RST-2501
Campus QoS Design

Kevin Turek

(kturek@cisco.com)

Recuerde siempre:

- **Apagar su teléfono móvil/pager, o usar el modo "silencioso".**

- **Completar la evaluación de esta sesión y entregarla a los asistentes de sala.**

- **Ser puntual para asistir a todas las actividades de entrenamiento, almuerzos y eventos sociales para un desarrollo óptimo de la agenda.**

- **Completar la evaluación general incluida en su mochila y entregarla el miércoles 8 de Junio en los mostradores de registración. Al entregarla recibirá un regalo recordatorio del evento.**

How is QoS Optimally Deployed?

1) Strategically define the business objectives to be achieved via QoS.

2) Analyze the service-level requirements of the various traffic classes to be provisioned for.

3) Design and test the QoS policies prior to production-network rollout.

4) Roll-out the tested QoS designs to the production-network in phases, during scheduled downtime.

5) Monitor service levels to ensure that the QoS objectives are being met.

General QoS Design Principles
Start with the Objectives: Not the Tools
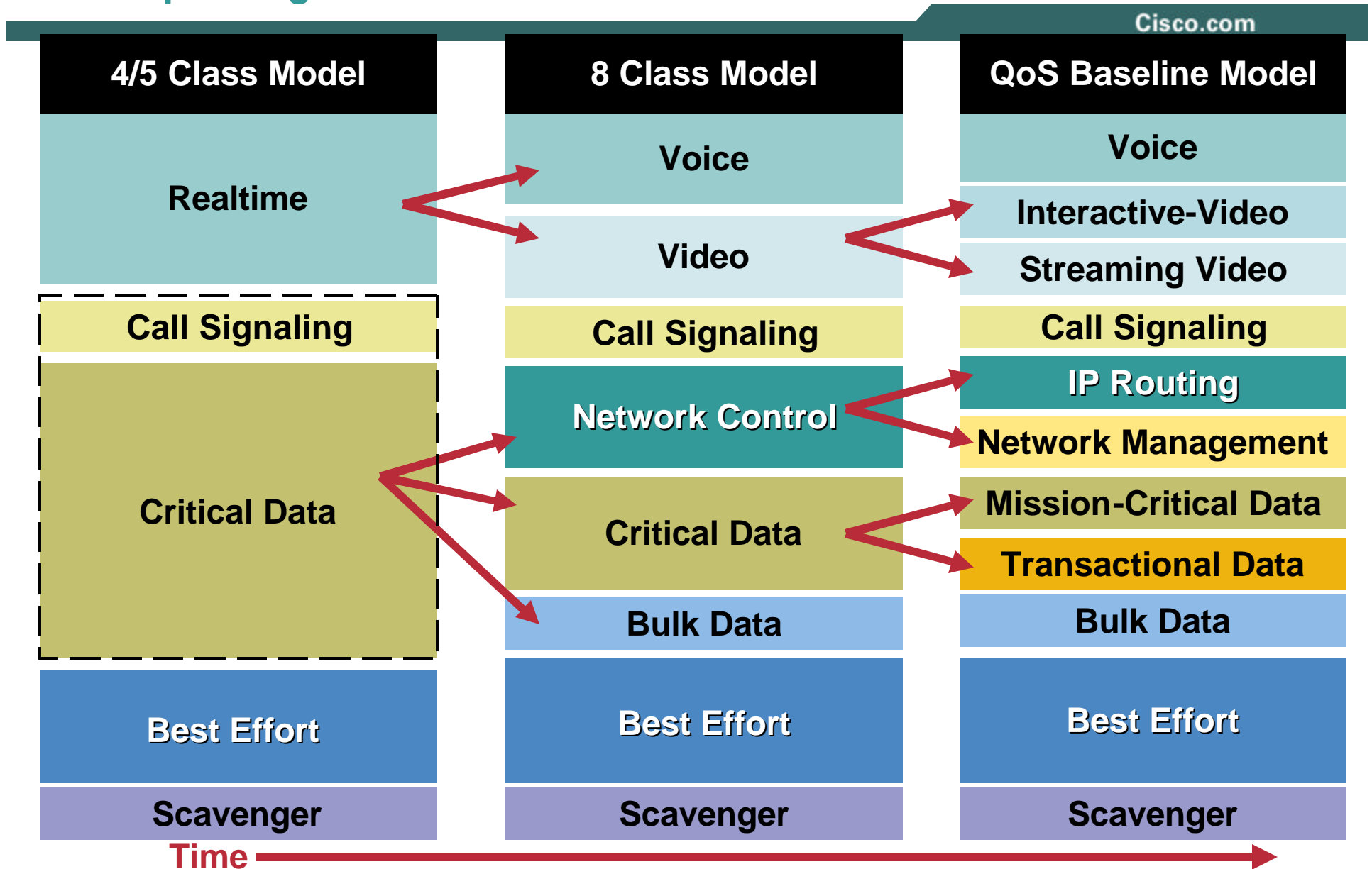
- **Clearly define the organizational objectives**

  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

How Many Classes of Service Do I Need?

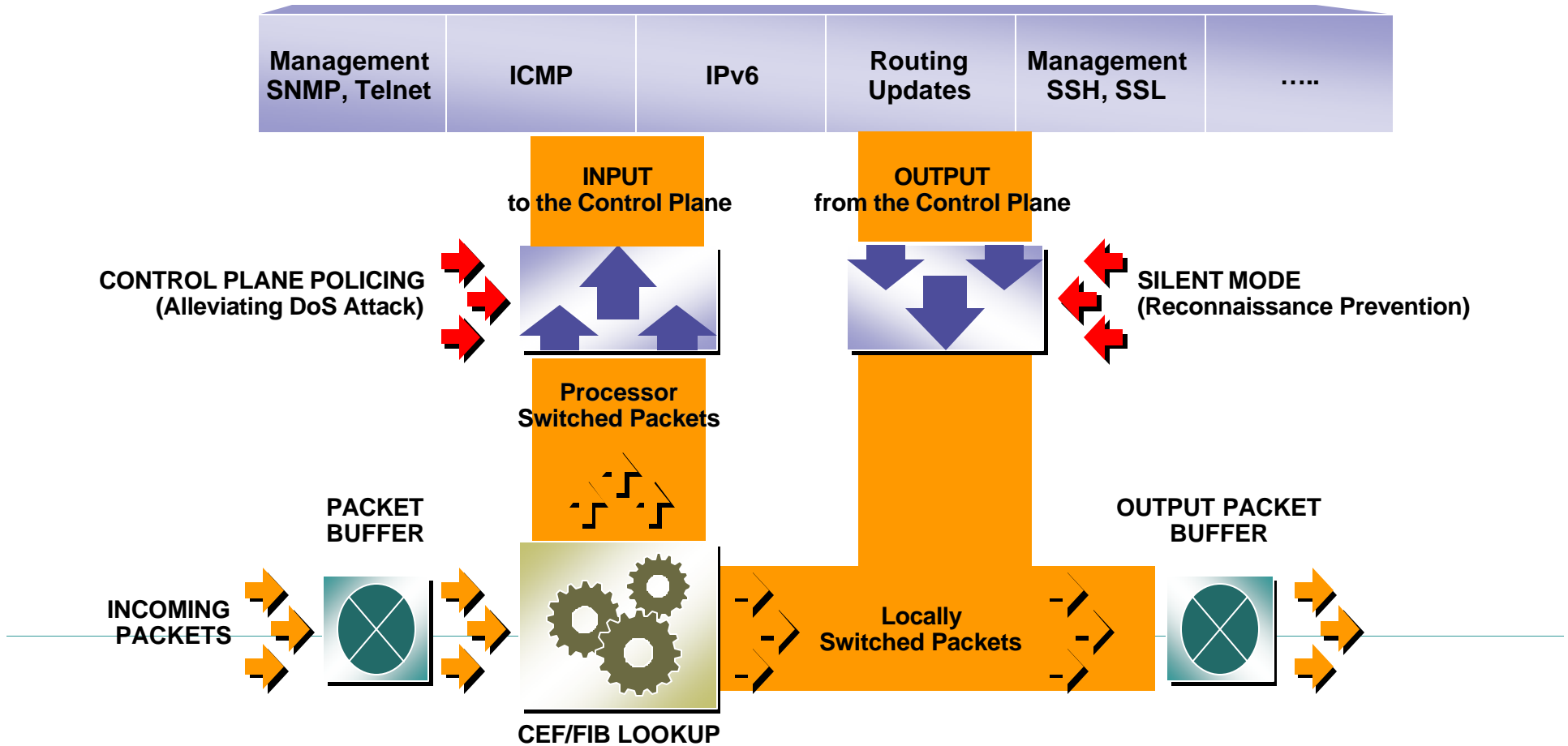## Expanding the Number of Classes of Service over Time

Cisco.com

4/5 Class Model	8 Class Model	QoS Baseline Model
Realtime	Voice	Voice
	Video	Interactive-Video
		Streaming Video
Call Signaling	Call Signaling	Call Signaling
Critical Data	Network Control	IP Routing
		Network Management
	Critical Data	Mission-Critical Data
		Transactional Data
	Bulk Data	Bulk Data
Best Effort	Best Effort	Best Effort
Scavenger	Scavenger	Scavenger

Time →

QoS for DoS/Worm Attack Mitigation
Introduction to Control Plane Policing

CONTROL PLANE

Management SNMP, Telnet	ICMP	IPv6	Routing Updates	Management SSH, SSL	.....

INPUT
to the Control Plane

OUTPUT
from the Control Plane

CONTROL PLANE POLICING
(Alleviating DoS Attack)

SILENT MODE
(Reconnaissance Prevention)

Processor Switched Packets

PACKET BUFFER

OUTPUT PACKET BUFFER

INCOMING PACKETS

Locally Switched Packets

CEF/FIB LOOKUP

QoS for DoS/Worm Attack Mitigation
Data Plane Policing via the Scavenger-Class

- **The Scavenger class is an Internet 2 Draft Specification for a "less-than best effort" service**

- **There is an implied "good faith" commitment for the "best effort" traffic class**

    It is generally assumed that at least some network resources will be available for the default class

- **Scavenger class markings can be used to distinguish out-of-profile/abnormal traffic flows from in-profile/normal flows**

    The Scavenger class marking is DSCP CS1 (8)

- **Scavenger traffic is assigned a "less-than best effort" queuing treatment whenever congestion occurs**

Data Plane Policing (Scavenger-Class QoS)
Part 1 - First Order Anomaly Detection

- **All end systems generate traffic spikes, but worms create sustained spikes**

- **Normal/Abnormal threshold set at approx 95% confidence**

- **No dropping at campus access-edge! Only remarking**

Policing and Remarking (if necessary)

Normal/Abnormal Threshold
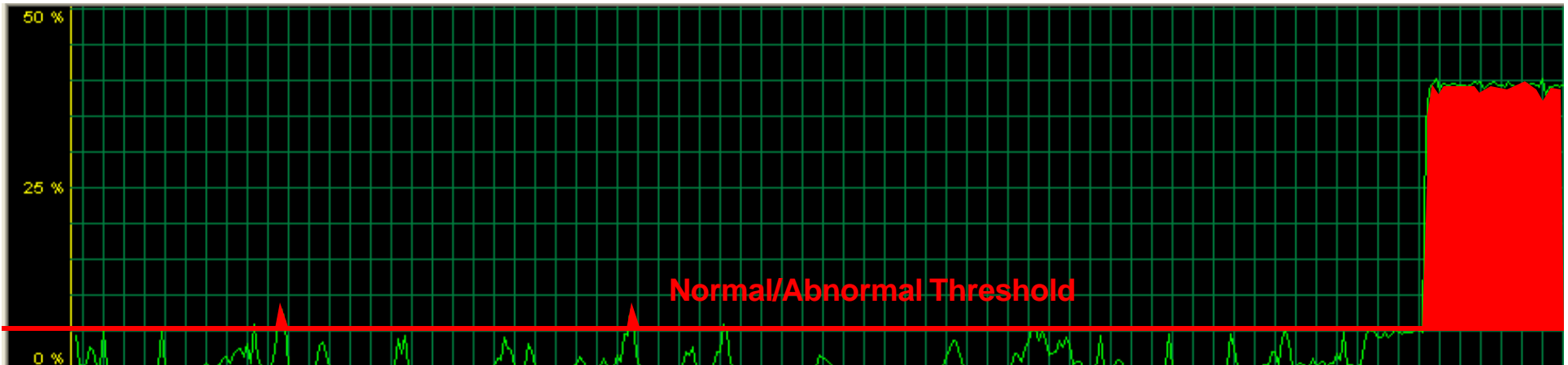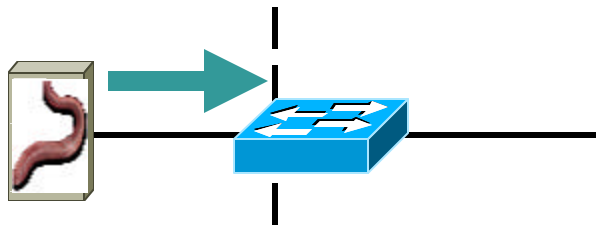
Data Plane Policing (Scavenger-Class QoS)
Part 2 - Second Order Anomaly Reaction

