS-X6148-GE-TX							
WS-X6148-GE-45AF							
WS-X6148A-GE-TX	1q2t	WRR	1p3q8t	WRR	5.5 MB	120 KB	5.4 MB
WS-X6148A-GE-45AF							

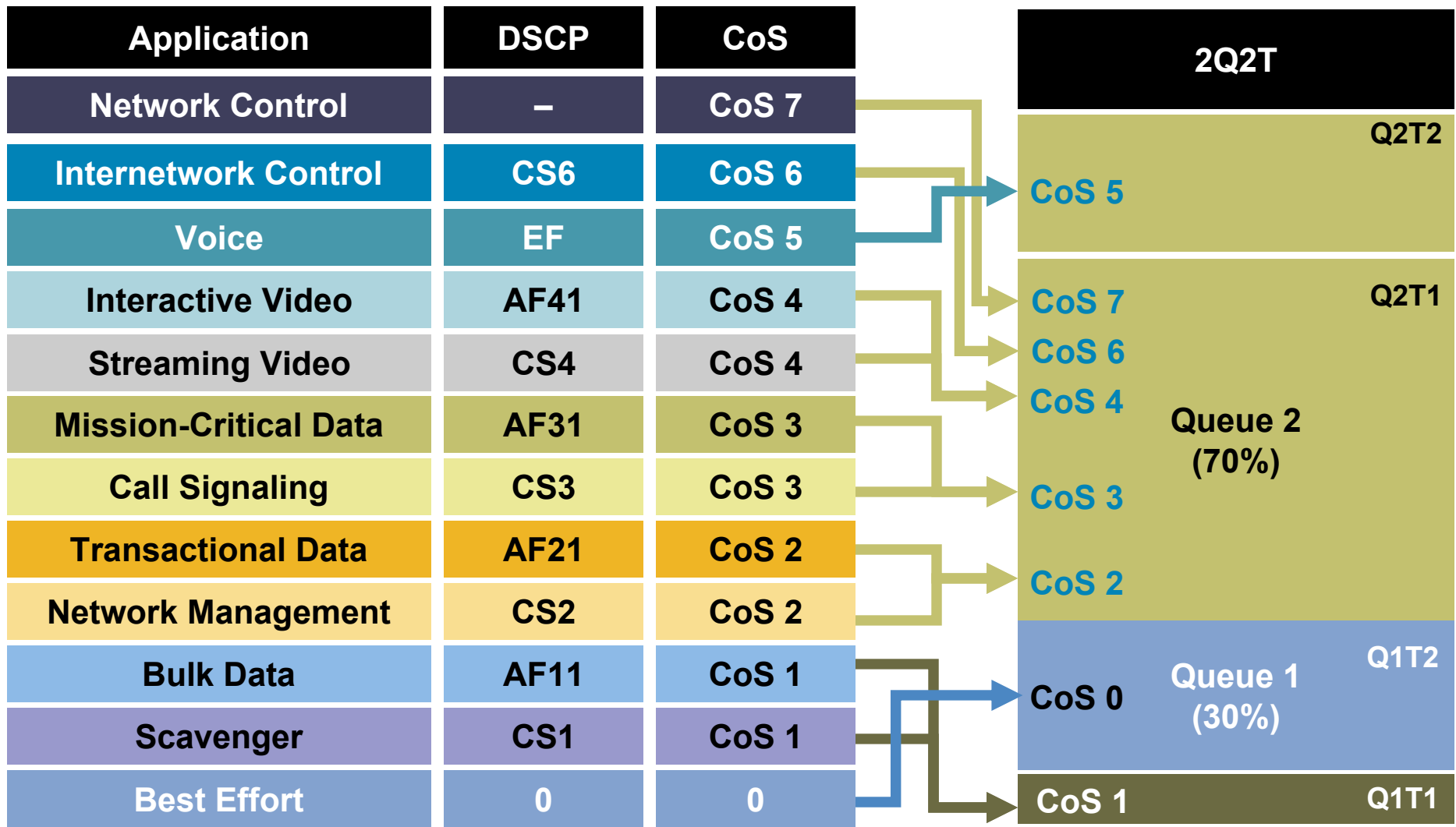
# Cisco Catalyst 6500

## Queuing Structures by 10GE Linecards

Modules	Ingress Queue and Drop Thresholds	Ingress Queue Scheduler	Egress Queue and Drop Thresholds	Egress Queue Scheduler	Total Buffer Size	Ingress Buffer Size	Egress Buffer Size
WS-X6708-10G-3C	8q4t	WRR	1p7q4t	WRR	256 MB	109 MB	92 MB
WS-X6708-10G-3CXL							
WS-X6704-10GE with DFC3	8q8t	WRR	1p7q8t	DWRR	16 MB	2 MB	14 MB
WS-X6704-10GE with CFC	1q8t	WRR					
WS-X6502-10GE	1p1q8t	WRR	1p2q1t	DWRR	64.2 MB	256 KB	64 MB
WS-X6501-10GEX4							

# Cisco Catalyst 6500

## Queuing Design: 2Q2T



# Cisco Catalyst 6500

## Queuing Design: 2Q2T (IOS)

```
CAT6500-PFC3-IOS(config)# interface range FastEthernet6/1 - 48
CAT6500-PFC3-IOS(config-if)# wrr-queue queue-limit 30 70
    ! Sets the buffer allocations to 30% for Q1 and 70% for Q2
CAT6500-PFC3-IOS(config-if)# wrr-queue bandwidth 30 70
    ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC3-IOS(config-if)#

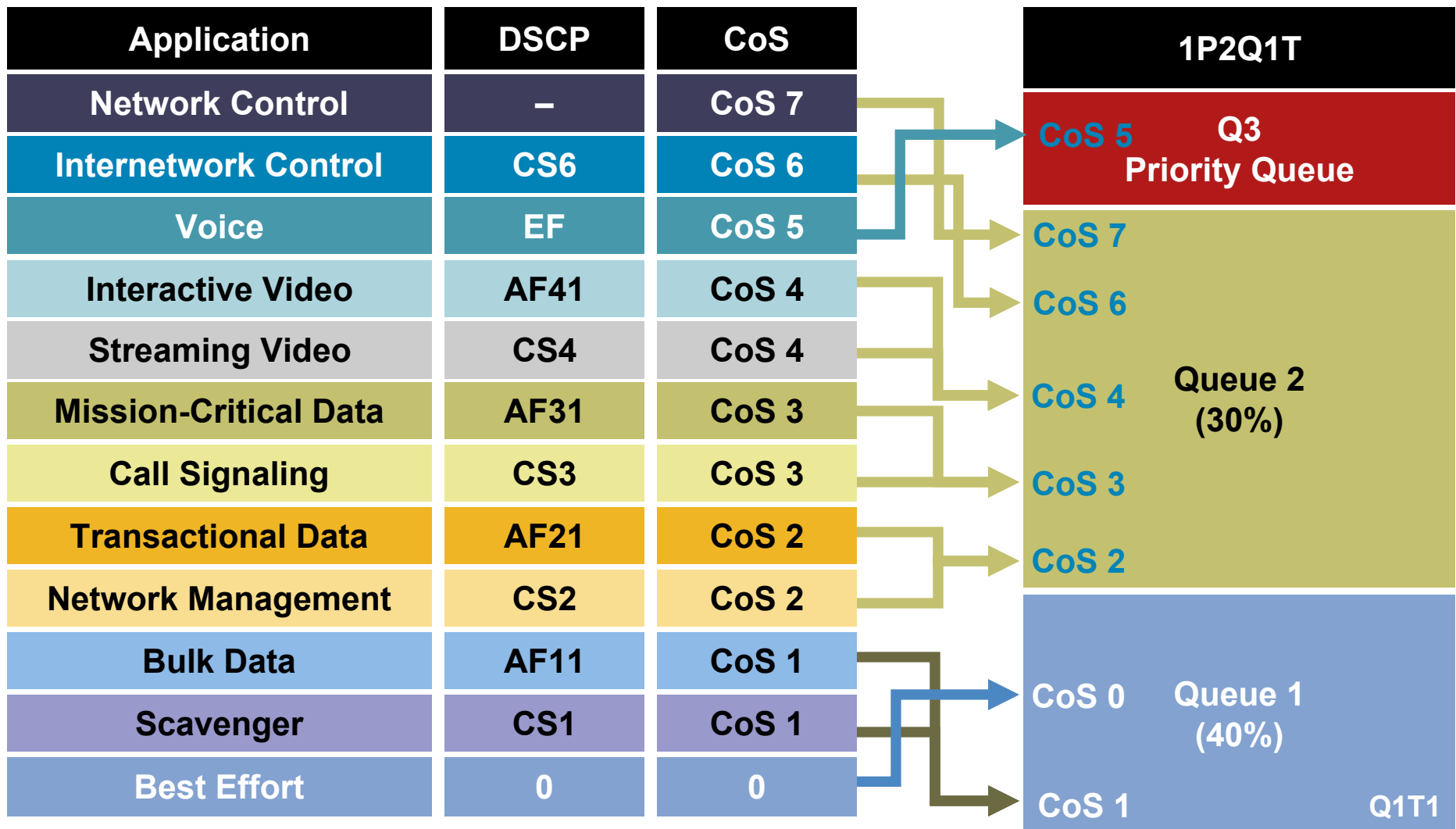
CAT6500-PFC3-IOS(config-if)# wrr-queue threshold 1 40 100
    ! Sets Q1T1 to 40% to limit Scavenger/Bulk within Q1
CAT6500-PFC3-IOS(config-if)# wrr-queue threshold 2 80 100
    ! Sets Q2T1 to 80% to always have room in Q2 for VoIP
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 1 1 1
    ! Maps Scavenger/Bulk to Q1T1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 1 2 0
    ! Maps Best Effort to Q1T2
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 2 1 2 3 4 6 7
    ! Maps CoS 2,3,4,6 and 7 to Q2T1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 2 2 5
    ! Maps VoIP to Q2T2
CAT6500-PFC3-IOS(config-if)#end
CAT6500-PFC3-IOS#
```