- **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**

Police

WAN/VPN links will likely congest first

Campus uplinks may also congest
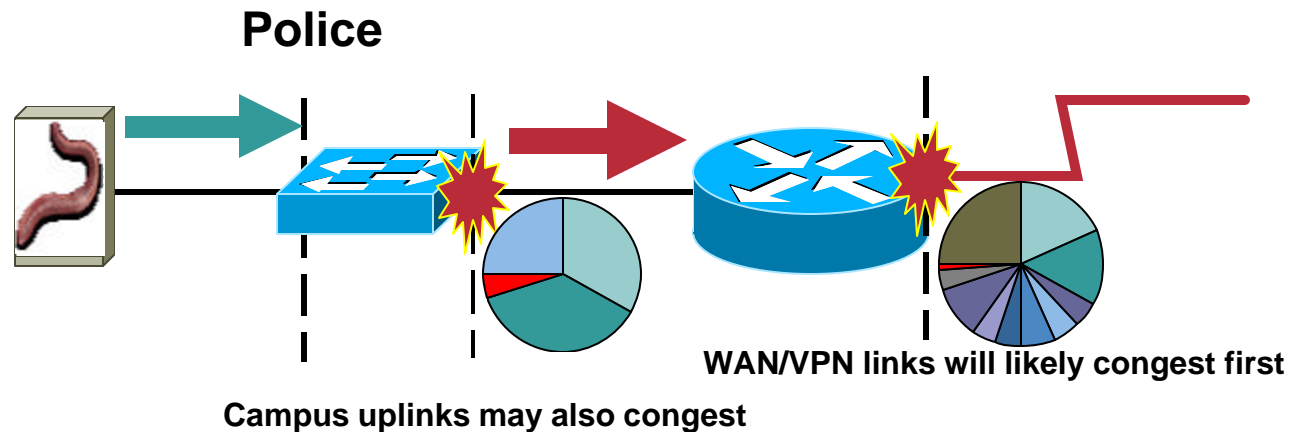
**Queuing will engage when links become congested
and traffic previously marked as Scavenger is dropped aggressively**

Classification and Marking Design Principles
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**

Classification and Marking
QoS Baseline Marking Recommendations

Application	L3 Classification			L2 CoS
	IPP	PHB	DSCP	
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
Scavenger	1	CS1	8	1
Best Effort	0	0	0	0

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

DoS/Worm Mitigation Design Principles
How Can QoS Tools Contain Attacks?

- **Profile applications to determine what constitutes "normal" vs. "abnormal" flows (within a 95% confidence interval)**

- **Deploy campus access-edge policers to remark abnormal traffic to Scavenger**

    DSCP CS1 (8)

- **Deploy a second-line of defense at the Distribution-Layer via per-user rate-limiting or per-user microflow policing**

    Cisco Catalyst 4500 or Catalyst 6500 PFC3

- **Provision end-to-end "less-than-Best-Effort" Scavenger-class queuing policies**

    Campus + WAN + VPN

- **Protect Control Plane via Control Plane Policing**

    Catalyst 6500 PFC3

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 Queuing Design
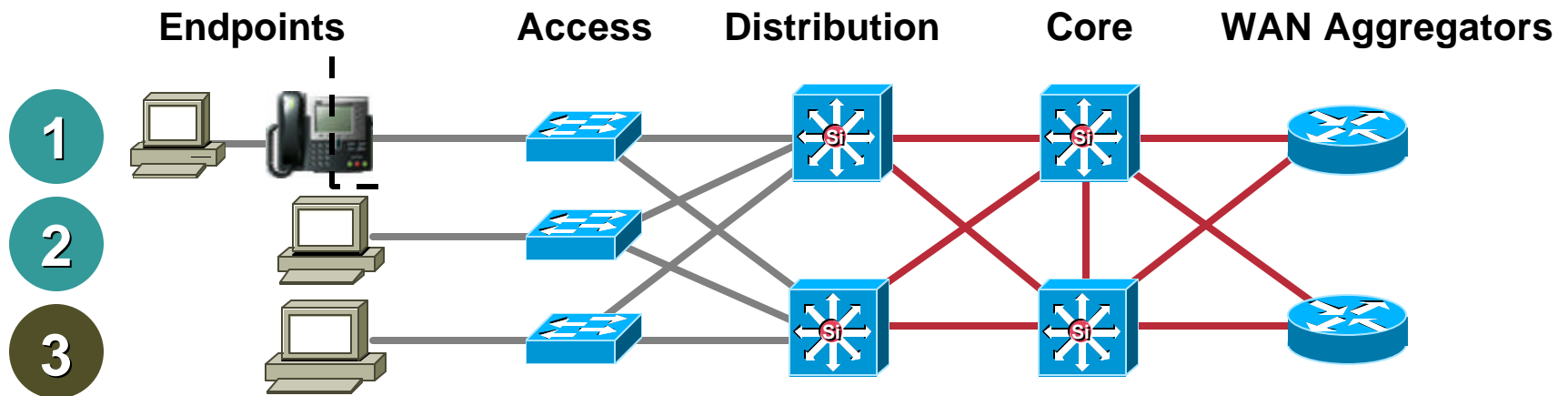## Realtime, Best Effort and Scavenger Queuing Rules

Best Effort = 25%

Real-Time = 33%

Scavenger/Bulk = 5%

Critical Data
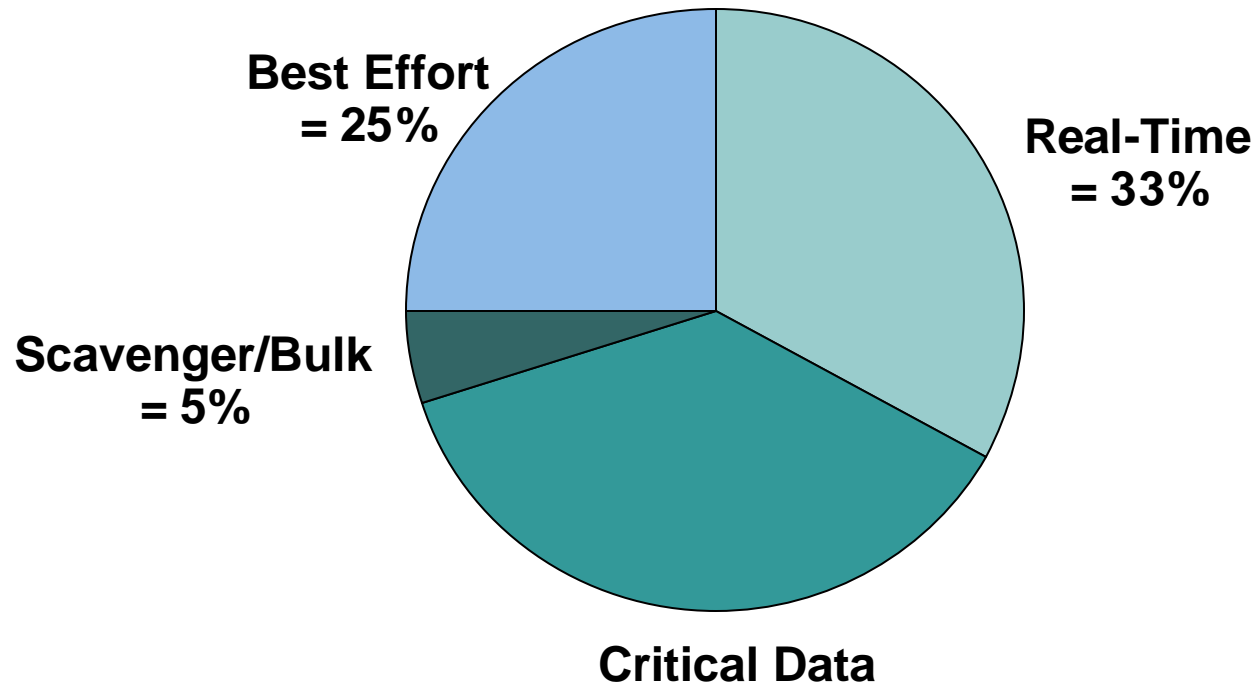
CAMPUS QoS DESIGN CONSIDERATIONS

Campus QoS Considerations
Establishing Trust-Boundaries

Endpoints	Access	Distribution	Core	WAN Aggregators

1

2

3

TRUST BOUNDARY

1   **Optimal Trust Boundary: Trusted Endpoint**

2   **Optimal Trust Boundary: Untrusted Endpoint**

3   **Sub-Optimal Trust Boundary**

Access-Edge Trust Models
Endpoints and Endpoint-Categories

Endpoints

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

Endpoint Categories

- **Trusted endpoints**
- **Untrusted endpoints**
- **Conditionally-trusted endpoints**

Campus QoS Considerations
Trust Boundary Extension and Operation

1 → **"I See You're an IP Phone,"**
So I Will Trust Your CoS"

PC VLAN = 10

Phone VLAN = 110

TRUST BOUNDARY

4 ← **2**

"CoS 5 = DSCP 46"
"CoS 3 = DSCP 24"
"CoS 0 = DSCP 0"

"Voice = 5, Signaling = 3"

3

All PC Traffic Is Reset to CoS 0   PC Sets CoS to 5 for All Traffic

1 Switch and Phone Exchange CDP; Trust Boundary Is Extended to IP Phone

2 Phone Sets CoS to 5 for VoIP and to 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
Cisco 7912G Breaks the Conditional Trust Boundary

1 "I See You're an IP Phone"

So I Will Trust Your CoS"

PC VLAN = 10

Phone VLAN = 110

TRUST BOUNDARY

4

"CoS 5 = DSCP 46"
"CoS 3 = DSCP 24"
"CoS 5 = DSCP 46"

2 "Voice = 5, Signaling = 3"

3

No PC Traffic Is Remarked   PC Sets CoS to 5 for All Traffic

1 Switch and Phone Exchange CDP; Trust Boundary Is Extended to IP Phone

2 Phone Sets CoS to 5 for VoIP and to 3 for Call-Signaling Traffic

3 Cisco 7912G IP Phone Does Not Rewrite CoS from PC Port to 0

4 Switch Trusts CoS from Phone and Maps CoS ➔ DSCP for Output Queuing

Campus QoS Access Edge Trust Models

- **Trusted Endpoint Model**

- **AutoQoS – VoIP Model**

- **PC + SoftPhone + Scavenger Model**

- **IP Phone + PC + Scavenger (Basic) Model**

- **IP Phone + PC + Scavenger (Advanced) Model**

Access-Edge Trust Models
Trusted Endpoint Model

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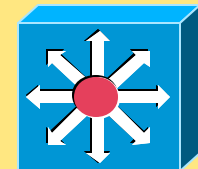
- **Policing is optional**

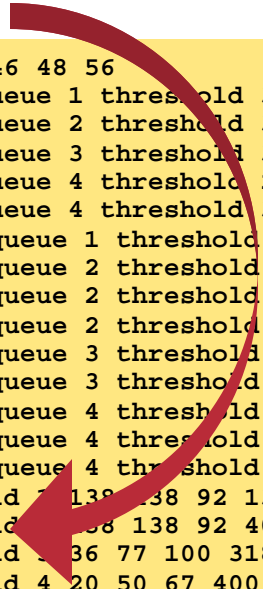| Start | → | Trust DSCP | → | Optional Policing | → | Transmit Packet with DSCP Unaltered |