# Cisco Catalyst 6500

## Queuing Design: 1P2Q1T



# Cisco Catalyst 6500

## Queuing Design: 1P2Q1T (IOS)

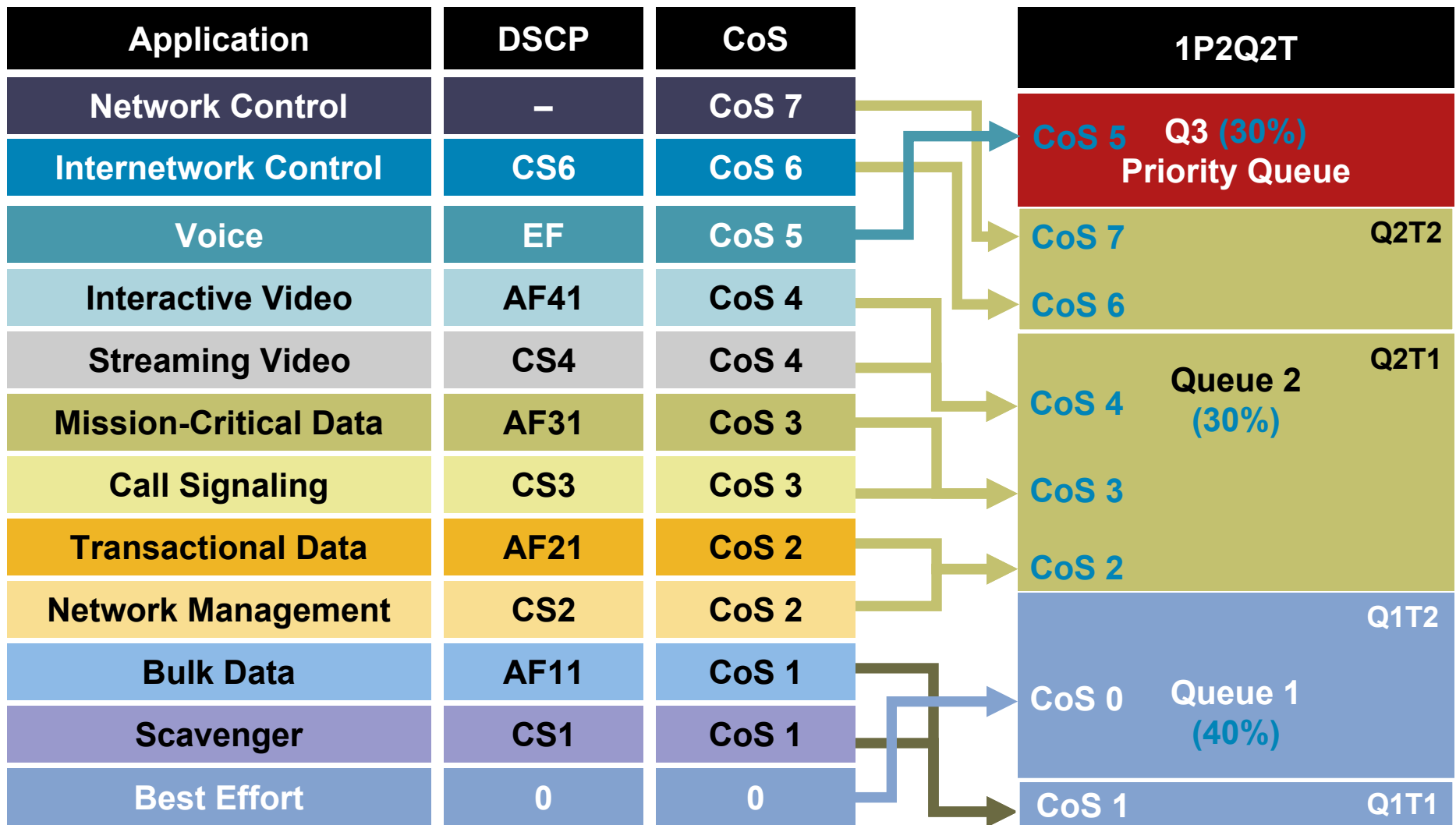
```
CAT6500-PFC3-IOS(config)#interface TenGigabitEthernet1/1
CAT6500-PFC3-IOS(config-if)# wrr-queue queue-limit 40 30
    ! Sets the buffer allocations to 30% for Q1 and 40% for Q2
CAT6500-PFC3-IOS(config-if)# wrr-queue bandwidth 30 70
    ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 1 80
    ! Sets Min WRED Threshold for Q1T1 to 80%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 1 100
    ! Sets Max WRED Threshold for Q1T1 to 100%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 2 80
    ! Sets Min WRED Threshold for Q2T1 to 80%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 2 100
    ! Sets Max WRED Threshold for Q2T1 to 100%
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 1 1 1 0
    ! Maps Scavenger/Bulk and Best Effort to Q1 WRED Threshold 1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 2 1 2 3 4 6 7
    ! Maps CoS 2,3,4,6 and 7 to Q2 WRED Threshold 1
CAT6500-PFC3-IOS(config-if)# priority-queue cos-map 1 5
    ! Assigns VoIP to PQ (Q3)
CAT6500-PFC3-IOS(config-if)#end
CAT6500-PFC3-IOS#
```

# Cisco Catalyst 6500

## Queuing Design: 1P2Q2T



# Cisco Catalyst 6500

## Queuing Design: 1P2Q2T (IOS) – Part One

```
CAT6500-PFC3-IOS(config)#interface range GigabitEthernet4/1 - 8
CAT6500-PFC3(config-if-range)# wrr-queue queue-limit 40 30
    ! Sets the buffer allocations to 40% for Q1 and 30% for Q2
    ! Indirectly sets PQ (Q3) size to equal Q2 (which is set to 30%)
CAT6500-PFC3(config-if-range)# wrr-queue bandwidth 30 70
    ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC3(config-if-range)#

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 1 40 80
    ! Sets Min WRED Thresholds for Q1T1 and Q1T2 to 40 and 80, respectively
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 1 80 100
    ! Sets Max WRED Thresholds for Q1T1 and Q1T2 to 80 and 100, respectively

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 2 70 80
    ! Sets Min WRED Thresholds for Q2T1 and Q2T2 to 70 and 80, respectively
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 2 80 100
    ! Sets Max WRED Thresholds for Q2T1 and Q2T2 to 80 and 100, respectively
```

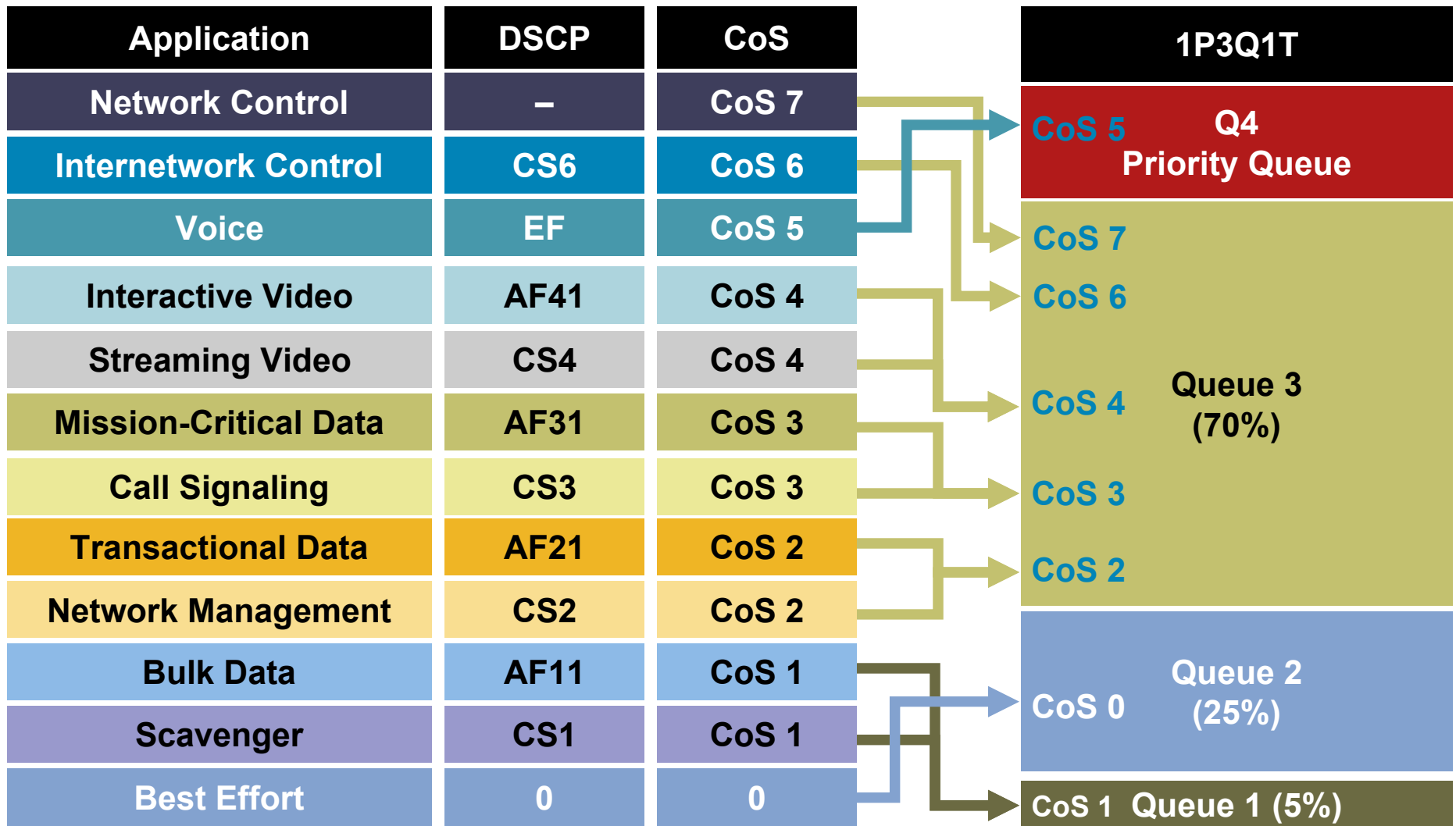
# Cisco Catalyst 6500

## Queuing Design: 1P2Q2T (IOS) – Part Two

```
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 1 1 1
! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 1 2 0
! Maps Best Effort to Q1 WRED Threshold 2
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 2 1 2 3 4
! Maps CoS 2,3,4 to Q2 WRED Threshold 1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 2 2 6 7
! Maps Network/Internetwork Control to Q2 WRED Threshold 2
CAT6500-PFC3(config-if-range)# priority-queue cos-map 1 5
! Maps VoIP to PQ
CAT6500-PFC3(config-if-range)#end
CAT6500-PFC3-IOS#
```

# Cisco Catalyst 6500

## Queuing Design: 1P3Q1T



# Cisco Catalyst 6500

## Queuing Design: 1P3Q1T (IOS) – Part One

```
CAT6500-PFC3-IOS(config)# interface range FastEthernet3/1 - 48
CAT6500-PFC3-IOS(config-if)# wrr-queue bandwidth 5 25 70
    ! Sets the WRR weights for 5:25:70 (Q1:Q2:Q3) bandwidth servicing
CAT6500-PFC3-IOS(config-if)#
CAT6500-PFC3-IOS(config-if)#
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 1      ! Enables WRED on Q1
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 2      ! Enables WRED on Q2
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 3      ! Enables WRED on Q3
CAT6500-PFC3-IOS(config-if)#
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 1 80
    ! Sets Min WRED Threshold for Q1T1 to 80%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 1 100
    ! Sets Max WRED Threshold for Q1T1 to 100%
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 2 80
    ! Sets Min WRED Threshold for Q2T1 to 80%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 2 100
    ! Sets Max WRED Threshold for Q2T1 to 100%
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 3 80
    ! Sets Min WRED Threshold for Q3T1 to 80%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 3 100
    ! Sets Max WRED Threshold for Q3T1 to 100%
CAT6500-PFC3-IOS(config-if)#
```

# Cisco Catalyst 6500

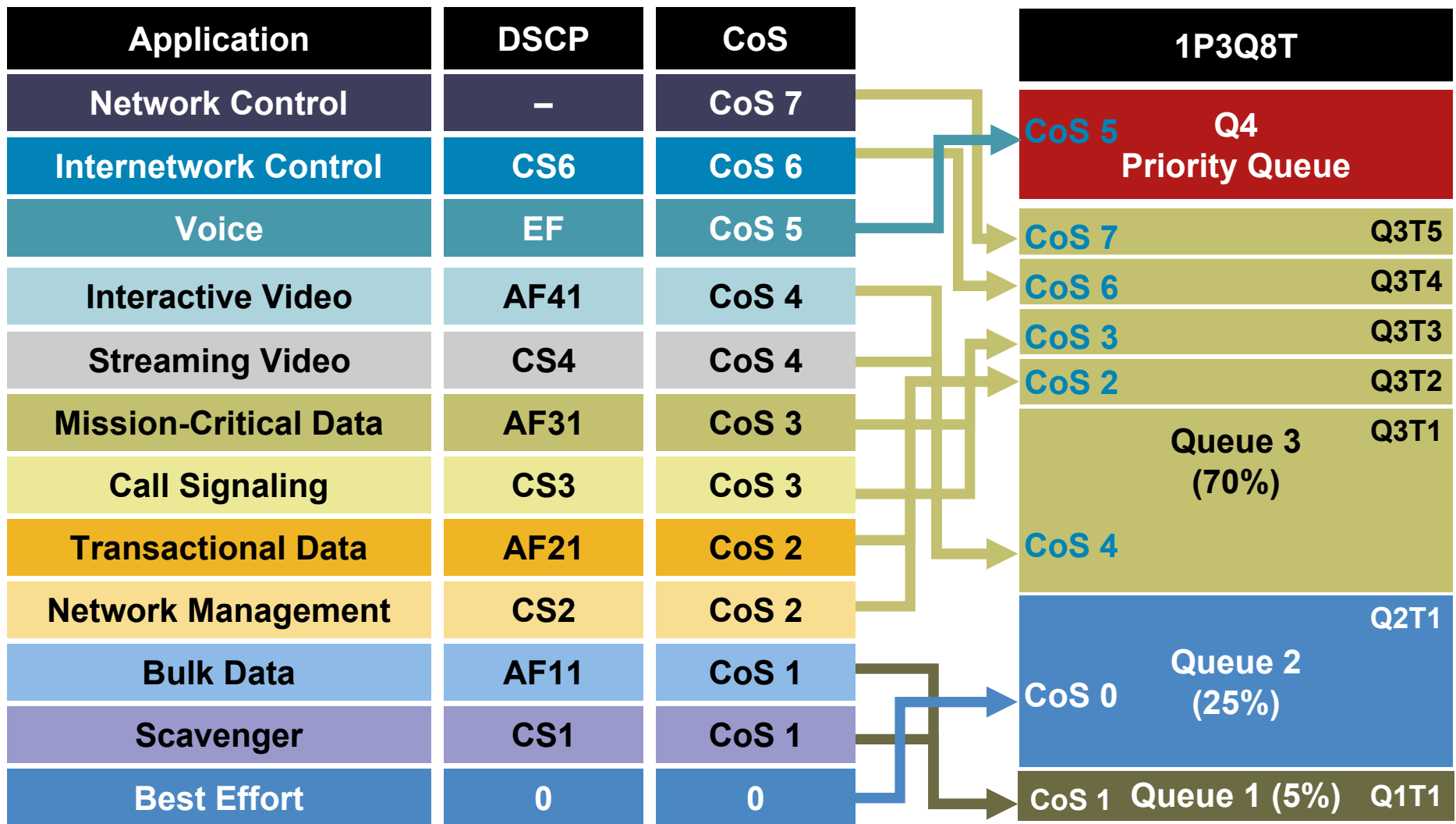
## Queuing Design: 1P3Q1T (IOS) – Part Two

```
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 1 1 1
    ! Maps Scavenger/Bulk to Q1 WRED Threshold 1 (80:100)
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 2 1 0
    ! Maps Best Effort to Q2 WRED Threshold 1 (80:100)
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 1 2 3 4 6 7
    ! Maps CoS 2,3,4,6 and 7 to Q3 WRED Threshold 1 (80:100)
CAT6500-PFC3-IOS(config-if)# priority-queue cos-map 1 5
    ! Maps VoIP to PQ (Q4)
CAT6500-PFC3-IOS(config-if)#end
CAT6500-PFC3-IOS#
```



# Cisco Catalyst 6500

## Queuing Design: 1P3Q8T



# Cisco Catalyst 6500

## Queuing Design: 1P3Q8T (IOS) – Part One

```
CAT6500-PFC3-IOS(config)# interface range GigabitEthernet1/1 - 48
CAT6500-PFC3-IOS(config-if)# wrr-queue queue-limit 5 25 40
    ! Allocates 5% for Q1, 25% for Q2 and 40% for Q3
CAT6500-PFC3-IOS(config-if)# wrr-queue bandwidth 5 25 70
    ! Sets the WRR weights for 5:25:70 (Q1:Q2:Q3) bandwidth servicing

CAT6500-PFC3(config-if-range)# wrr-queue random-detect 1      ! Enables WRED on Q1
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 2      ! Enables WRED on Q2
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 3      ! Enables WRED on Q3
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 1 80
    100 100 100 100 100 100 100
    ! Sets Min WRED Threshold for Q1T1 to 80% and all others to 100%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 1 100
    100 100 100 100 100 100 100
    ! Sets Max WRED Threshold for Q1T1 to 100% and all others to 100%
CAT6500-PFC3-IOS(config-if)#

CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 2 80
    100 100 100 100 100 100 100
    ! Sets Min WRED Threshold for Q2T1 to 80% and all others to 100%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 2 100
    100 100 100 100 100 100 100
    ! Sets Max WRED Threshold for Q2T1 to 100% and all others to 100%
```

# Cisco Catalyst 6500

## Queuing Design: 1P3Q8T (IOS) – Part Two

```
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect min-threshold 3 50
60 70 80 90 100 100 100
! Sets Min WRED Threshold for Q3T1 to 50%, Q3T2 to 60%, Q3T3 to 70%
! Q3T4 to 80%, Q3T5 to 90% and all others to 100%
CAT6500-PFC3-IOS(config-if)# wrr-queue random-detect max-threshold 3 60
70 80 90 100 100 100 100
! Sets Max WRED Threshold for Q3T1 to 60%, Q3T2 to 70%, Q3T3 to 80%
! Q3T4 to 90%, Q3T5 to 100% and all others to 100%

CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 1 1 1
! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 2 1 0
! Maps Best Effort to Q2 WRED Threshold 1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 1 4
! Maps Video to Q3 WRED Threshold 1
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 2 2
! Maps Net-Mgmt and Transactional Data to Q3 WRED T2
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 3 3
! Maps Call-Signaling and Mission-Critical Data to Q3 WRED T3
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 4 6
! Maps Internetwork-Control (IP Routing) to Q3 WRED T4
CAT6500-PFC3-IOS(config-if)# wrr-queue cos-map 3 5 7
! Maps Network-Control (Spanning Tree) to Q3 WRED T5
CAT6500-PFC3-IOS(config-if)# priority-queue cos-map 1 5
! Maps VoIP to the PQ (Q4)
CAT6500-PFC3-IOS(config-if)#end
CAT6500-PFC3-IOS#
```

# Cisco Catalyst 6500

## Queuing Design: 1P7Q4T and/or 1P7Q8T

Application	DSCP	CoS		1P7Q8T		
Network Control	–	CoS 7		CoS 5	Q8 (PQ)	
Interwork Control	CS6	CoS 6		CoS 7	Q7 (5%)	Q7T1
Voice	EF	CoS 5		CoS 6	Q6 (5%)	Q6T1
Interactive Video	AF41	CoS 4		CoS 3	Q5 (20%)	Q5T1
Streaming Video	CS4	CoS 4		CoS 2	Q4 (20%)	Q4T1
Mission-Critical Data	AF31	CoS 3		CoS 4	Q3 (20%)	Q3T1
Call Signaling	CS3	CoS 3		CoS 0	Q2 (25%)	Q2T1
Transactional Data	AF21	CoS 2		CoS 1	Q1 (5%)	Q1T1
Network Management	CS2	CoS 2				
Bulk Data	AF11	CoS 1				
Scavenger	CS1	CoS 1				
Best Effort	0	0				

# Cisco Catalyst 6500

## Queuing Design: 1P7Q4T/1P7Q8T (IOS) – Part One

```
CAT6500-PFC3-IOS(config)#interface range TenGigabitEthernet4/1 - 4
CAT6500-PFC3(config-if-range)# wrr-queue queue-limit 5 25 10 10 10 5 5
    ! Allocates 5% to Q1, 25% to Q2, 10% to Q3, 10% to Q4,
    ! Allocates 10% to Q5, 5% to Q6 and 5% to Q7
CAT6500-PFC3(config-if-range)# wrr-queue bandwidth 5 25 20 20 20 5 5
    ! Sets the WRR weights for 5:25:20:20:20:5:5 (Q1 through Q7)

CAT6500-PFC3(config-if-range)# wrr-queue random-detect 1      ! Enables WRED on Q1
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 2      ! Enables WRED on Q2
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 3      ! Enables WRED on Q3
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 4      ! Enables WRED on Q4
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 5      ! Enables WRED on Q5
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 6      ! Enables WRED on Q6
CAT6500-PFC3(config-if-range)# wrr-queue random-detect 7      ! Enables WRED on Q7
```

# Cisco Catalyst 6500

## Queuing Design: 1P7Q4T/1P7Q8T (IOS) – Part Two

```
CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 1 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q1T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 1 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q1T1 to 100% and all others to 100%

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 2 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q2T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 2 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q2T1 to 100% and all others to 100%

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 3 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q3T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 3 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q3T1 to 100% and all others to 100%

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 4 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q4T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 4 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q4T1 to 100% and all others to 100%
```

# Cisco Catalyst 6500

## Queuing Design: 1P7Q4T/1P7Q8T (IOS) – Part Three

```
CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 5 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q5T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 5 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q5T1 to 100% and all others to 100%

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 6 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q6T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 6 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q6T1 to 100% and all others to 100%

CAT6500-PFC3(config-if-range)# wrr-queue random-detect min-threshold 7 80
100 100 100 100 100 100 100
! Sets Min WRED Threshold for Q7T1 to 80% and all others to 100%
CAT6500-PFC3(config-if-range)# wrr-queue random-detect max-threshold 7 100
100 100 100 100 100 100 100
! Sets Max WRED Threshold for Q7T1 to 100% and all others to 100%
```

# Cisco Catalyst 6500

## Queuing Design: 1P7Q4T/1P7Q8T (IOS) – Part Four

```
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 1 1 1
    ! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 2 1 0
    ! Maps Best Effort to Q2 WRED Threshold 1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 3 1 4
    ! Maps Video to Q3 WRED Threshold 1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 4 1 2
    ! Maps Net-Mgmt and Transactional Data to Q4 WRED T1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 5 1 3
    ! Maps Call-Signaling and Mission-Critical Data to Q5 WRED T1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 6 1 6
    ! Maps Internetwork-Control (IP Routing) to Q6 WRED T1
CAT6500-PFC3(config-if-range)# wrr-queue cos-map 7 1 7
    ! Maps Network-Control (Spanning Tree) to Q7 WRED T1
CAT6500-PFC3(config-if-range)# priority-queue cos-map 1 5
    ! Maps VoIP to the PQ (Q4)
CAT6500-PFC3(config-if-range)#end
CAT6500-PFC3-IOS#
```



# At-a-Glance Summaries



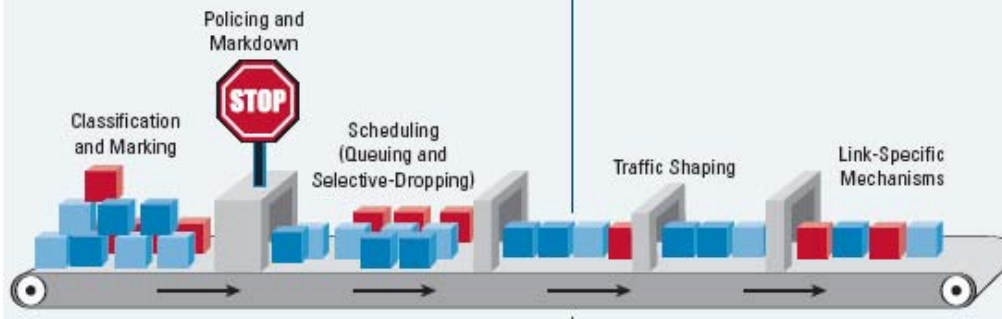
Quality of Service (QoS) is the measure of transmission quality and service availability of a network (or internetworks). The transmission quality of the network is determined by the following factors: Latency, Jitter, and Loss.



QoS technologies refer to the set of tools and techniques to manage network resources and are considered the key enabling technologies for the transparent convergence of voice, video, and data networks. Additionally, QoS tools can play a strategic role in significantly mitigating DoS/worm attacks.