AutoQoS – VoIP Model
AutoQoS VoIP for Catalyst Switches

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

```
mls qos map cos-dscp 0 0 10 20 32 46 48 56
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 2 138 138 92 400
mls qos queue-set output 1 threshold 3 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
!
```
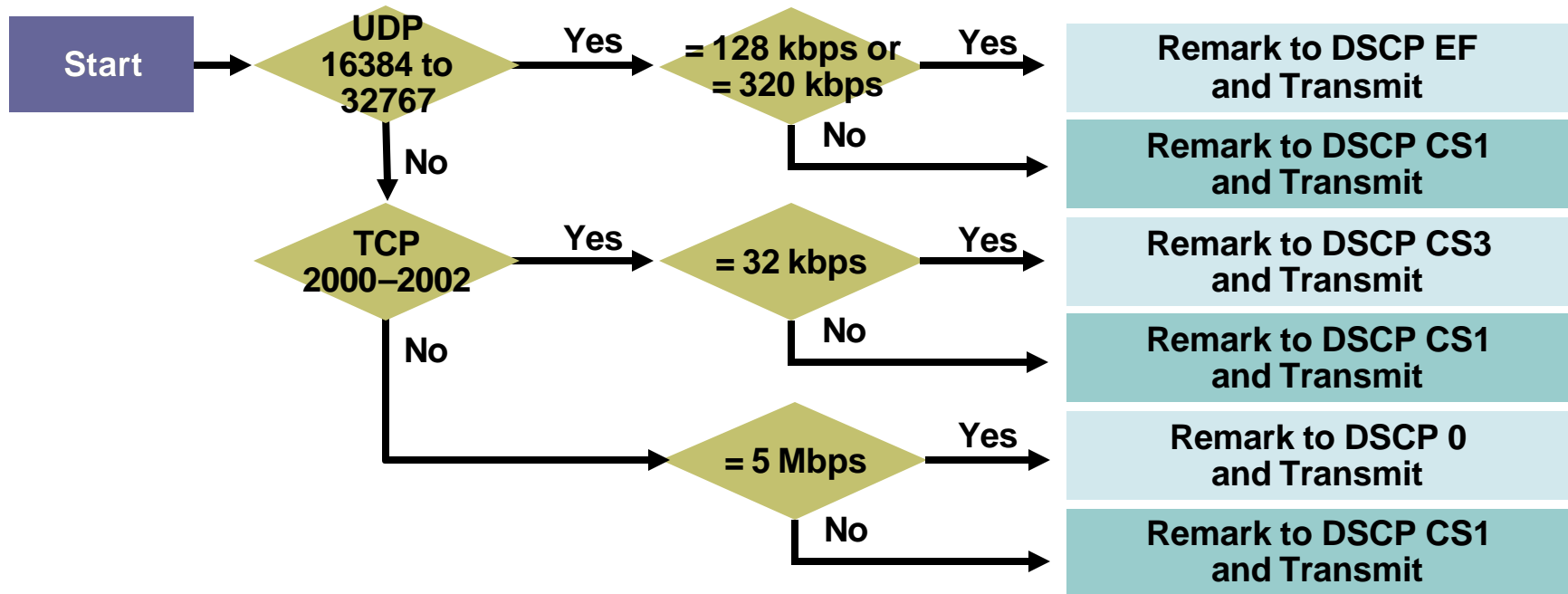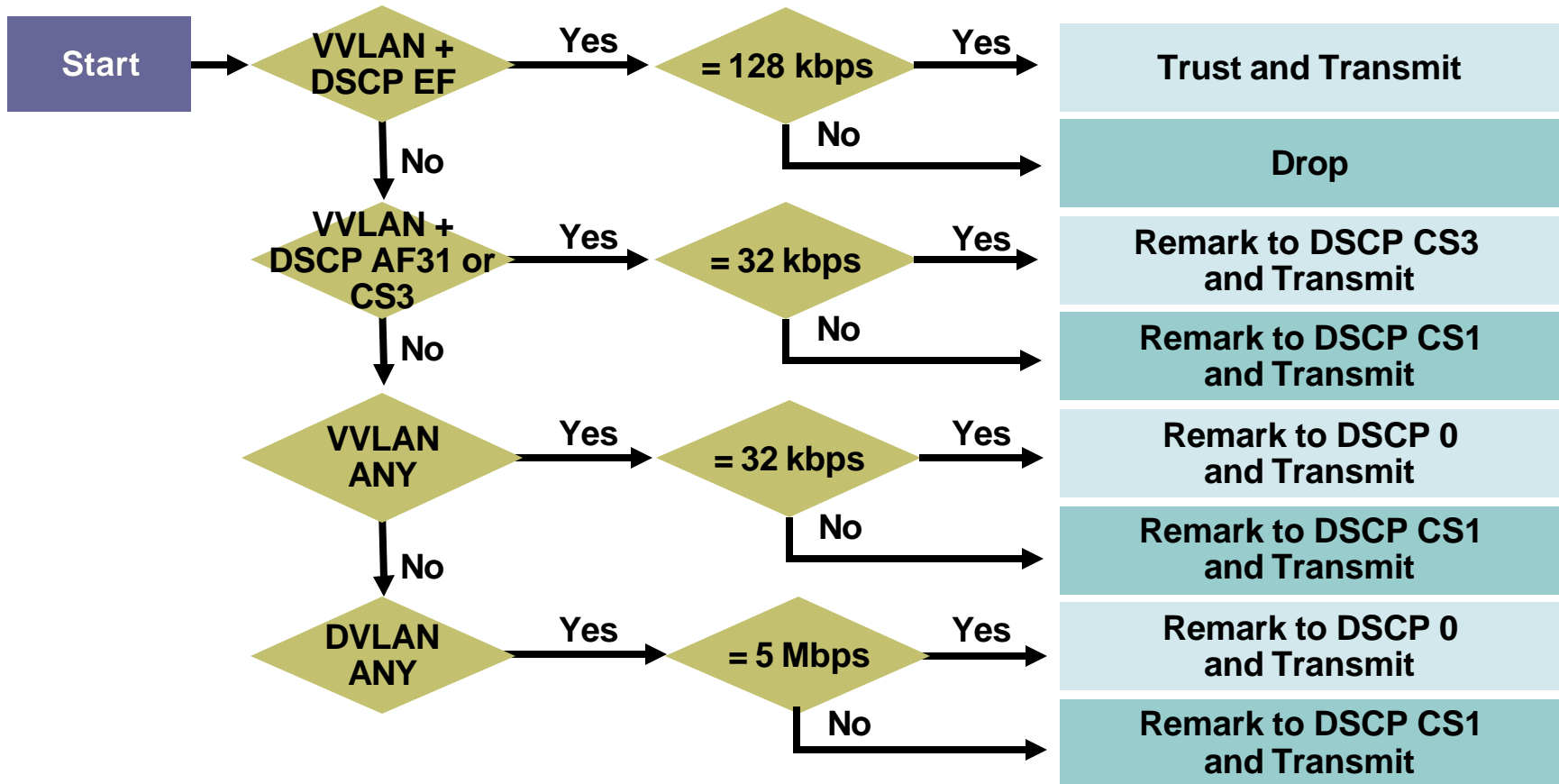
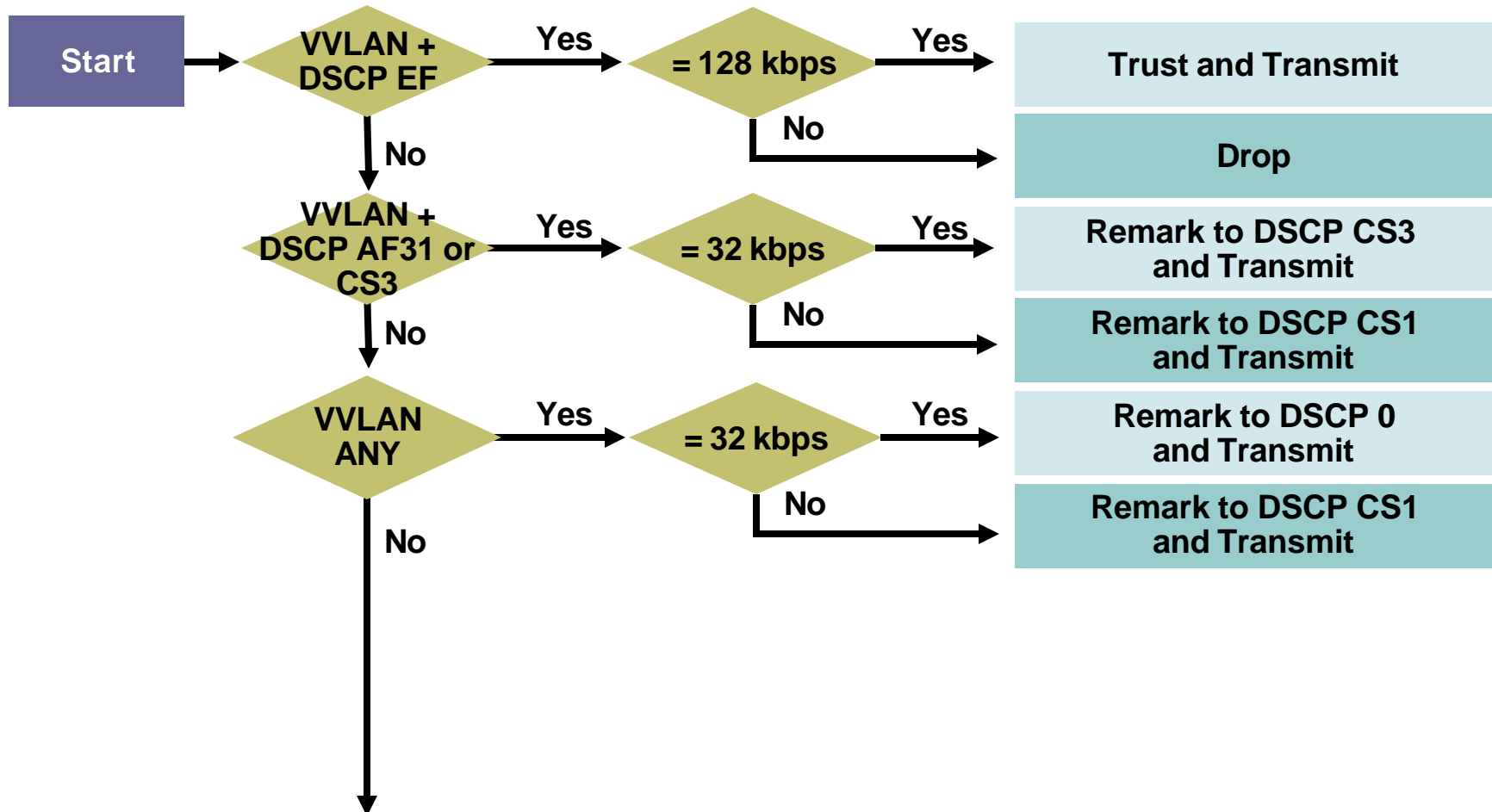# Access-Edge Trust Models
PC + SoftPhone + Scavenger Model

Start → **UDP 16384 to 32767**

— Yes → **= 128 kbps or = 320 kbps**
  — Yes → **Remark to DSCP EF and Transmit**
  — No → **Remark to DSCP CS1 and Transmit**

— No → **TCP 2000–2002**

— Yes → **= 32 kbps**
  — Yes → **Remark to DSCP CS3 and Transmit**
  — No → **Remark to DSCP CS1 and Transmit**

— No → **= 5 Mbps**
  — Yes → **Remark to DSCP 0 and Transmit**
  — No → **Remark to DSCP CS1 and Transmit**

Access-Edge Trust Models
IP Phone + PC + Scavenger (Basic) Model

Start → **VVLAN + DSCP EF** — Yes → **= 128 kbps** — Yes → **Trust and Transmit**

= 128 kbps — No → **Drop**

VVLAN + DSCP EF — No → **VVLAN + DSCP AF31 or CS3** — Yes → **= 32 kbps** — Yes → **Remark to DSCP CS3 and Transmit**

= 32 kbps — No → **Remark to DSCP CS1 and Transmit**

VVLAN + DSCP AF31 or CS3 — No → **VVLAN ANY** — Yes → **= 32 kbps** — Yes → **Remark to DSCP 0 and Transmit**

= 32 kbps — No → **Remark to DSCP CS1 and Transmit**

VVLAN ANY — No → **DVLAN ANY** — Yes → **= 5 Mbps** — Yes → **Remark to DSCP 0 and Transmit**

= 5 Mbps — No → **Remark to DSCP CS1 and Transmit**

Access-Edge Trust Models
IP Phone + PC + Scavenger (Advanced) Model: Part 1

Start → **VVLAN + DSCP EF** — Yes → **= 128 kbps** — Yes → **Trust and Transmit**

= 128 kbps — No → **Drop**

VVLAN + DSCP EF — No ↓

VVLAN + DSCP AF31 or CS3 — Yes → **= 32 kbps** — Yes → **Remark to DSCP CS3 and Transmit**