Cisco QoS toolset consists of the following:

- Classification and Marking tools
- Policing and Markdown tools
- Scheduling tools
- Link-specific tools
- AutoQoS tools



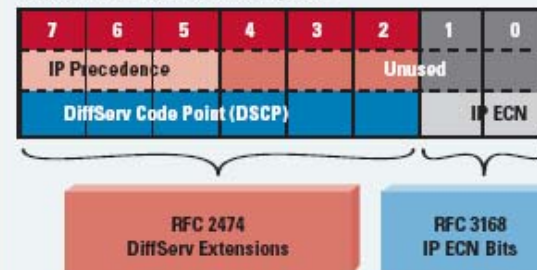
Classification can be Done at Layers 2-7



Marking can be done at Layers 2 or Layer 3:

- Layer 2: 802.1Q/p CoS, MPLS EXP
- Layer 3: IP Precedence, DSCP and/or IP ECN

Layer 3 (IP ToS Byte) Marking Options

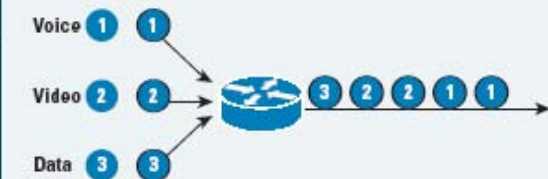


Cisco recommends end-to-end marking at Layer 3 with standards-based DSCP values.

Policing tools can complement marking tools by marking metering flows and marking-down out-of-contract traffic.



Scheduling tools re-order and selectively-drop packets whenever congestion occurs.



Link-Specific tools are useful on slow-speed WAN/VPN links and include shaping, compression, fragmentation, and interleaving.

AutoQoS features automatically configure Cisco recommended QoS on Cisco Catalyst® switches and Cisco IOS® Software routers with just one or two commands.

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# THE QoS BASELINE AT-A-GLANCE

The QoS Baseline is a strategic document designed to unify QoS within Cisco. The QoS Baseline provides uniform, standards-based recommendations to help ensure that QoS products, designs, and deployments are unified and consistent.

The QoS Baseline defines up to 11 classes of traffic that may be viewed as critical to a given enterprise. A summary of these classes and their respective standards-based markings and recommended QoS configurations are shown below.

Interactive-Video refers to IP Video-Conferencing; Streaming Video is either unicast or multicast uni-directional video.

The (Locally-Defined) Mission-Critical class is intended for a subset of Transactional Data applications that contribute most significantly to the business objectives (this is a non-technical assessment).

The Transactional Data class is intended for foreground, user-interactive applications such as database access, transaction services, interactive messaging, and preferred data services.

The Bulk Data class is intended for background, non-interactive traffic flows, such as large file transfers, content distribution, database synchronization, backup operations, and email.

The IP Routing class is intended for IP Routing protocols, such as Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), and etc.

The Call-Signaling class is intended for voice and/or video signaling traffic, such as Skinny, SIP, H.323, etc.

The Network Management class is intended for network management protocols, such as SNMP, Syslog, DNS, etc.

Standards-based marking recommendations allow for better integration with service-provider offerings as well as other internetworking scenarios.

In Cisco IOS Software, rate-based queuing translates to CBWFQ; priority queuing is LLQ.

Application	L3 Classification PHB	DSCP	Referencing Standard	Recommended Configuration
IP Routing	CS6	48	RFC 2474-4.2.2	Rate-Based Queuing + RED
Voice	EF	46	RFC 3246	RSVP Admission Control + Priority Queuing
Interactive-Video	AF41	34	RFC 2597	RSVP + Rate-Based Queuing + DSCP-WRED
Streaming Video	CS4	32	RFC 2474-4.2.2	RSVP + Rate-Based Queuing + RED
Mission-Critical	AF31	26	RFC 2597	Rate-Based Queuing + DSCP-WRED
Call-Signaling	CS3	24	RFC 2474-4.2.2	Rate-Based Queuing + RED
Transactional Data	AF21	18	RFC 2597	Rate-Based Queuing + DSCP-WRED
Network Mgmt	CS2	16	RFC 2474-4.2.2	Rate-Based Queuing + RED
Bulk Data	AF11	10	RFC 2597	Rate-Based Queuing + DSCP-WRED
Scavenger	CS1	8	Internet 2	No BW Guarantee + RED
Best Effort	0	0	RFC 2474-4.1	BW Guarantee Rate-Based Queuing + RED

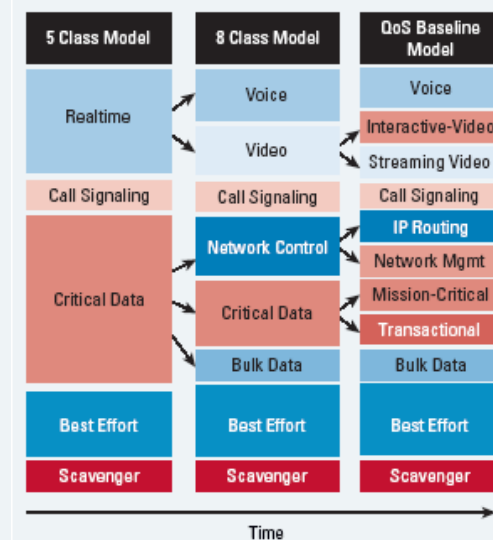
DSCP-Based WRED (based on RFC 2597) drops AFx3 before AFx2, and in turn drops AFx2 before AFx1. RSVP is recommended (whenever supported) for Voice and/or Interactive-Video admission control.

Cisco products that support QoS features will use these QoS Baseline recommendations for marking, scheduling, and admission control.

The Scavenger class is based on an Internet 2 draft that defines a “less-than-Best Effort” service. In the event of link congestion, this class will be dropped the most aggressively.

The Best Effort class is also the default class. Unless an application has been assigned for preferential/deferential service, it will remain in this default class. Most enterprises have hundreds—if not thousands—of applications on their networks; the majority of which will remain in the Best Effort service class.

The QoS Baseline recommendations are intended as a standards-based guideline for customers—not as a mandate.



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# QoS BEST-PRACTICES AT-A-GLANCE

A successful QoS deployment includes three key phases:

- 1) Strategically defining the business objectives to be achieved via QoS
- 2) Analyzing the service-level requirements of the traffic classes
- 3) Designing and testing QoS policies


## 1) STRATEGICALLY DEFINING THE BUSINESS OBJECTIVES TO BE ACHIEVED BY QoS

Business QoS objectives need to be defined:

- Is the objective to enable VoIP only or is video also required?
- If so, is video-conferencing or streaming video required? Or both?
- Are there applications that are considered mission-critical? If so, what are they?
- Does the organization wish to squelch certain types of traffic? If so, what are they?
- Does the business want to use QoS tools to mitigate DoS/worm attacks?
- How many classes of service are needed to meet the business objectives?


Because QoS introduces a system of managed unfairness, most QoS deployments inevitably entail political repercussions when implemented. To minimize the effects of non-technical obstacles to deployment, address political/organizational issues as early as possible, garnishing executive endorsement whenever possible.

## 2) ANALYZE THE APPLICATION SERVICE-LEVEL REQUIREMENTS




**Voice**

- Predictable Flows
- Drop + Delay Sensitive
- UDP Priority
- 150 ms One-Way Delay
- 30 ms Jitter
- 1% Loss
- 17 kbps-106 kbps VoIP + Call-Signaling



**Video**

- Unpredictable Flows
- Drop + Delay Sensitive
- UDP Priority
- 150 ms One-Way Delay
- 30 ms Jitter
- 1% Loss
- Overprovision Stream by 20% to Account for Headers + Bursts



**Data**

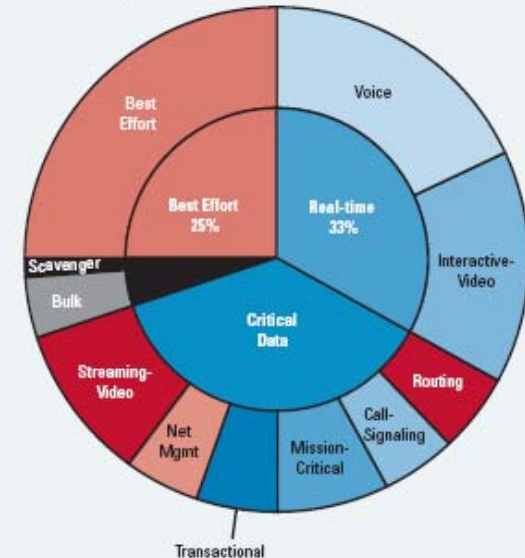
- No "One-Size Fits All"
- Smooth/Bursty
- Benign/Greedy
- TCP Retransmits/UDP Does Not

## 3) DESIGN AND TEST THE QoS POLICIES

Application	L3 Classification	
	PHB	DSCP
Routing	CS6	48
Voice	EF	46
Interactive-Video	AF41	34
Streaming Video	CS4	32
Mission-Critical	AF31	26
Call-Signaling	CS3	24
Transactional Data	AF21	18
Network Mgmt	CS2	16
Bulk Data	AF11	10
Scavenger	CS1	8
Best Effort	0	0

Classify, mark, and police as close to the traffic-sources as possible; following Differentiated-Services standards, such as RFC 2474, 2475, 2597, 2698 and 3246.

Provision queuing in a consistent manner (according to hardware capabilities).



Thoroughly test QoS policies prior to production-network deployment.

A successful QoS policy rollout is followed by ongoing monitoring of service levels and periodic adjustments and tuning of QoS policies.

As business conditions change, the organization will need to adapt to these changes and may be required to begin the QoS deployment cycle anew, by redefining their objectives, tuning and testing corresponding designs, rolling these new designs out and monitoring them to see if they match the redefined objectives.

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# SCAVENGER-CLASS QoS STRATEGY FOR DOS/WORM ATTACK MITIGATION

## AT-A-GLANCE

DoS and worm attacks are exponentially increasing in frequency, complexity, and scope of damage.

QoS tools and strategic designs can mitigate the effects of worms and keep critical applications available during DoS attacks.

One such strategy, referred to as Scavenger-class QoS, uses a two-step tactical approach to provide first- and second-order anomaly detection and reaction to DoS/worm attack-generated traffic.

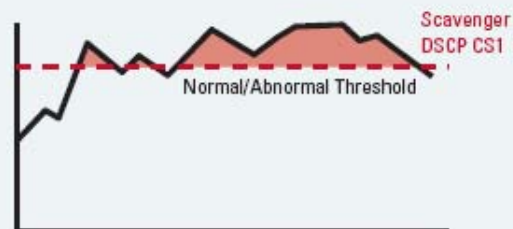
The first step in deploying Scavenger-class QoS is to profile applications to determine what constitutes a normal vs. abnormal flow (within a 95% confidence interval).

Application traffic exceeding this normal rate will be subject to first-order anomaly detection at the Campus Access-Edge, specifically: excess traffic will be marked down to Scavenger (DSCP CS1/8).

Note that anomalous traffic is not dropped or penalized at the edge; it is simply remarked.



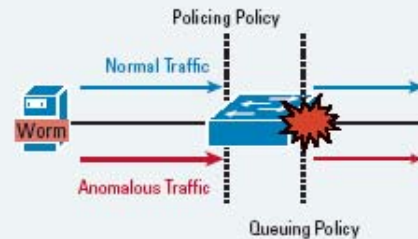
Only traffic in excess of the normal/abnormal threshold is remarked to Scavenger.



Campus Access-Edge policing policies are coupled with Scavenger-class queuing policies on the uplinks to the Campus Distribution Layer.

Queuing policies only engage when links are congested. Therefore, only if uplinks become congested, traffic begin to be dropped.

Anomalous traffic—previously marked to Scavenger—is dropped the most aggressively (only after all other traffic types have been fully-serviced).