= 32 kbps — No → **Remark to DSCP CS1 and Transmit**

VVLAN + DSCP AF31 or CS3 — No ↓

VVLAN ANY — Yes → **= 32 kbps** — Yes → **Remark to DSCP 0 and Transmit**

= 32 kbps — No → **Remark to DSCP CS1 and Transmit**

VVLAN ANY — No ↓

Access-Edge Trust Models
IP Phone + PC + Scavenger (Advanced) Model: Part 2

No

DVLAN + UDP 16384-32767 — **Yes** → **= 500 kbps** — **Yes** → **Remark to DSCP AF41 and Transmit**

No → **Remark to DSCP CS1 and Transmit**

Mission Critical Data ACLs

No

DVLAN + MCD ACLs — **Yes** → **= 5 Mbps** — **Yes** → **Remark to DSCP AF31 and Transmit**

No → **Remark to DSCP CS1 and Transmit**

Transactional Data ACLs

DVLAN + TD ACLs — **Yes** → **= 5 Mbps** — **Yes** → **Remark to DSCP AF21 and Transmit**

No → **Remark to DSCP CS1 and Transmit**

Bulk Data ACLs

No

DVLAN + BD ACLs — **Yes** → **= 5 Mbps** — **Yes** → **Remark to DSCP AF11 and Transmit**

No → **Remark to DSCP CS1 and Transmit**

No

DVLAN ANY — **Yes** → **= 5 Mbps** — **Yes** → **Remark to DSCP 0 and Transmit**

No → **Remark to DSCP CS1 and Transmit**

Campus QoS Considerations
Typical Campus Oversubscription Ratios

Core

Distribution

Access

Typical 4:1
Oversubscription

Typical 20:1
Oversubscription
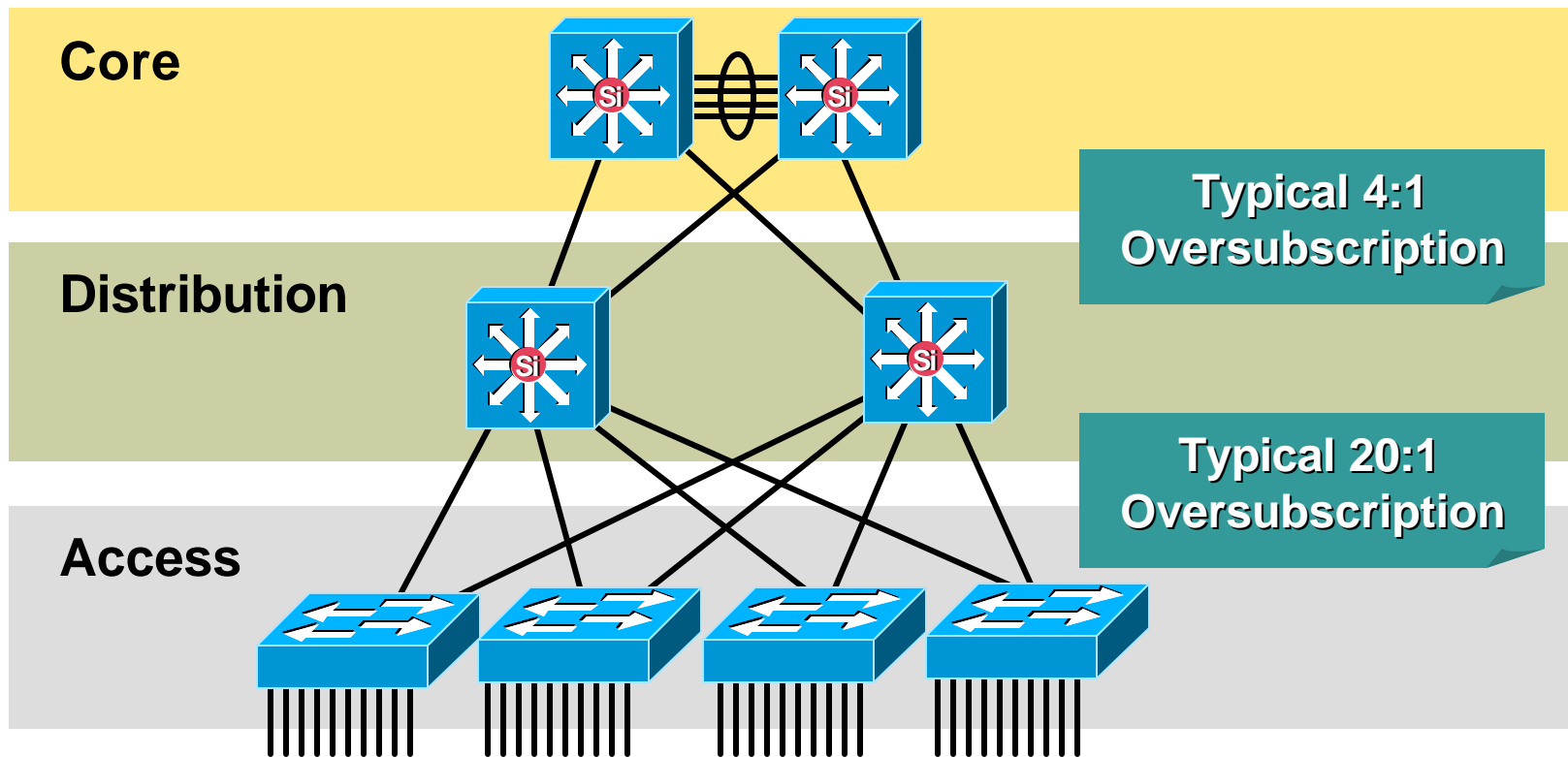
Campus QoS Considerations
Where Is QoS Required Within the Campus?

Legend:
- FastEthernet
- GigabitEthernet
- TenGigabitEthernet

- No Trust + Policing + Queuing
- Conditional Trust + Policing + Queuing
- Trust DSCP + Queuing
- Per-User Microflow Policing

Catalyst 6500 Sup720

WAN Aggregator

Server Farms

IP Phones + PCs

IP Phones + PCs
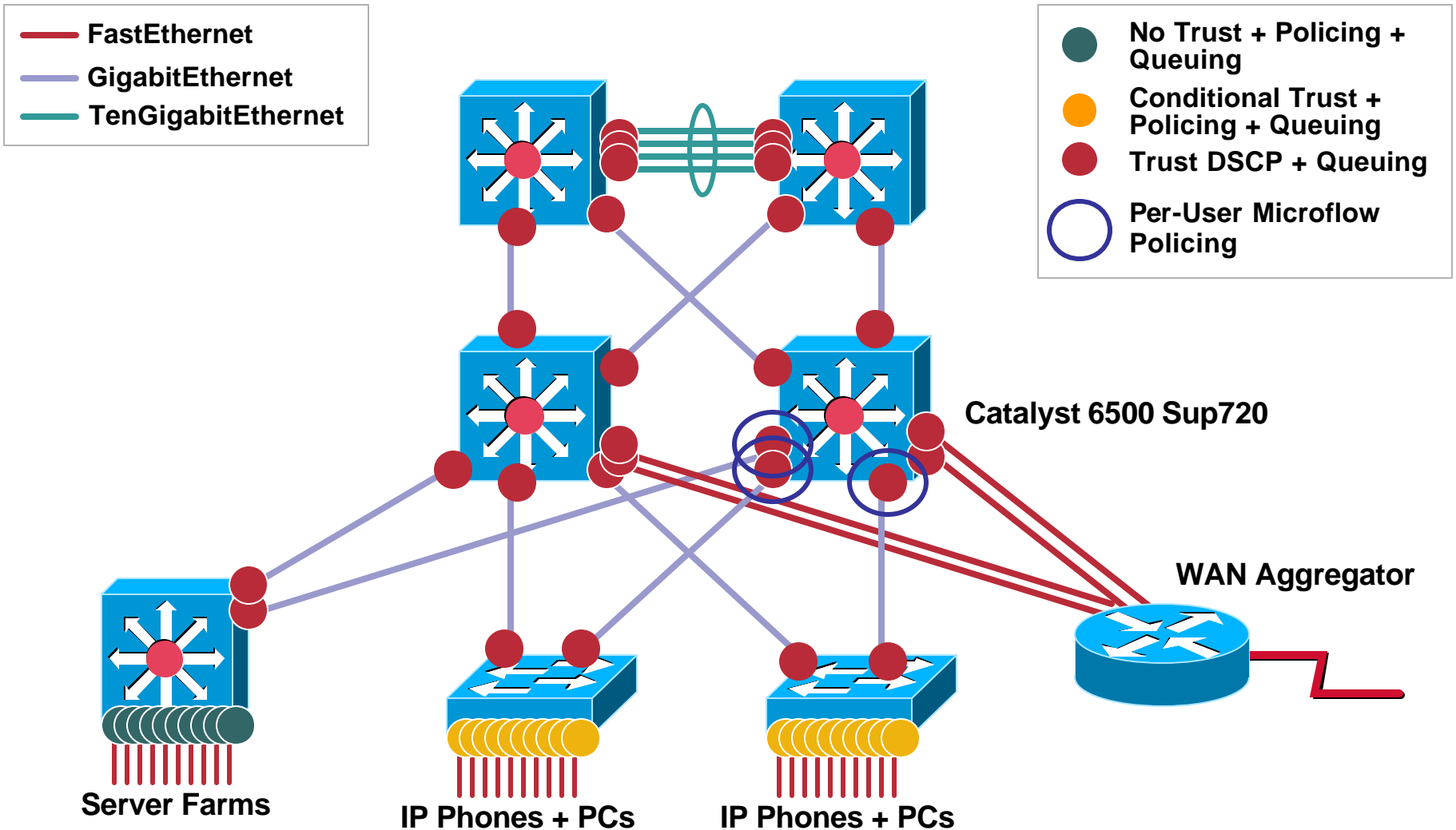
CISCO CATALYST 2950
QOS DESIGN
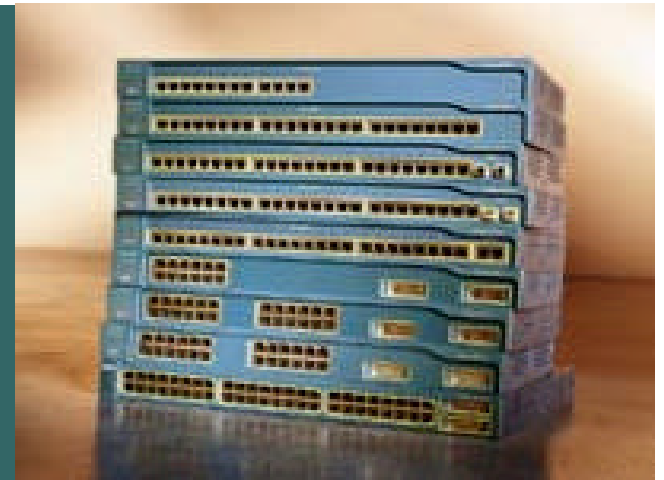
Catalyst 2950
QoS Design Considerations

- **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 QoS Design
Access-Layer Cisco Catalyst 2950 Design Options

Access-Edges

Uplinks to Distribution Layer

```
Trusted-Endpoint Model  ─────┐
                             ↓
AutoQoS – VoIP Model  ──→  Trust-DSCP  ──→  Global1P3Q1T Queuing
                             ↑
IP Phone + PC + Scavenger (Basic) Model  ─┘
```
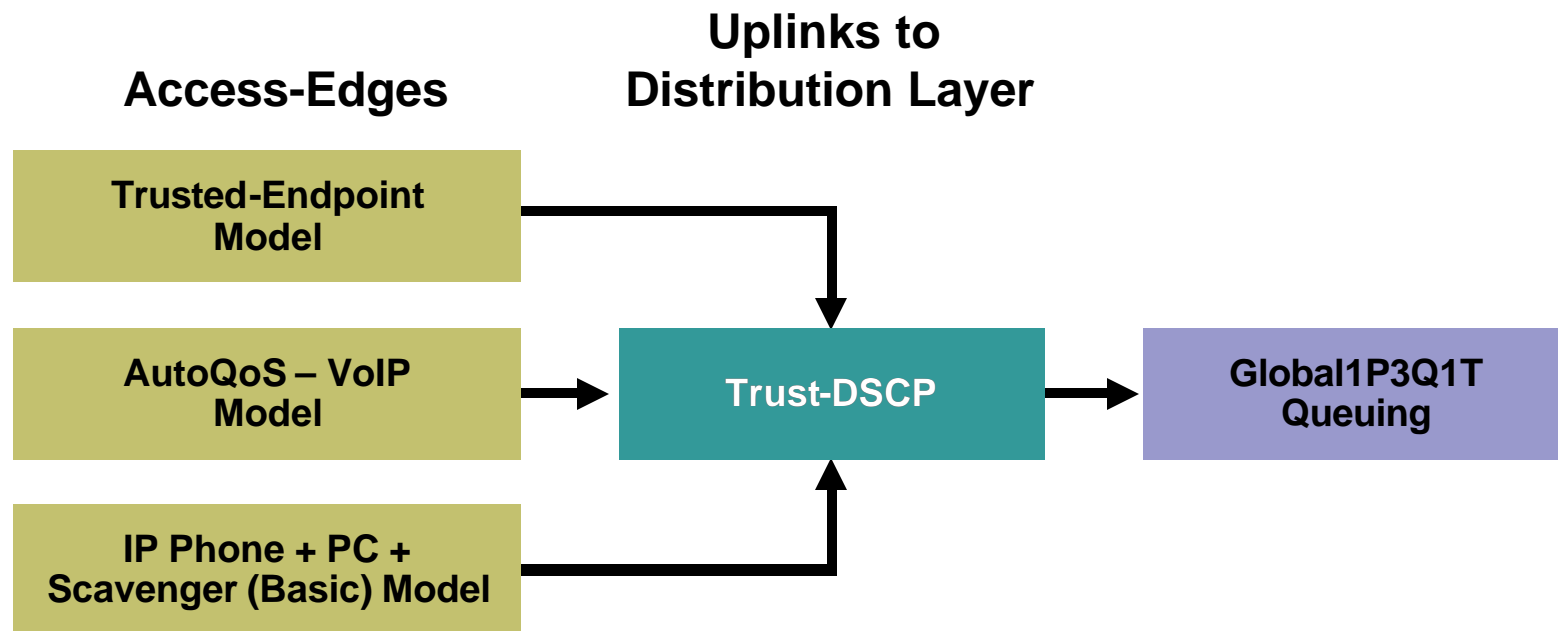
Cisco Catalyst 2950
AutoQoS VoIP Model Example
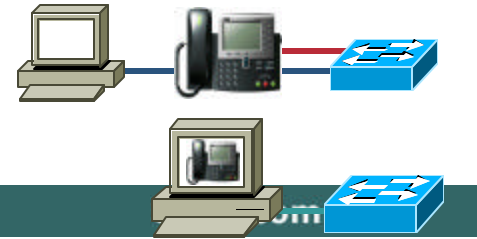
```
C2950(config-if)#auto qos voip cisco-phone
```

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 QoS Design
IP Phone + PC + Scavenger (Basic) Model for the Catalyst 2950

```
Start ──▶ VVLAN ANY ──Yes──▶ = 1 Mbps ──Yes──▶ Trust and Transmit
             │                    │
             No                   No ──▶ Drop
             ▼
          DVLAN ANY ──Yes──▶ = 5 Mbps ──Yes──▶ Remark to DSCP 0 and Transmit
                                 │
                                 No ──▶ Remark to DSCP CS1 and Transmit
```

Cisco Catalyst 2950 QoS Design
Queuing Design (1P3Q1T)

Application	DSCP	CoS
Network Control	-	CoS 7
Internetwork Control	CS6	CoS 6
Voice	EF	CoS 5
Interactive Video	AF41	CoS 4
Streaming Video	CS4	CoS 4
Mission-Critical Data	AF31	CoS 3
Call Signaling	CS3	CoS 3
Transactional Data	AF21	CoS 2
Network Management	CS2	CoS 2
Bulk Data	AF11	CoS 1
Scavenger	CS1	CoS 1
Best Effort	0	0

1P3Q1T

CoS 5 — Q4 Priority Queue

CoS 7
CoS 6
CoS 4
CoS 3
CoS 2 — Queue 3 (70%)

CoS 0 — Queue 2 (25%)

CoS 1 — Queue 1 (5%)

Cisco Catalyst 2950 QoS Design
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)#
```

CISCO CATALYST 3550
QOS DESIGN

Catalyst 3550
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 QoS Design
Access-Layer Cisco Catalyst 3550 QoS Design Options
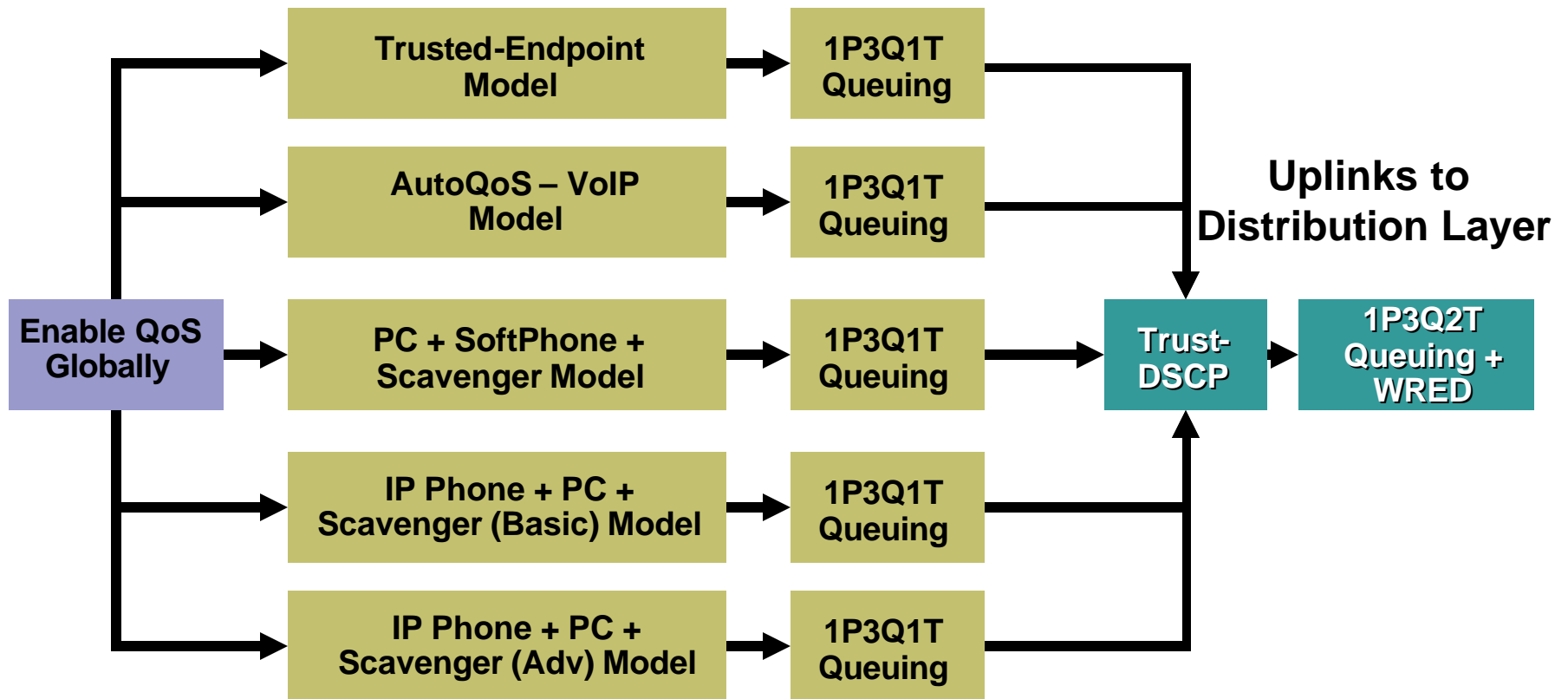
Access-Edges

Flow diagram:

- **Enable QoS Globally** →
  - **Trusted-Endpoint Model** → **1P3Q1T Queuing**
  - **AutoQoS – VoIP Model** → **1P3Q1T Queuing**
  - **PC + SoftPhone + Scavenger Model** → **1P3Q1T Queuing**
  - **IP Phone + PC + Scavenger (Basic) Model** → **1P3Q1T Queuing**
  - **IP Phone + PC + Scavenger (Adv) Model** → **1P3Q1T Queuing**

Uplinks to Distribution Layer

→ **Trust-DSCP** → **1P3Q2T Queuing + WRED**

Cisco Catalyst 3550 QoS Design
Distribution-Layer Cisco Catalyst 3550 QoS Design

Enable QoS Globally	→	Trust-DSCP	→	1P3Q2T Queuing + WRED

Interswitch-Links
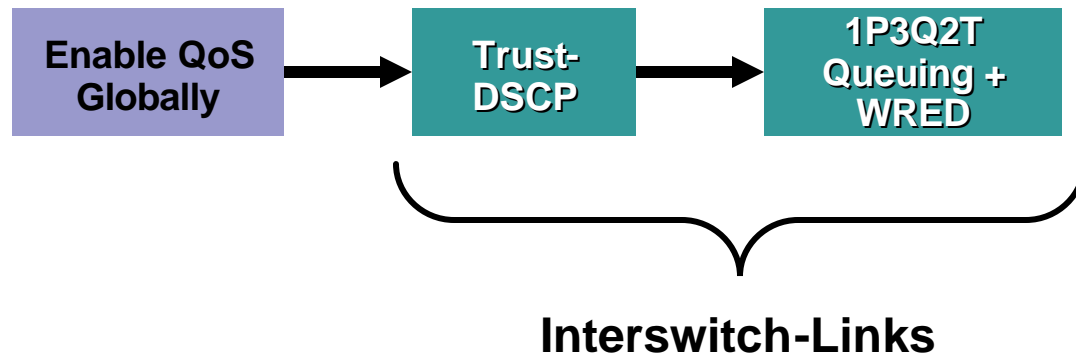
Cisco Catalyst 3550
AutoQoS VoIP Model Example
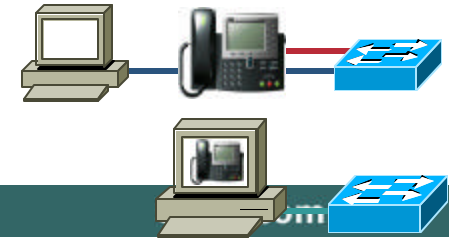
```
C3550(config-if)#auto qos voip cisco-softphone
```

Options:

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

```
                                            s to 0
                                            46 48 56
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
!
```
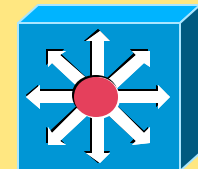
Cisco Catalyst 3550 QoS Design
Queuing Design (1P3Q1T on FE and 1P3Q2T on GE)

Application	DSCP	CoS	1P3Q2T
Network Control	-	CoS 7	
Internetwork Control	CS6	CoS 6	CoS 5 Q4 Priority Queue
Voice	EF	CoS 5	
Interactive Video	AF41	CoS 4	CoS 7 Q3T2
Streaming Video	CS4	CoS 4	CoS 6
Mission-Critical Data	AF31	CoS 3	CoS 4 Q3T1
Call Signaling	CS3	CoS 3	CoS 3 Queue 3 (70%)
Transactional Data	AF21	CoS 2	CoS 2
Network Management	CS2	CoS 2	
Bulk Data	AF11	CoS 1	CoS 0 Queue 2 (25%)
Scavenger	CS1	CoS 1	CoS 1 Queue 1 (5%) Q1T2
Best Effort	0	0	Q1T1

Cisco Catalyst 3550 QoS Design
Queuing Design (1P3Q1T for FE Interfaces)

```
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 QoS Design
Queuing Design (1P3Q2T for GE Interfaces)

```
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)# priority-queue out              ! Enables Q4 as PQ
CAT3550(config-if-range)#end
CAT3550#
```

CISCO CATALYST 2970/3560/3750 QOS DESIGN

Catalyst 2970/3560/3750
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 & policing by port or by Switched Virtual Interface (SVI) via hierarchical class maps

- Minimum policing granularity is 8 kbps

- Supports 4Q3T queuing or 1P3Q3T queuing

  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)

Cisco Catalyst 2970/3560/3750 QoS Design
Access-Layer Cisco Catalyst 2970/3560/3750 QoS Design Options

Access-Edges

Enable QoS Globally

Trusted-Endpoint Model	1P3Q3T Queuing + WTD
AutoQoS – VoIP Model	1P3Q3T Queuing + WTD
PC + SoftPhone + Scavenger Model	1P3Q3T Queuing + WTD
IP Phone + PC + Scavenger (Basic) Model	1P3Q3T Queuing + WTD
IP Phone + PC + Scavenger (Adv) Model	1P3Q3T Queuing + WTD