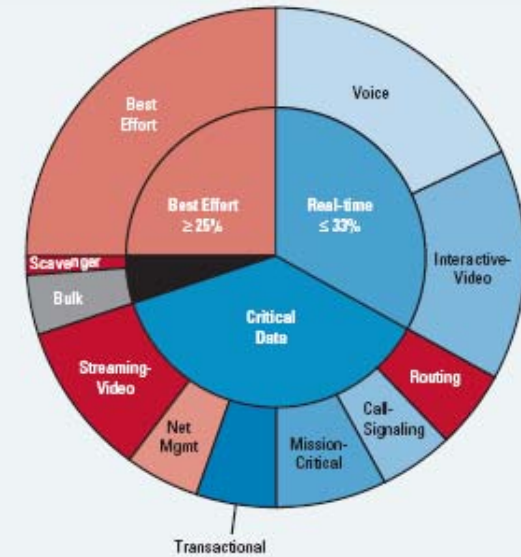


A key point of this strategy is that legitimate traffic flows that temporarily exceed thresholds are not penalized by Scavenger-class QoS.

Only sustained, abnormal streams generated simultaneously by multiple hosts (highly-indicative of DoS/worm attacks) are subject to aggressive dropping—and such dropping only occurs *after* legitimate traffic has been fully-serviced.

The Campus uplinks are not the only points in the network infrastructure where congestion could occur. Typically WAN and VPN links are the first to congest.

Therefore, Scavenger-class “less-than-Best-Effort” queuing should be provisioned on all network devices in a consistent manner (according to hardware capabilities).



Thoroughly test QoS policies prior to production-network deployment.

It is critically important to recognize, that even when Scavenger-class QoS has been deployed end-to-end, this tactic only mitigates the effects of certain types of DoS/worm attacks, and does not prevent them or remove them entirely. Scavenger-class QoS is just one element of a comprehensive Cisco Self-Defending Networks (SDN) strategy.

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# CAMPUS QoS DESIGN AT-A-GLANCE

QoS policies should always be enabled in Cisco Catalyst® switches—rather than router software—whenever a choice exists.

Three main types of QoS policies are required within the Campus:

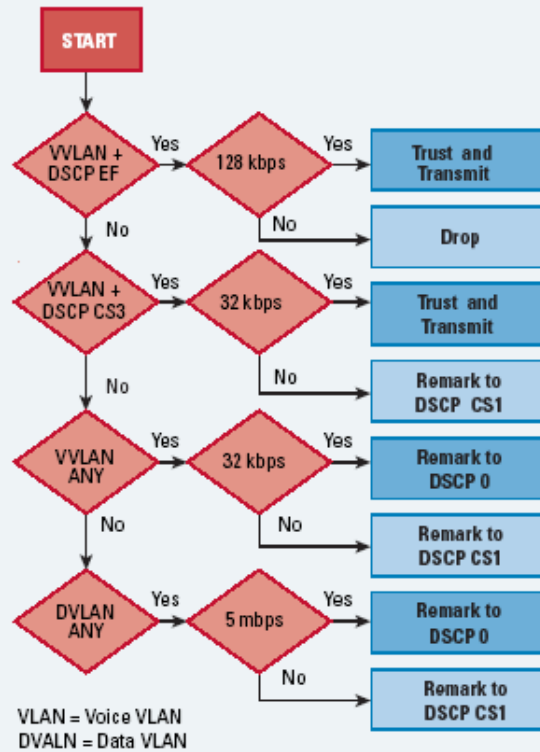
- 1) Classification and Marking
- 2) Policing and Markdown
- 3) Queuing

Classification, marking, and policing should be performed as close to the traffic-sources as possible, specifically at the Campus Access-Edge. Queuing, on the other hand, needs to be provisioned at all Campus Layers (Access, Distribution, Core) due to oversubscription ratios.

Classify and mark as close to the traffic-sources as possible following Cisco QoS Baseline marking recommendations, which are based on Differentiated-Services standards, such as: RFC 2474, 2597 & 3246.

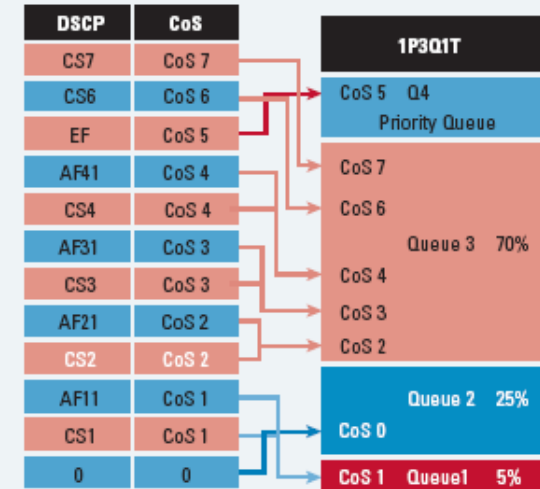
Application	L3 Classification	
	PHB	DSCP
Routing	CS6	48
Voice	EF	46
Interactive-Video	AF41	34
Streaming Video	CS4	32
Mission-Critical	AF31	26
Call-Signaling	CS3	24
Transactional Data	AF21	18
Network Mgmt	CS2	16
Bulk Data	AF11	10
Scavenger	CS1	8
Best Effort	0	0

Access-Edge policers, such as this one, detect anomalous flows and remark these to Scavenger (DSCP CS1).



Queuing policies will vary by platform:

E.g. 1P3Q1T P = Priority Queue  
Q = Non-Priority Queue  
T = WRED Threshold



Campus Access switches require the following QoS policies:

- Appropriate (endpoint-dependant) trust policies, and/or classification and marking policies
- Policing and markdown policies
- Queuing policies.

Campus Distribution and Core switches require the following QoS policies:

- DSCP trust policies
- Queuing policies
- Optional per-user microflow policing policies (only on distribution layer Catalyst 6500s with Sup720s.)

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# References



# Reference Materials

## *Enterprise QoS Solution Reference Network Design Guide*

- <http://www.cisco.com/go/srnd>
- QoS design overview
- Campus QoS design
- WAN QoS design
- Branch QoS design
- MPLS VPN (CE) QoS design



### **Enterprise QoS Solution Reference Network Design Guide**

Version 3.3  
November 2005

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# Reference Materials

## *DiffServ Standards*

- RFC 2474 “Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers”  
<http://www.apps.ietf.org/rfc/rfc2474.html>
- RFC 2475 “An Architecture for Differentiated Services”  
<http://www.ietf.org/rfc/rfc2475.txt>
- RFC 2597 “Assured Forwarding PHB Group”  
<http://www.ietf.org/rfc/rfc2597.txt>
- RFC 2697 “A Single Rate Three Color Marker”  
<http://www.ietf.org/rfc/rfc2697.txt>
- RFC 2698 “A Two Rate Three Color Marker”  
<http://www.ietf.org/rfc/rfc2698.txt>
- RFC 3246 “An Expedited Forwarding PHB (Per-Hop Behavior)”  
<http://www.ietf.org/rfc/rfc3246.txt>
- RFC 3662 “A Lower Effort Per-Domain Behavior (PDB) for Differentiated Services”  
<http://www.ietf.org/rfc/rfc3662.txt>
- RFC 4594 “Configuration Guidelines for DiffServ Service Classes”  
<http://www.ietf.org/rfc/rfc4594.txt>

# Reference Materials

## *Cisco Catalyst QoS Documentation*

- Cisco Catalyst 2950 QoS Configuration Documentation  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/12122ea7/scg/swqos.htm>
- Cisco Catalyst 2960 QoS Configuration Documentation  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/12122ea7/scg/swqos.htm>
- Cisco Catalyst 3550 QoS Configuration Documentation  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/c3550/12225see/scg/swqos.htm>
- Cisco Catalyst 3560 QoS Configuration Documentation  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3560/12225see/scg/swqos.htm>
- Cisco Catalyst 3750 QoS Configuration Documentation  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3750/12225see/scg/swqos.htm>
- Cisco Catalyst 4500 QoS Configuration Documentation  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12\\_2\\_31s/conf/qos.htm](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_31s/conf/qos.htm)
- Cisco Catalyst 6500 QoS Configuration Documentation (CatOS)  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw\\_8\\_5/config\\_gd/qos.htm](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw_8_5/config_gd/qos.htm)
- Cisco Catalyst 6500 QoS Configuration Documentation (Cisco IOS)  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/qos.htm>

# Reference Materials

## *Cisco Catalyst AutoQoS-VoIP Documentation*

- AutoQoS VoIP for the Cisco Catalyst 2950  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/12122ea7/scg/swqos.htm#wp1125412>
- AutoQoS VoIP for the Cisco Catalyst 2960  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2960/12225see/scg/swqos.htm#wp1231112>
- AutoQoS VoIP for the Cisco Catalyst 3550  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/c3550/12225see/scg/swqos.htm#wp1185065>
- AutoQoS VoIP for the Cisco Catalyst 3560  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3560/12225see/scg/swqos.htm#wp1231112>
- AutoQoS VoIP for the Cisco Catalyst 3750  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3750/12225see/scg/swqos.htm#wp1231112>
- AutoQoS VoIP for the Cisco Catalyst 4550  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12\\_2\\_31s/conf/qos.htm#wp1281380](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_31s/conf/qos.htm#wp1281380)
- AutoQoS VoIP for the Cisco Catalyst 6500 (Cisco Catalyst OS Only)  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw\\_8\\_5/config\\_gd/autoqos.htm](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw_8_5/config_gd/autoqos.htm)

# Reference Materials

## *C4500 UBRL & C6500 Microflow Policing + CoPP*

- User-Based Rate Limiting (Cat4500)  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12\\_2\\_25a/conf/qos.htm#wp1327746](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_25a/conf/qos.htm#wp1327746)
- Per-User Microflow Policing (C6500—Cisco IOS)  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/qos.htm#wp1020702>
- Control Plane Policing (C6500 Cisco IOS)  
<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/dos.htm>

# Meet the Experts

## Campus and Wireless Evolution

- Mark Montanez  
Corporate Dev Consulting Engineer



- Tim Szigeti  
Technical Leader



- Sujit Ghosh  
Technical Mktg Eng



- Victor Moreno  
Technical Leader



- Mike Herbert  
Technical Leader



# Recommended Reading

## *End-to-End QoS Design: QoS in LANs, WANs and VPNs*

<http://www.ciscopress.com/title/1587051761>

ISBN: 1587051761

Publish Date: Nov 2004

### LAN

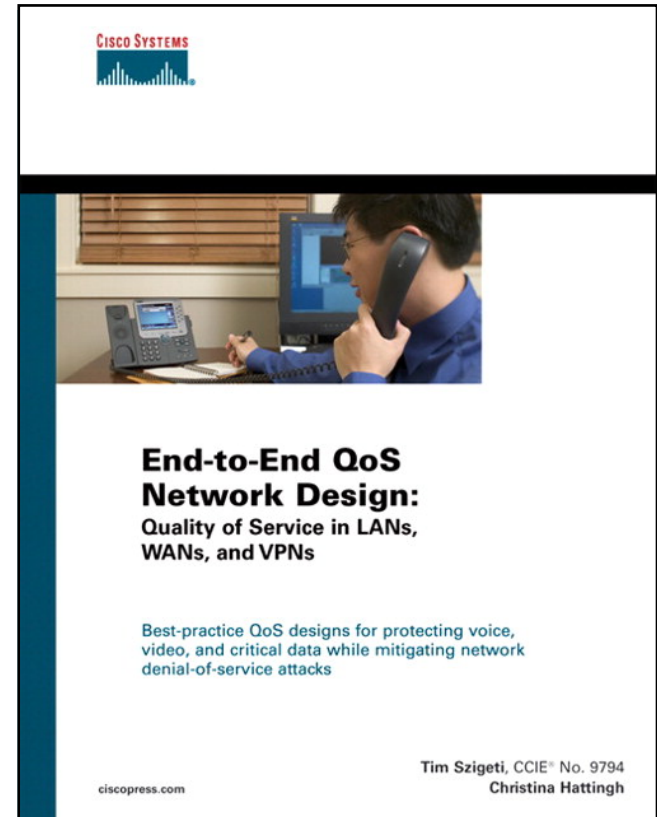
- Cisco Catalyst 2950
- Cisco Catalyst 3550
- Cisco Catalyst 2960/2970/3560/3750
- Cisco Catalyst 4500
- Cisco Catalyst 6500