Uplinks to Distribution Layer

Trust-DSCP

1P3Q3T Queuing + WTD
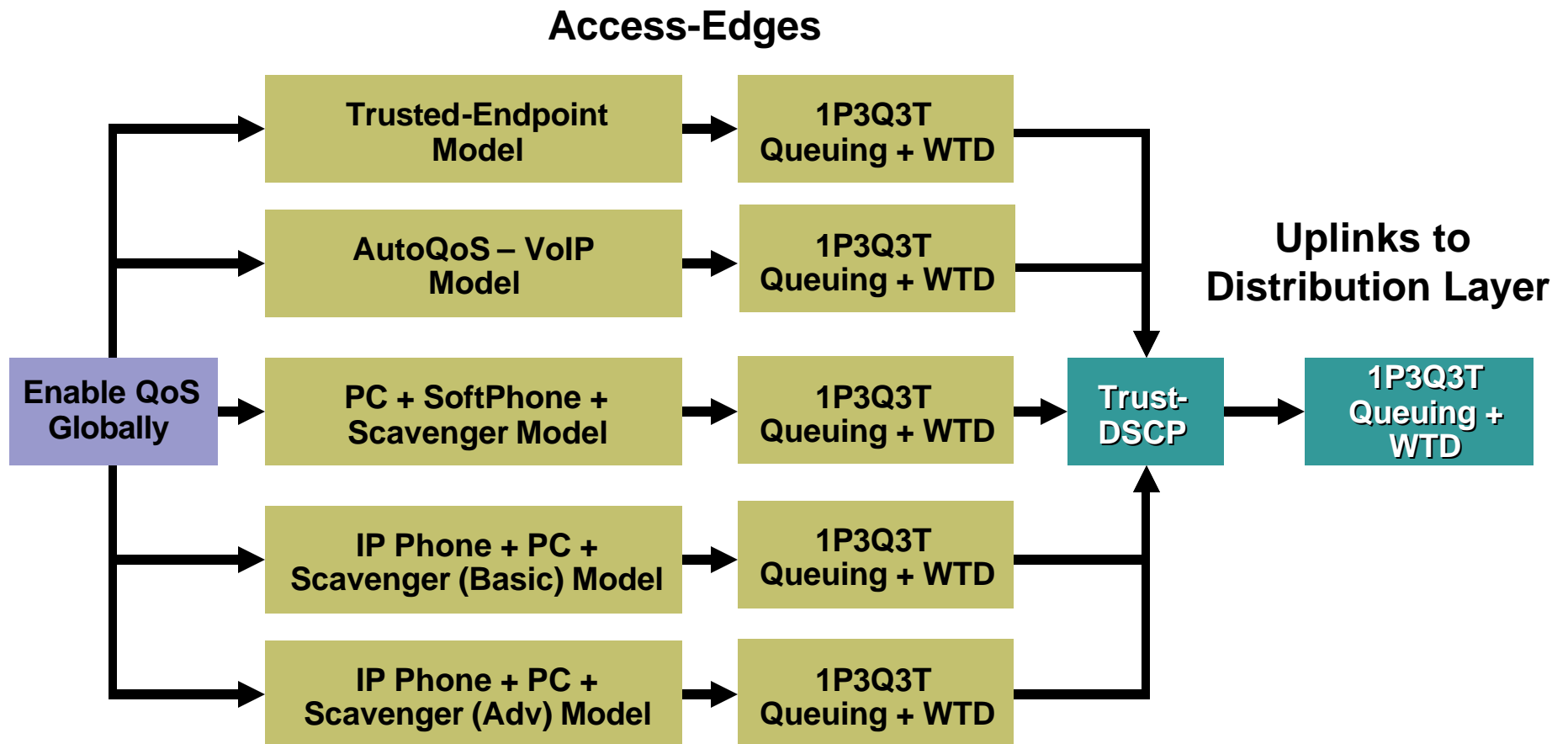
Cisco Catalyst 2970/3560/3750
AutoQoS VoIP Model Example
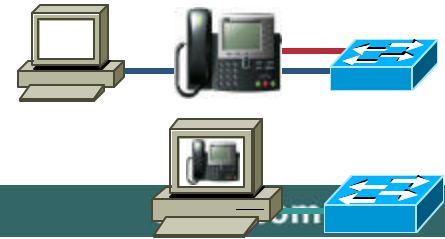
```
CAT2970(config-if)#auto qos voip cisco-phone
```

Options:

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

```
mls qos map cos-dscp 0 0 10 20 32 46 48 56
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   138 138 92 138
mls qos queue-set output 1 threshold   38 138 92 400
mls qos queue-set output 1 threshold   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
!
```

Cisco Catalyst 2970/3560/3750 QoS Design
Queuing Design (1P3Q3T)

Application	DSCP	CoS	1P3Q3T
Network Control	-	CoS 7	CoS 1 Queue 4 (5%) Q4T2
Internetwork Control	CS6	CoS 6	Q4T1
Voice	EF	CoS 5	CoS 0 Queue 3 (25%)
Interactive Video	AF41	CoS 4	
Streaming Video	CS4	CoS 4	CoS 7 Q2T3
Mission-Critical Data	AF31	CoS 3	CoS 6
Call Signaling	CS3	CoS 3	CoS 3 Queue 2 (70%) Q2T2
Transactional Data	AF21	CoS 2	
Network Management	CS2	CoS 2	CoS 4 Q2T1
Bulk Data	AF11	CoS 1	CoS 2
Scavenger	CS1	CoS 1	
Best Effort	0	0	CoS 5 Q1 Priority Queue

Cisco Catalyst 2970/3560/3750 QoS Design
Queuing Design (1P3Q3T): Part 1

```
CAT2970(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)
CAT2970(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
CAT2970(config)#mls qos srr-queue output cos-map queue 2 threshold 2  3
        ! Maps CoS 3 to Queue 2 Threshold 2
CAT2970(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
CAT2970(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)
CAT2970(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)
CAT2970(config)#
```

Cisco Catalyst 2970/3560/3750 QoS Design
Queuing Design (1P3Q3T): Part 2

```
CAT2970(config)#mls qos srr-queue output dscp-map queue 1 threshold 3  46
        ! Maps DSCP EF (Voice) to Queue 1 Threshold 3
CAT2970(config)#mls qos srr-queue output dscp-map queue 2 threshold 1  16
        ! Maps DSCP CS2 (Network Management) to Queue 2 Threshold 1
CAT2970(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
CAT2970(config)#mls qos srr-queue output dscp-map queue 2 threshold 1  26
        ! Maps DSCP AF31 (Mission-Critical Data) to Queue 2 Threshold 1
CAT2970(config)#mls qos srr-queue output dscp-map queue 2 threshold 1  32
        ! Maps DSCP CS4 (Streaming Video) to Queue 2 Threshold 1
CAT2970(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
CAT2970(config)#mls qos srr-queue output dscp-map queue 2 threshold 2  24
        ! Maps DSCP CS3 (Call-Signaling) to Queue 2 Threshold 2
CAT2970(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
CAT2970(config)#mls qos srr-queue output dscp-map queue 3 threshold 3  0
        ! Maps DSCP 0 (Best Effort) to Queue 3 Threshold 3
CAT2970(config)#mls qos srr-queue output dscp-map queue 4 threshold 1  8
        ! Maps DSCP CS1 (Scavenger) to Queue 4 Threshold 1
CAT2970(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
CAT2970(config)#
```

CISCO CATALYST 4500 (SUPII+ through SUP V) QOS DESIGN
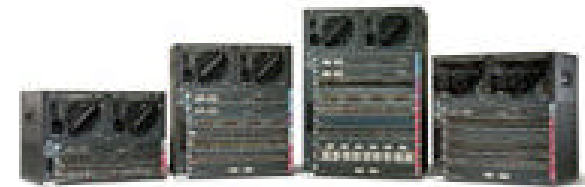
Catalyst 4500 (Sup II+ through Sup V)
QoS Design Considerations

- 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 and hierarchical policing

- 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

  Congestion Avoidance algorithm is Dynamic Buffer Limiting (DBL)

Cisco Catalyst 4500 QoS Design
Access-Layer Cisco Catalyst 4500 QoS Design Options

Access-Edges

```
Enable QoS Globally
    ├──▶ Trusted-Endpoint Model ──▶ 1P3Q1T Queuing + DBL ──┐
    ├──▶ AutoQoS - VoIP Model ──▶ 1P3Q1T Queuing + DBL ──┤
    ├──▶ PC + SoftPhone + Scavenger Model ──▶ 1P3Q1T Queuing + DBL ──▶ Trust-DSCP ──▶ 1P3Q1T Queuing + DBL
    ├──▶ IP Phone + PC + Scavenger (Basic) Model ──▶ 1P3Q1T Queuing + DBL ──┤
    └──▶ IP Phone + PC + Scavenger (Adv) Model ──▶ 1P3Q1T Queuing + DBL ──┘
```

Uplinks to Distribution Layer
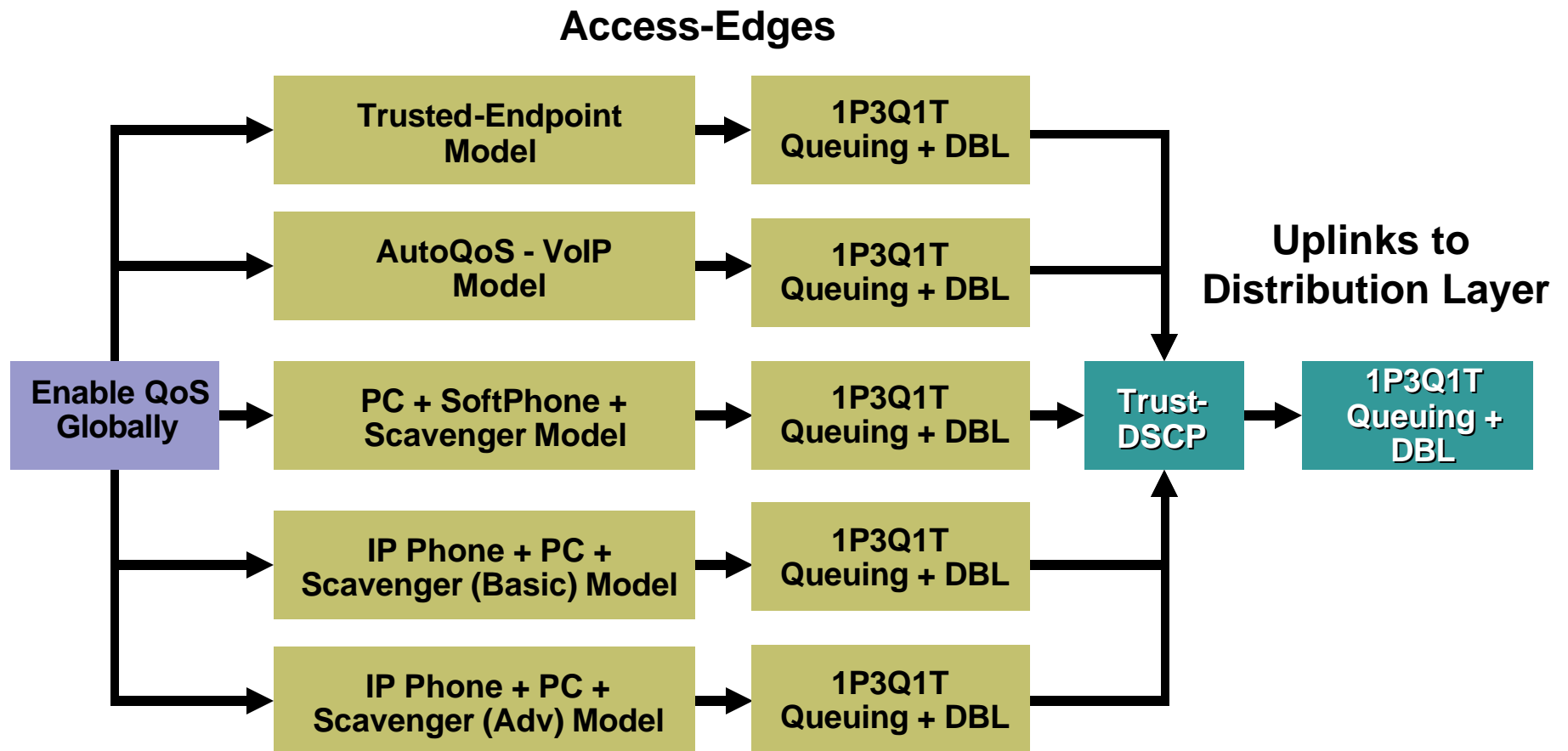
Cisco Catalyst 4500 QoS Design

Distribution and/or Core-Layer Cisco Catalyst 4500 QoS Design

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│  Enable QoS  │─────▶│    Trust-    │─────▶│    1P3Q1T    │
│   Globally   │      │     DSCP     │      │  Queuing +   │
│              │      │              │      │     DBL      │
└──────────────┘      └──────────────┘      └──────────────┘
```

Interswitch-Links
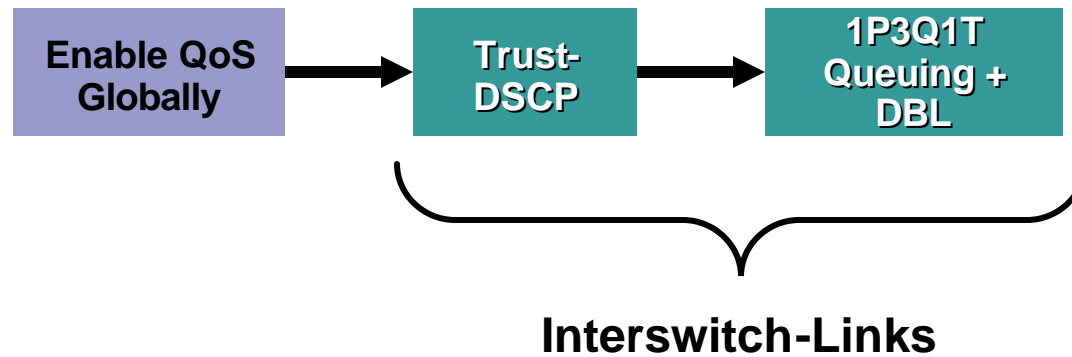
Cisco Catalyst 4500
AutoQoS – VoIP Model

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

Options:

auto qos voip cisco-phone
auto qos voip trust

```
!
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
!
```
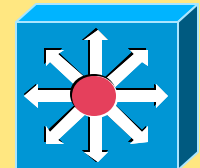
Cisco Catalyst 4500 QoS Design
Queuing Design (1P3Q1T + DBL)

Application	DSCP	1P3Q1T
Network Control	(CS7)	
Internetwork Control	CS6	CS6/CS7
Voice	EF	CS4/AF41/AF42/AF43
Interactive Video	AF41	Queue 4 (40%)
Streaming Video	CS4	CS3/AF31/AF32/AF33
Mission-Critical Data	AF31	CS2/AF21/AF22/AF23
Call Signaling	CS3	
Transactional Data	AF21	EF Q3 (30%) Priority Queue
Network Management	CS2	
Bulk Data	AF11	0 Queue 2 (25%)
Scavenger	CS1	
Best Effort	0	CS1/AF11 Queue 1 (5%)
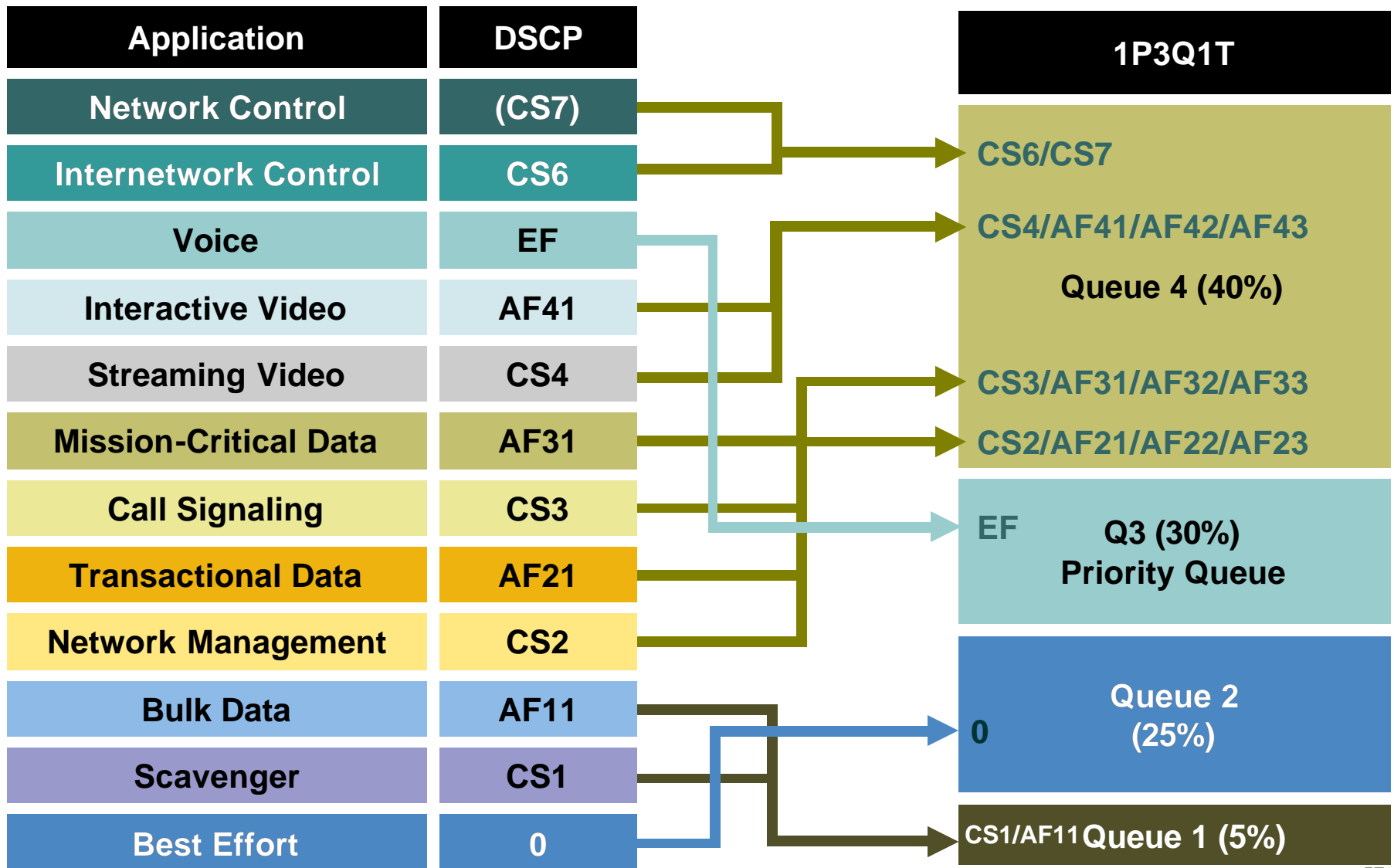
Cisco Catalyst 4500 QoS Design
Queuing Design (1P3Q1T + DBL): Part 1

```
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)# exit
CAT4500-SUP4(config-pmap)#exit
CAT4500-SUP4(config)#
```

Cisco Catalyst 4500 QoS Design
Queuing Design (1P3Q1T + DBL): Part 2 (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#
```

CISCO CATALYST 6500-PFC2/PFC3 ACCESS-LAYER QOS DESIGN

Catalyst 6500 (PFC2/PFC3)
QoS Design Considerations

- **QoS disabled by default**

- **Configuration may be CatOS or IOS**

    IOS does not (yet) support Conditional Trust or AutoQoS

- **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 (Sup720 & Sup32)**

- **Linecards determine queuing structure**

    2Q2T

    1P2Q1T   **1P2Q2T**

    1P3Q1T   **1P3Q8T**

    1P1Q8T

Cisco Catalyst 6500 QoS Design

Access-Layer Cisco Catalyst 6500 QoS Design Options

Access-Edges


```
Enable QoS Globally
    → Trusted-Endpoint Model
    → AutoQoS – VoIP Model (CatOS Only)
    → PC + SoftPhone + Scavenger Model
    → IP Phone + PC + Scavenger (Basic) Model
    → IP Phone + PC + Scavenger (Adv) Model

Uplinks to Distribution Layer

Trust-DSCP → Globally-Defined Linecard-Dependant Queuing + Dropping
```
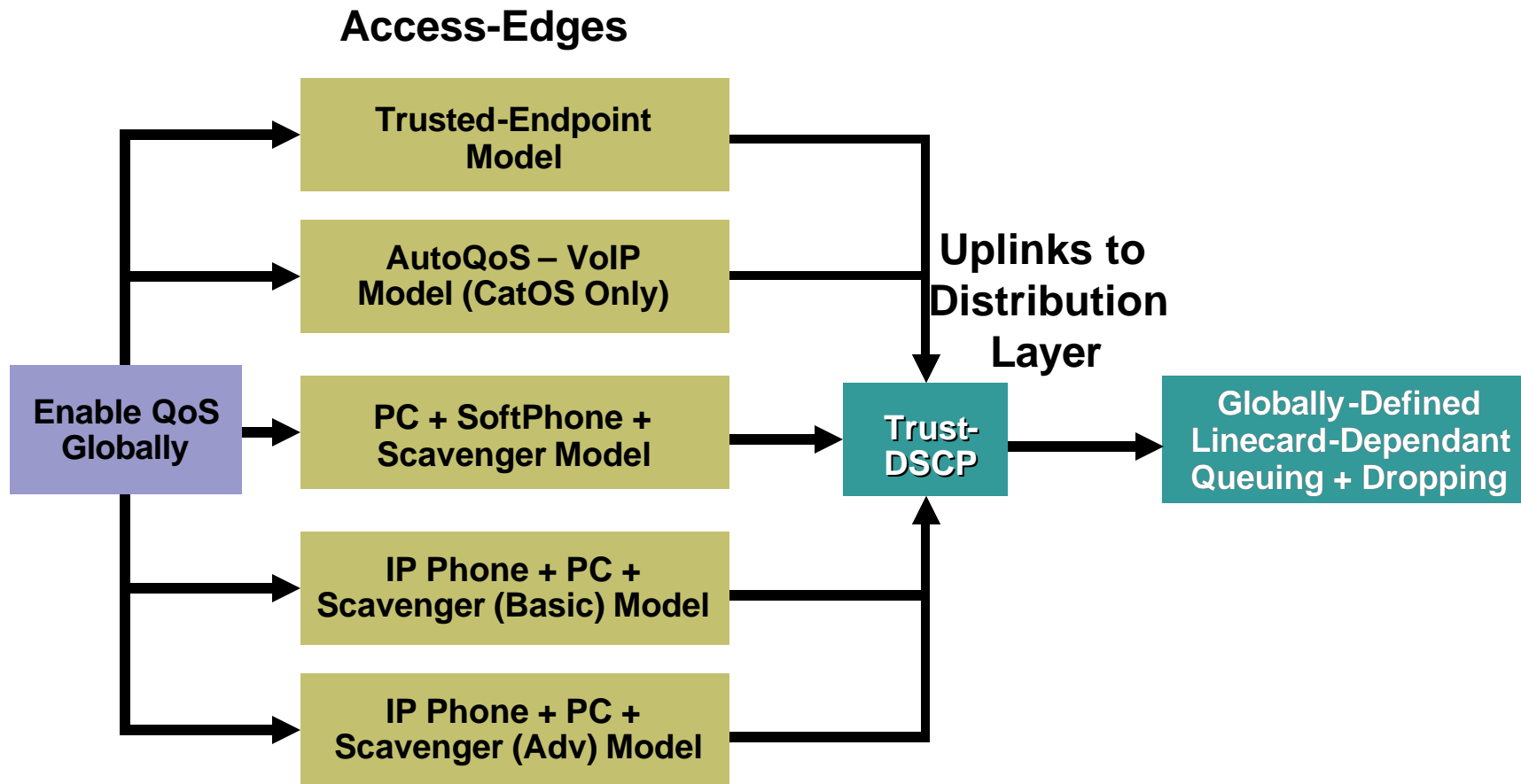
Cisco Catalyst 6500 QoS Design

Distribution and/or Core-Layer (Cisco IOS) Cisco Catalyst 6500 QoS Design

Distribution Layer:

Uplinks from Access-Layer Only

| Enable QoS Globally | → | Trust-DSCP | → | Optional (PFC3 Only): Per-User Microflow Policing | → | Interface-Group Linecard-Dependant Queuing + Dropping |

Interswitch-Links

Core Layer:

| Enable QoS Globally | → | Trust-DSCP | —— | Interface-Group Linecard-Dependant Queuing + Dropping |