### WAN/Branch

- Leased lines
- Frame Relay
- ATM
- ATM-to-FR SIW

- NBAR for worm policing
- VPN
- MPLS (for enterprise subscribers)
- MPLS (for service providers)
- IPSec (site-to-site)
- IPSec (teleworker)

**Available Onsite at the  
Cisco Company Store**



# Q and A

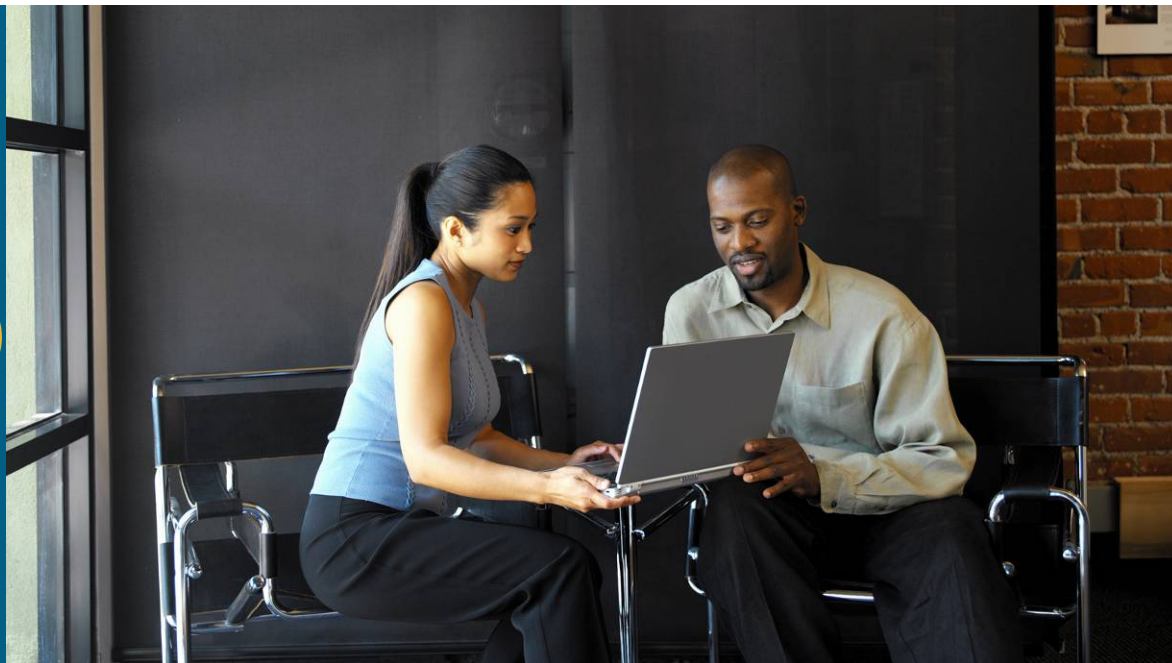






# Appendix A

## Cisco Catalyst 2950 QoS Design



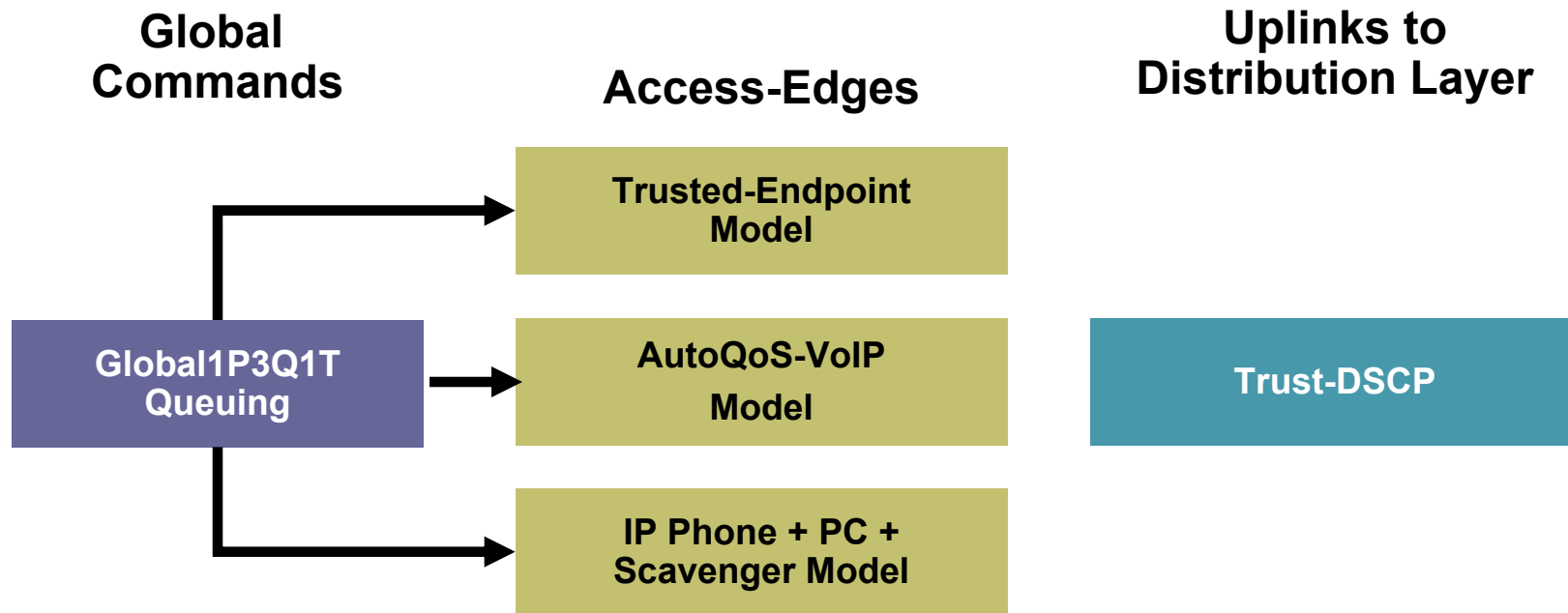
# Cisco Catalyst 2950

## *Platform-Specific QoS Design Considerations*

- Certain QoS features require the Enhanced Image (EI)
- Not all DSCP values are supported
  - Only DSCP values 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56
- System-defined masks are allowed in class maps restrictions
- There is no support for policing at a VLAN level
- Minimum policing granularity is 1 mbps (for 10/100 ports)
- Supports 4Q1T queuing or 1P3Q1T queuing
  - Q4 can be enabled as a priority queue

# Cisco Catalyst 2950

## Access-Layer QoS Design



# Cisco Catalyst 2950

## AutoQoS – VoIP Example

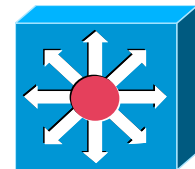


```
C2950(config-if)#auto qos voip cisco-phone
```

### Options:

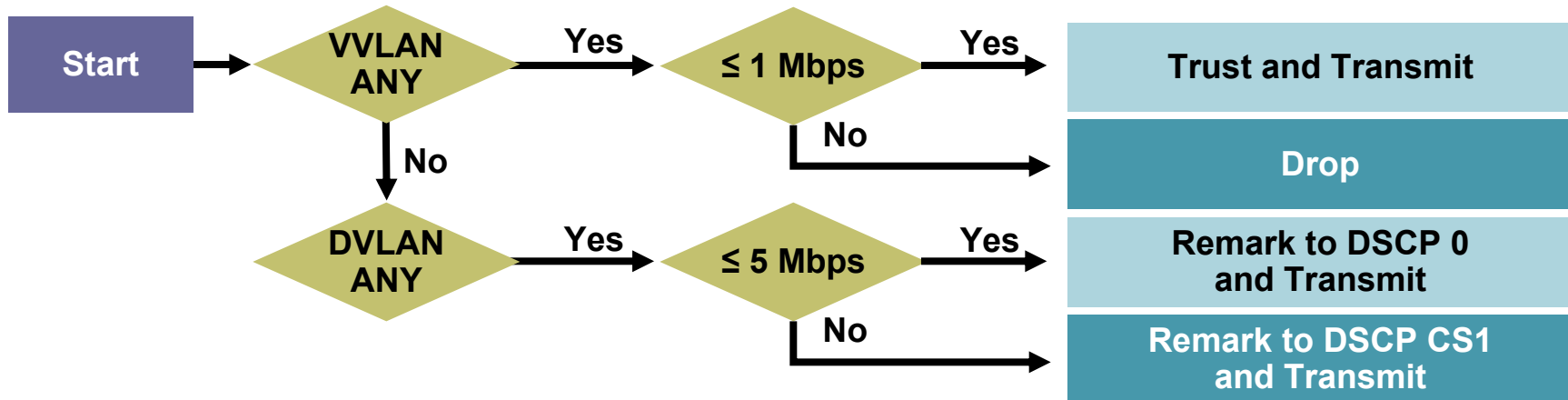
```
auto qos voip cisco-phone  
auto qos voip cisco-softphone  
auto qos voip trust
```

```
!  
wrr-queue bandwidth 10 20 70 1  
wrr-queue cos-map 1 0 1  
wrr-queue cos-map 2 2 4  
wrr-queue cos-map 3 3 6 7  
wrr-queue cos-map 4 5  
mls qos map cos-dscp 0 8 1 26 32 46 48 56  
!  
!  
interface FastEthernet0/1  
  mls qos trust device cisco-phone  
  mls qos trust cos  
  auto qos voip cisco-phone  
!
```



# Cisco Catalyst 2950

## Modified IP Phone + PC + Scavenger Model



# Cisco Catalyst 2950

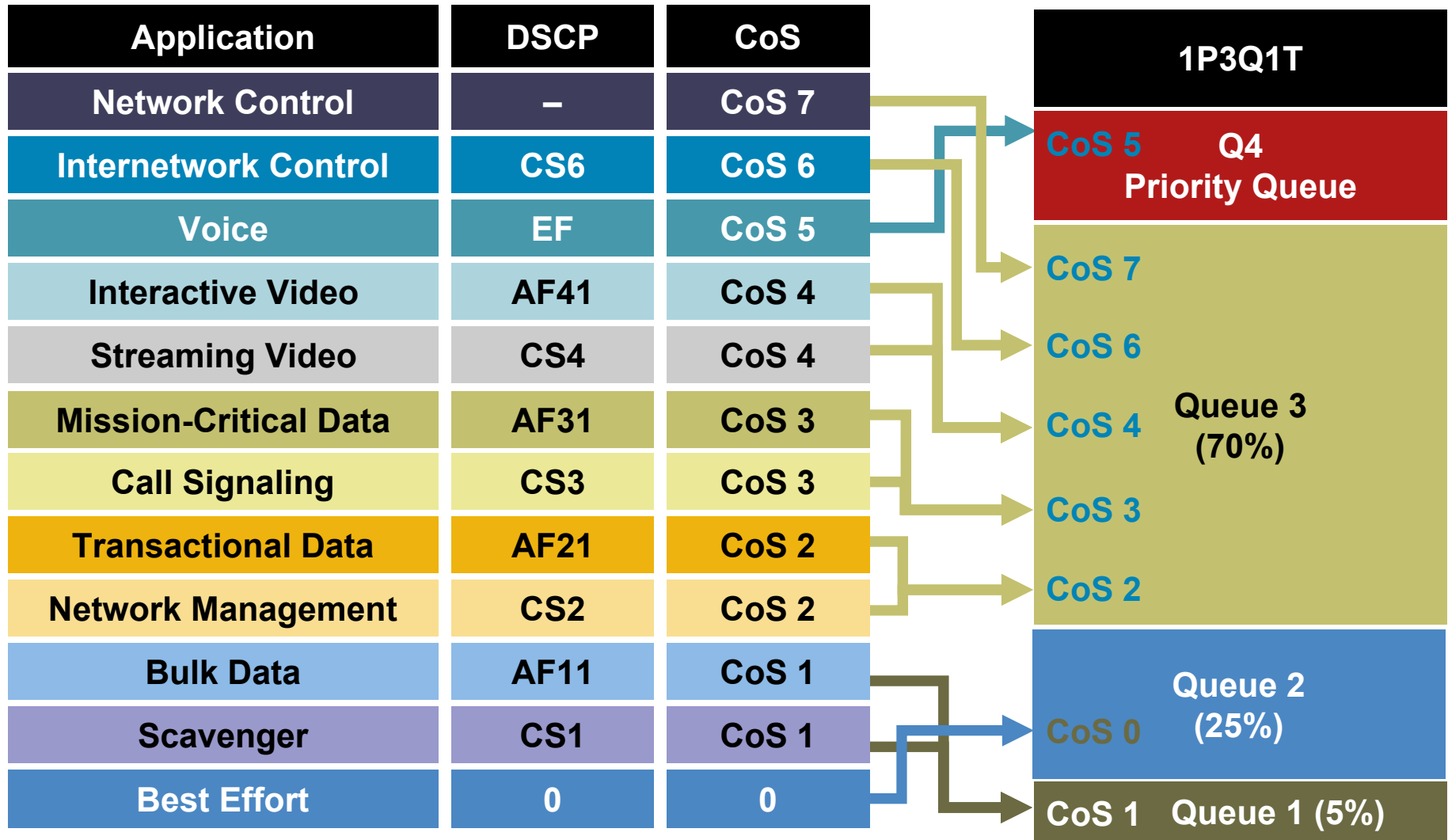
## Modified IP Phone + PC + Scavenger Model



```
CAT2950(config)#mls qos map cos-dscp 0 8 16 24 32 46 48 56      ! Maps CoS 5 to EF
CAT2950(config)#class-map VVLAN-ANY
CAT2950(config-cmap)# match access-group name VVLAN-ANY
CAT2950(config-cmap)#class-map DVLAN-ANY
CAT2950(config-cmap)# match access-group name DVLAN-ANY
CAT2950(config-cmap)#policy-map IPPHONE+PC
CAT2950(config-pmap)#  class VVLAN-ANY
CAT2950(config-pmap-c)# police 1000000 8192 exceed-action drop      ! Excess VoIP
CAT2950(config-pmap-c)#class DVLAN-ANY
CAT2950(config-pmap-c)# set ip dscp 0
CAT2950(config-pmap-c)# police 5000000 8192 exceed-action dscp 8    ! Excess Data
CAT2950(config-pmap-c)#
CAT2950(config)#interface range FastEthernet0/1 - 48
CAT2950(config-if)# switchport access vlan 10
CAT2950(config-if)# switchport voice vlan 110
CAT2950(config-if)# mls qos trust device cisco-phone              ! Conditional trust
CAT2950(config-if)# mls qos trust cos                             ! Trust IP Phone CoS
CAT2950(config-if)# service-policy input IPPHONE+PC              ! Policing policy
CAT2950(config-if)#exit
CAT2950(config)#
CAT2950(config)#ip access-list standard VVLAN-ANY
CAT2950(config-std-nacl)# permit 10.1.110.0 0.0.0.255            ! VVLAN subnet
CAT2950(config-std-nacl)#
CAT2950(config-std-nacl)#ip access-list standard DVLAN-ANY
CAT2950(config-std-nacl)# permit 10.1.10.0 0.0.0.255           ! DVLAN subnet
CAT2950(config-std-nacl)#end
CAT2950#
```

# Cisco Catalyst 2950

## Queuing Design: 1P3Q1T



# Cisco Catalyst 2950

## Queuing Design: 1P3Q1T

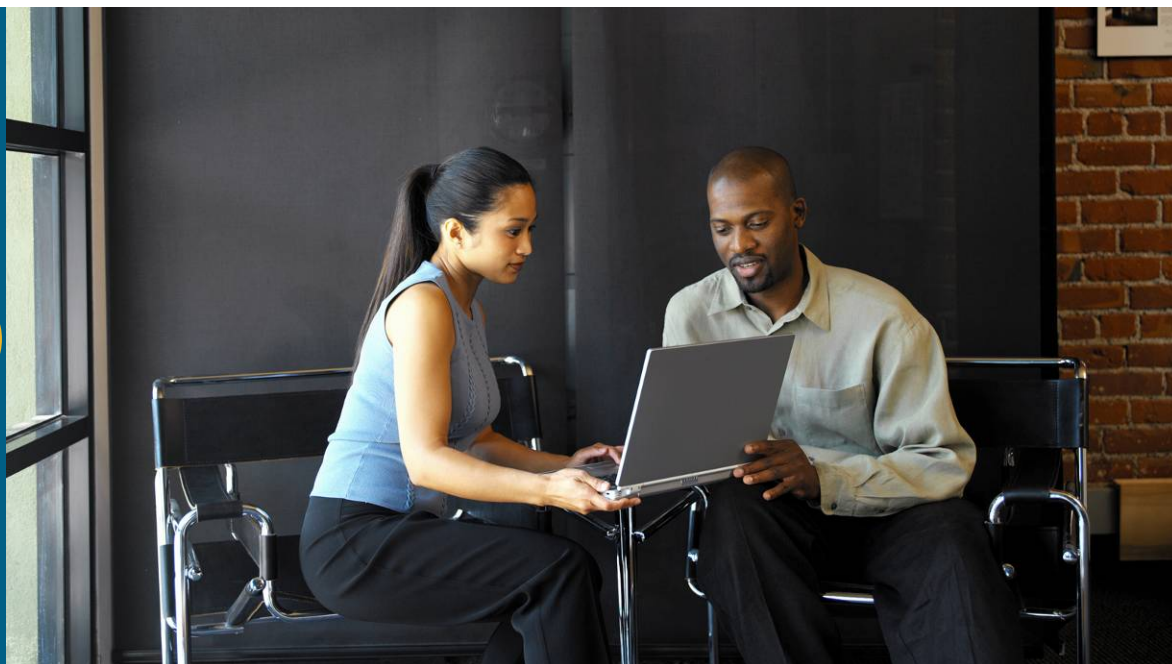
```
CAT2950(config)#wrr-queue bandwidth 5 25 70 0
    ! Q1 gets 5% BW, Q2 gets 25% BW, Q3 gets 70%, Q4 is PQ

CAT2950(config)#
CAT2950(config)#wrr-queue cos-map 1 1           ! Maps Scavenger/Bulk to Q1
CAT2950(config)#wrr-queue cos-map 2 0           ! Maps Best Effort to Q2
CAT2950(config)#wrr-queue cos-map 3 2 3 4 6 7   ! Maps CoS 2,3,4,6,7 to Q3
CAT2950(config)#wrr-queue cos-map 4 5           ! Maps VoIP to Q4 (PQ)
CAT2950(config)#
```



# Appendix B

## Cisco Catalyst 3550 QoS Design



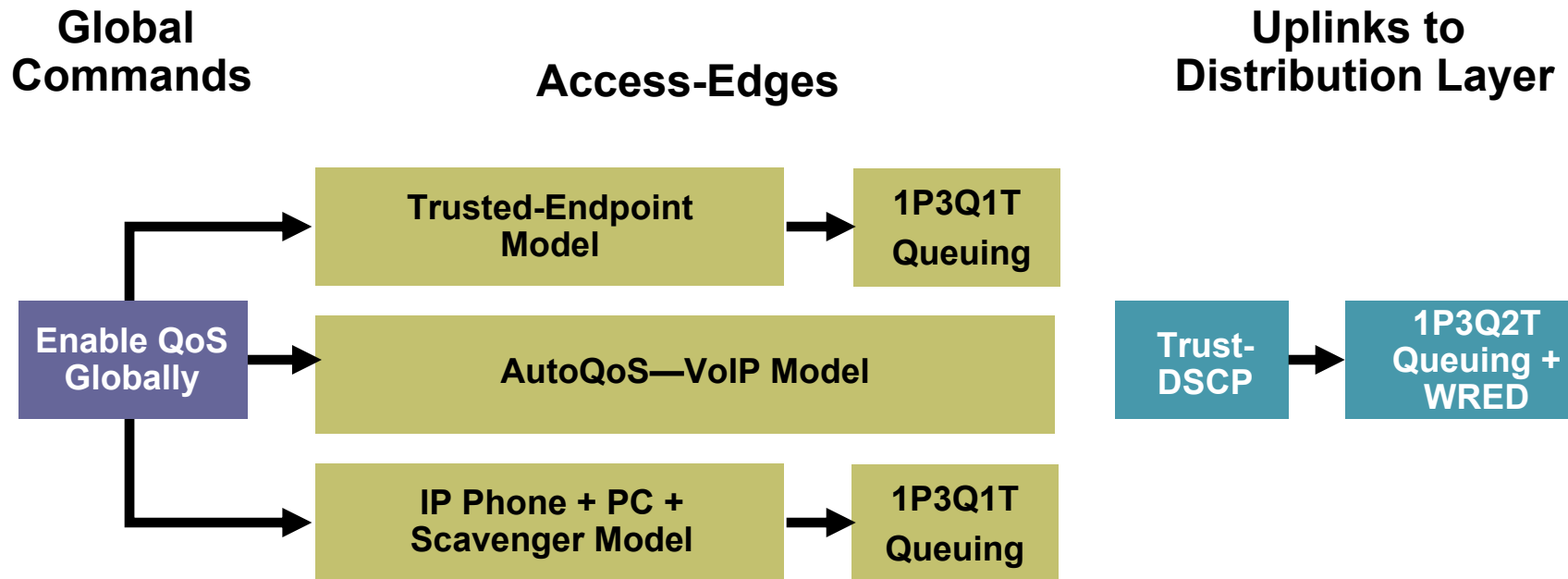
# Cisco Catalyst 3550

## *Platform-Specific QoS Design Considerations*

- QoS disabled by default
- Full DSCP-range is supported
- Classification can be done by trust states, standard and advanced IP ACLs, or MAC ACLs
- Per-port/per-VLAN policing is supported
- Minimum policing granularity is 8 kbps
- Supports 4Q1T queuing or 1P3Q1T queuing on FE ports
  - Q4 can be enabled as a priority queue
- Supports 4Q2T queuing or 1P3Q2T queuing on GE ports
  - Drop thresholds can be tail drop or WRED

# Cisco Catalyst 3550

## Access-Layer QoS Design



# Cisco Catalyst 3550

## Enabling QoS + Trusted Endpoint Example

```
CAT3550#show mls qos
QoS is disabled                                ! By default QoS is disabled

CAT3550#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
CAT3550(config)#mls qos                        ! Enables QoS globally
CAT3550(config)#exit
CAT3550#

CAT3550#show mls qos
QoS is enabled                                ! Verifies that QoS is enabled globally
CAT3550#

CAT3550(config)#interface range FastEthernet0/1 - 48
CAT3550(config-if)#mls qos trust dscp        ! Trusted Endpoint Example
```

# Cisco Catalyst 3550

## AutoQoS – VoIP Model Example

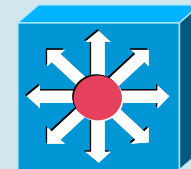


```
C3550(config-if)#auto qos voip cisco-softphone
```