Interswitch-Links
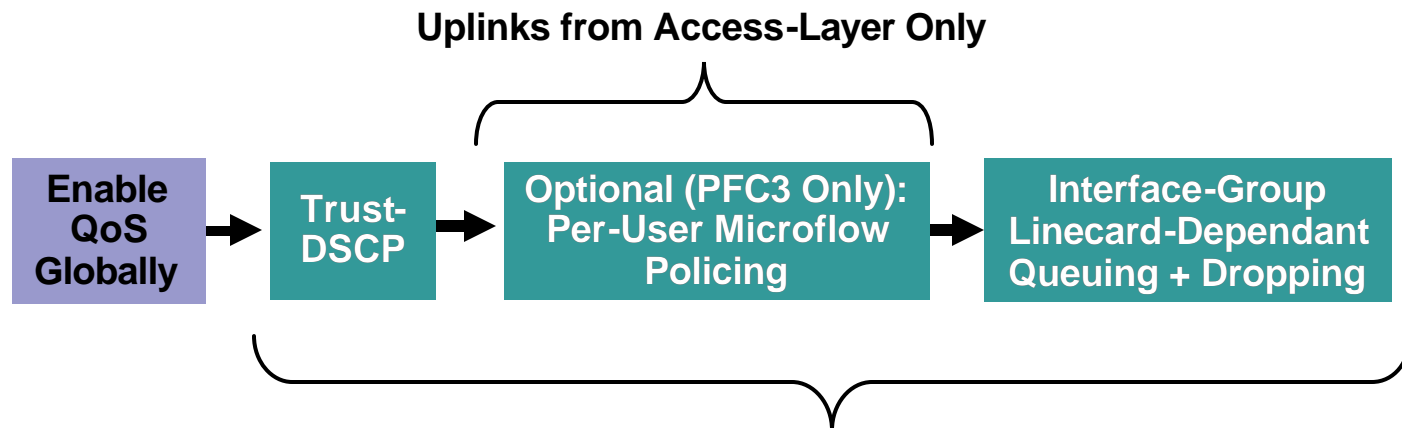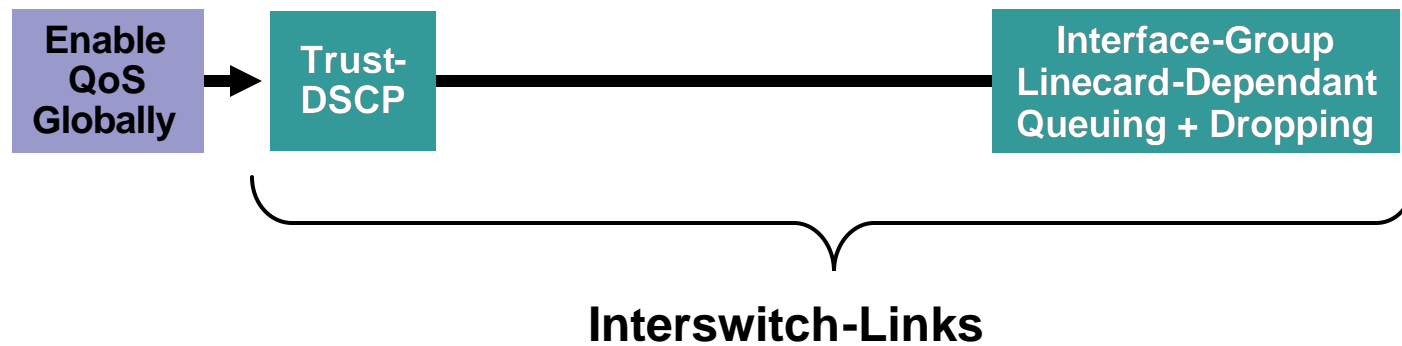
Cisco Catalyst 6500
AutoQoS VoIP (CatOS Only)
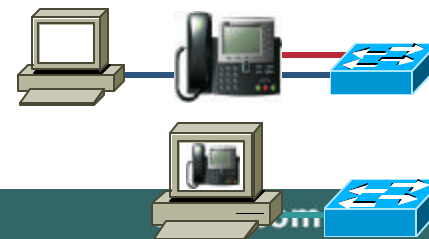
```
set qos autoqos
set port qos 3/1 autoqos voip ciscoipphone
```

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
```
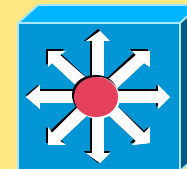
CISCO CATALYST 6500-PFC2/PFC3 LINECARD QUEUING DESIGN

Cisco Catalyst 6500 QoS Design
Queuing Structures by Linecard

Classic/CEF256 Ethernet Modules	Description	Rx Queuing	Tx Queuing	Buffer Size
WS-X6024-10FL-MT	Catalyst 6000 24-Port 10BaseFL MT-RJ Module	1Q4T	2Q2T	64KB per Port
WS-X6148-RJ21	Catalyst 6500 48-Port 10/100 RJ-21 Module (Upgradable to Voice)	1Q4T	2Q2T	128KB per Port
WS-X6148-RJ21V	Catalyst 6500 48-Port 10/100 Inline Power RJ-21 Module	1Q4T	2Q2T	128KB per Port
WS-X6148-RJ45	Catalyst 6500 48-Port 10/100; RJ-45 Module (Upgradable to Voice)	1Q4T	2Q2T	128KB per Port
WS-X6148-RJ45V	Catalyst 6500 48-Port 10/100 Inline Power RJ-45 Module	1Q4T	2Q2T	128KB per Port
WS-X6148-GE-TX	Catalyst 6500 48-Port 10/100/1000 RJ-45 Module	1Q2T	1P2Q2T	1MB per 8 Ports
WS-X6148V-GE-TX	Catalyst 6500 48-Port 10/100/1000 Inline Power RJ-45 Module	1Q2T	1P2Q2T	1MB per 8 Ports
WS-X6316-GE-TX	Catalyst 6000 16-Port 1000TX GigabitEthernet RJ-45 Module	1P1Q4T	1P2Q2T	512KB per Port
WS-X6324-100FX-MM	Catalyst 6000 24-Port 100FX MT-RJ MMF Module (with Enhanced QoS)	1Q4T	2Q2T	128KB per Port
WS-X6324-100FX-SM	Catalyst 6000 24-Port 100FX MT-RJ SMF Module (with Enhanced QoS)	1Q4T	2Q2T	128KB per Port
WS-X6348-RJ-21	Catalyst 6000 48-Port 10/100 RJ-21 Module	1Q4T	2Q2T	128KB per Port
WS-X6348-RJ21V	Catalyst 6000 48-Port 10/100 Inline Power RJ-21 Module	1Q4T	2Q2T	128KB per Port
WS-X6348-RJ-45	Catalyst 6500 48-Port 10/100 RJ-45 Module (Upgradable to Voice)	1Q4T	2Q2T	128KB per Port
WS-X6348-RJ45V	Catalyst 6500 48-Port 10/100 Inline Power RJ-45 Module	1Q4T	2Q2T	128KB per Port

Cisco Catalyst 6500 QoS Design
Queuing Structures by Linecard

Classic/CEF256 Ethernet Modules	Description	Rx Queuing	Tx Queuing	Buffer Size
WS-X6408A-GBIC	Catalyst 6000 8 Port GigabitEthernet Module (with Enhanced QoS; Requires GBICs)	1P1Q4T	1P2Q2T	512KB per Port
WS-X6416-GBIC	Catalyst 6000 16-Port GigabitEthernet Module (Requires GBICs)	1P1Q4T	1P2Q2T	512KB per Port
WS-X6416-GE-MT	Catalyst 6000 16-Port GigabitEthernet MT-RJ Module	1P1Q4T	1P2Q2T	512KB per Port
WS-X6501-10GEX4	Port 10 GigabitEthernet Module	1P1Q8T	1P2Q1T	64MB per Port
WS-X6502-10GE	Catalyst 6500 10 GigabitEthernet Base Module (Requires OIM)	1P1Q8T	1P2Q1T	64MB per Port
WS-X6516A-GBIC	Catalyst 6500 16-Port GigabitEthernet Module (Fabric-Enabled; Requires GBICs)	1P1Q4T	1P2Q2T	1MB per Port
WS-X6516-GBIC	Catalyst 6500 16-Port GigabitEthernet Module (Fabric-Enabled; Requires GBICs)	1P1Q4T	1P2Q2T	512KB per Port
WS-X6516-GE-TX	Catalyst 6500 16-Port GigabitEthernet Copper Module; (Crossbar-Enabled)	1P1Q4T	1P2Q2T	512KB per Port
WS-X6524-100FX-MM	Catalyst 6500 24-Port 100FX MT-RJ Module (Fabric-Enabled)	1P1Q0T	1P3Q1T	1MB per Port
WS-X6548-RJ-21	Catalyst 6500 48-Port 10/100 RJ-21 Module (Fabric-Enabled)	1P1Q0T	1P3Q1T	1MB per Port
WS-X6548-RJ-45	Catalyst 6500 48-Port 10/100 RJ-45 Module (Crossbar-Enabled)	1P1Q0T	1P3Q1T	1MB per Port
WS-X6548V-GE-TX	Catalyst 6500 48-Port 10/100/1000 Inline Power RJ-45 Module (Fabric-Enabled)	1Q2T	1P2Q2T	1MB per 8 Ports
WS-X6548-GE-TX	Catalyst 6500 48-Port 10/100/1000 RJ-45 Module (Fabric-Enabled)	1Q2T	1P2Q2T	1MB per 8 Ports
WS-X6816-GBIC	Catalyst 6500 16-Port GigabitEthernet Module (Fabric-Enabled; Requires GBICs)	1P1Q4T	1P2Q2T	512KB per Port

Cisco Catalyst 6500 QoS Design
Queuing Structures by Linecard

C2 (xCEF720) Modules	Description	Rx-Queuing	Tx-Queuing	Buffer Size
WS-X6704-10GE	Catalyst 6500 4-Port 10 GigabitEthernet Module	1Q8T (8Q8T with DFC3a)	1P7Q8T	16MB per Port
WS-X6724-SFP	Catalyst 6500 24-Port GigabitEthernet SFP Module	1Q8T; (2Q8T with DFC3a)	1P3Q8T	1MB per Port
WS-X6748-GE-TX	Catalyst 6500 48-Port 10/100/1000 RJ-45 Module	1Q8T; (2Q8T with DFC3a)	1P3Q8T	1MB per Port
WS-X6748-SFP	Catalyst 6500 48-Port GigabitEthernet SFP Module	1Q8T; (2Q8T with DFC3a)	1P3Q8T	1MB per Port

Cisco Catalyst 6500 QoS Design
Queuing Design (2Q2T)

Application	DSCP	CoS
Network Control	-	CoS 7
Internetwork Control	CS6	CoS 6
Voice	EF	CoS 5
Interactive Video	AF41	CoS 4
Streaming Video	CS4	CoS 4
Mission-Critical Data	AF31	CoS 3
Call Signaling	CS3	CoS 3
Transactional Data	AF21	CoS 2
Network Management	CS2	CoS 2
Bulk Data	AF11	CoS 1
Scavenger	CS1	CoS 1
Best Effort	0	0

2Q2T

CoS 5 — Q2T2

CoS 7
CoS 6 — Queue 2 (70%) — Q2T1
CoS 4

CoS 3

CoS 2

CoS 0 — Queue 1 (30%) — Q1T2

CoS 1 — Q1T1

Cisco Catalyst 6500 QoS Design
Queuing Design (2Q2T: Cisco Catalyst OS)

```
CAT6500-PFC2-CATOS> (enable) set qos txq-ratio 2q2t 30 70
        ! Sets the buffer allocations to 30% for Q1 and 70% for Q2
CAT6500-PFC2-CATOS> (enable) set qos wrr 2q2t 30 70
        ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos drop-threshold 2q2t tx queue 1 40 100
        ! Sets Q1T1 to 40% to limit Scavenger/Bulk within Q1
CAT6500-PFC2-CATOS> (enable) set qos drop-threshold 2q2t tx queue 2 80 100
        ! Sets Q2T1 to 80% to always have room in Q2 for VoIP
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos map 2q2t tx 1 1 cos 1
        ! Maps Scavenger/Bulk to Q1T1
CAT6500-PFC2-CATOS> (enable) set qos map 2q2t tx 1 2 cos 0
        ! Maps Best Effort to Q1T2
CAT6500-PFC2-CATOS> (enable) set qos map 2q2t tx 2 1 cos 2,3,4,6,7
        ! Maps CoS 2,3,4,6 and 7 to Q2T1
CAT6500-PFC2-CATOS> (enable) set qos map 2q2t tx 2 2 cos 5
        ! Maps VoIP to Q2T2
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (2Q2T: Cisco 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 QoS Design
Queuing Design (1P2Q1T: Cisco Catalyst OS