### Options:

- auto qos voip cisco-phone
- auto qos voip cisco-softphone
- auto qos voip trust

```
mls qos map policed-dscp 24 26 46 to 0
mls qos map cos-dscp 0 8 16 26 32 46 48 56
mls qos min-reserve 5 170
mls qos min-reserve 6 85
mls qos min-reserve 7 51
mls qos min-reserve 8 34
mls qos
!
!
class-map match-all AutoQoS-VoIP-RTP-Trust
  match ip dscp 46
class-map match-all AutoQoS-VoIP-Control-Trust
  match ip dscp 24 26
!
!
policy-map AutoQoS-Police-SoftPhone
  class AutoQoS-VoIP-RTP-Trust
    set ip dscp 46
    police 320000 8000 exceed-action policed-dscp-transmit
  class AutoQoS-VoIP-Control-Trust
    set ip dscp 24
    police 32000 8000 exceed-action policed-dscp-transmit
!
!
interface FastEthernet0/1
  switchport mode dynamic desirable
  auto qos voip cisco-softphone
  wrr-queue bandwidth 10 20 70 1
  wrr-queue min-reserve 1 5
  wrr-queue min-reserve 2 6
  wrr-queue min-reserve 3 7
  wrr-queue min-reserve 4 8
  wrr-queue cos-map 1 0 1
  wrr-queue cos-map 2 2 4
  wrr-queue cos-map 3 3 6 7
  wrr-queue cos-map 4 5
  priority-queue out
  service-policy input AutoQoS-Police-SoftPhone
!
```



# Cisco Catalyst 3550

## IP Phone + PC + Scavenger Model Example - Part One



```
CAT3550(config)#mls qos map cos-dscp 0 8 16 24 32 46 48 56
! Modifies CoS-to-DSCP mapping to map CoS 5 to DSCP EF
CAT3550(config)#mls qos map policed-dscp 0 24 to 8
! Excess DVLAN & VVLAN traffic will be remarked to Scavenger (CS1)
CAT3550(config)#
CAT3550(config)#class-map match-all VOICE
CAT3550(config-cmap)# match ip dscp 46 ! DSCP EF (Voice)
CAT3550(config-cmap)#class-map match-all CALL-SIGNALING
CAT3550(config-cmap)# match ip dscp 24 ! DSCP CS3 (Call-Signaling)
CAT3550(config-cmap)#
CAT3550(config-cmap)#class-map match-all VVLAN-VOICE
CAT3550(config-cmap)# match vlan 110 ! VLAN 110 is VVLAN
CAT3550(config-cmap)# match class-map VOICE ! Matches VVLAN DSCP EF
CAT3550(config-cmap)#
CAT3550(config-cmap)#class-map match-all VVLAN-CALL-SIGNALING
CAT3550(config-cmap)# match vlan 110 ! VLAN 110 is VVLAN
CAT3550(config-cmap)# match class-map CALL-SIGNALING ! Matches VVLAN CS3
CAT3550(config-cmap)#
CAT3550(config-cmap)#class-map match-all ANY
CAT3550(config-cmap)# match access-group name ANY ! Workaround ACL
CAT3550(config-cmap)#
CAT3550(config-cmap)#class-map match-all VVLAN-ANY
CAT3550(config-cmap)# match vlan 110 ! VLAN 110 is VVLAN
CAT3550(config-cmap)# match class-map ANY ! Matches other VVLAN traffic
CAT3550(config-cmap)#
CAT3550(config-cmap)#class-map match-all DVLAN-ANY
CAT3550(config-cmap)# match vlan 10 ! VLAN 10 is DVLAN
CAT3550(config-cmap)# match class-map ANY ! Matches other DVLAN traffic
```

# Cisco Catalyst 3550

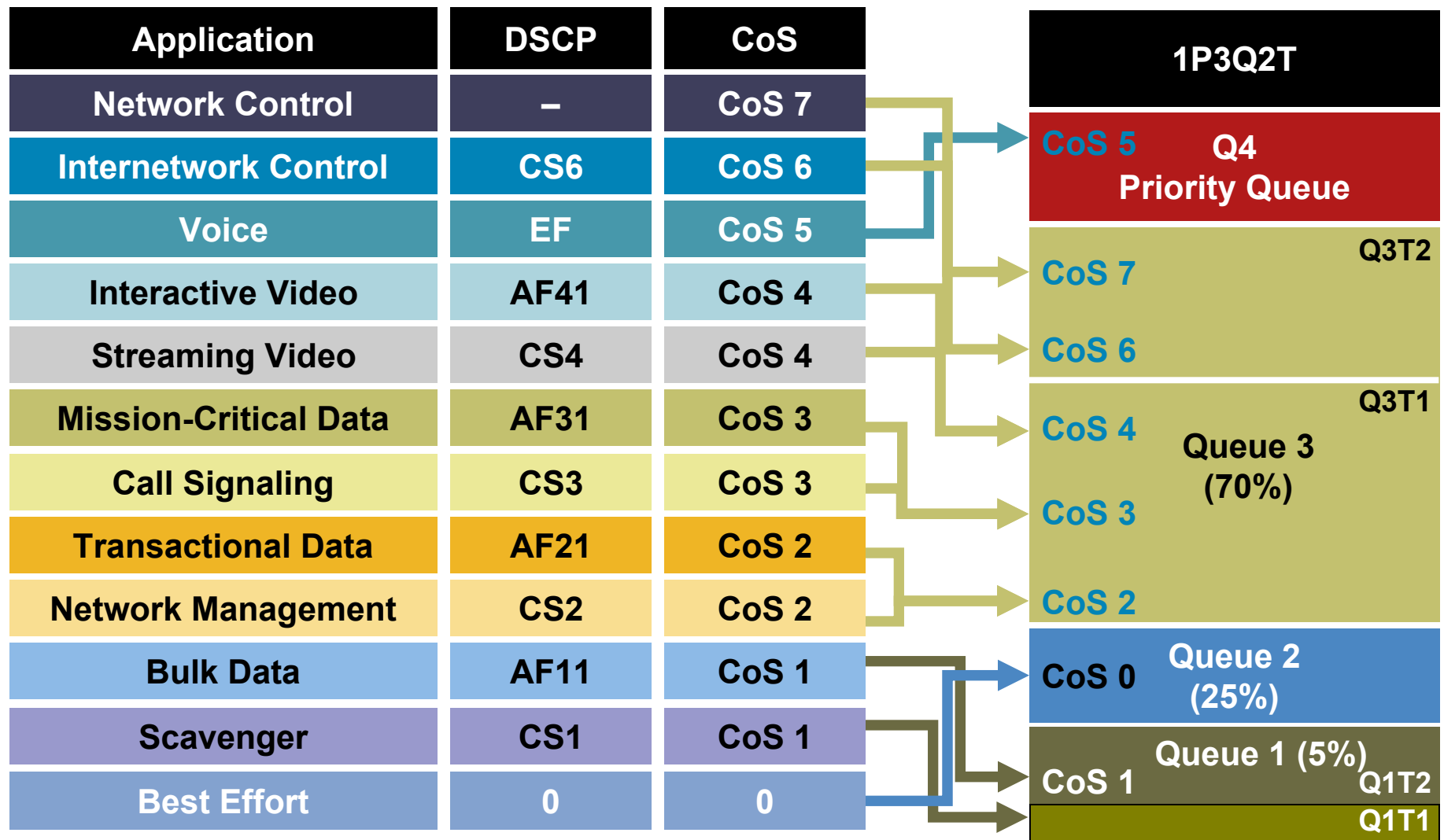
## IP Phone + PC + Scavenger Model Example - Part Two



```
CAT3550(config-cmap)#policy-map IPPHONE+PC-BASIC
CAT3550(config-pmap)#class VVLAN-VOICE
CAT3550(config-pmap-c)# set ip dscp 46                ! DSCP EF (Voice)
CAT3550(config-pmap-c)# police 128000 8000 exceed-action drop
                ! Only one voice call is permitted per switchport VVLAN
CAT3550(config-pmap-c)#class VVLAN-CALL-SIGNALING
CAT3550(config-pmap-c)# set ip dscp 24                ! DSCP CS3 (Call-Signaling)
CAT3550(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
                ! Out-of-profile Call-Signaling is marked down to Scavenger (CS1)
CAT3550(config-pmap-c)#class VVLAN-ANY
CAT3550(config-pmap-c)# set ip dscp 0
CAT3550(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
                ! Unauthorized VVLAN traffic is marked down to Scavenger (CS1)
CAT3550(config-pmap-c)#class DVLAN-ANY
CAT3550(config-pmap-c)# set ip dscp 0
CAT3550(config-pmap-c)# police 5000000 8000 exceed-action policed-dscp-transmit
                ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT3550(config-pmap-c)# exit
CAT3550(config)#
CAT3550(config)#interface FastEthernet0/1
CAT3550(config-if)# switchport access vlan 10        ! DVLAN
CAT3550(config-if)# switchport voice vlan 110       ! VVLAN
CAT3550(config-if)# mls qos trust device cisco-phone ! Conditional Trust
CAT3550(config-if)# service-policy input IPPHONE+PC-BASIC
CAT3550(config-if)#exit
CAT3550(config)#ip access-list standard ANY         ! Workaround ACL
CAT3550(config-std-nacl)# permit any
CAT3550(config-std-nacl)#end
CAT3550#
```

# Cisco Catalyst 3550

## Queuing Design: 1P3Q1T on FE and 1P3Q2T on GE





# Cisco Catalyst 3550

## Queuing Design: 1P3Q1T on FE

```
CAT3550(config)#interface range FastEthernet0/1 - 48
CAT3550(config-if)# wrr-queue bandwidth 5 25 70 1
    ! Q1 gets 5 BW%, Q2 gets 25% BW, Q3 gets 70% BW, Q4 is PQ

CAT3550(config-if)# wrr-queue cos-map 1 1           ! Maps Scavenger/Bulk to Q1
CAT3550(config-if)# wrr-queue cos-map 2 0           ! Maps Best Effort to Q2
CAT3550(config-if)# wrr-queue cos-map 3 2 3 4 6 7   ! Maps CoS 2,3,4,6,7 to Q3
CAT3550(config-if)# wrr-queue cos-map 4 5           ! Maps VoIP to Q4 (PQ)
CAT3550(config-if)# priority-queue out             ! Enables Q4 as PQ
CAT3550(config-if)#exit
CAT3550(config)#
```

# Cisco Catalyst 3550

## Queuing Design: 1P3Q2T on GE

```
CAT3550(config)#interface range GigabitEthernet 0/1 - 2
CAT3550(config-if-range)# wrr-queue bandwidth 5 25 70 1
    ! Q1 gets 5% BW, Q2 gets 25% BW, Q3 gets 70% BW, Q4 is the PQ
CAT3550(config-if-range)# wrr-queue queue-limit 5 25 40 30
    ! Tunes buffers to 5% for Q1, 25% for Q2, 40% for Q3 and 30% for Q4

CAT3550(config-if-range)# wrr-queue random-detect max-threshold 1 40 100
    ! Sets Q1 WRED threshold 1 to 40% and threshold 2 to 100%
CAT3550(config-if-range)# wrr-queue random-detect max-threshold 2 80 100
    ! Sets Q2 WRED threshold 1 to 80% and threshold 2 to 100%
CAT3550(config-if-range)# wrr-queue random-detect max-threshold 3 80 100
    ! Sets Q3 WRED threshold 1 to 80% and threshold 2 to 100%

CAT3550(config-if)# wrr-queue cos-map 1 1                ! Maps Scavenger/Bulk to Q1
CAT3550(config-if)# wrr-queue cos-map 2 0                ! Maps Best Effort to Q2
CAT3550(config-if)# wrr-queue cos-map 3 2 3 4 6 7        ! Maps CoS 2,3,4,6,7 to Q3
CAT3550(config-if)# wrr-queue cos-map 4 5                ! Assigns VoIP to Q4 (PQ)
CAT3550(config-if-range)# wrr-queue dscp-map 2 10 12 14 48 56
    ! Maps Bulk (10/12/14), Routing (48) and Spanning Tree (Internal DSCP 56)
    ! to WRED threshold 2 of their respective queues;
    ! All other DSCP values are mapped (by default) to WRED threshold 1
    ! of their respective queues
CAT3550(config-if-range)# priority-queue out             ! Enables Q4 as PQ
CAT3550(config-if-range)#end
CAT3550#
```

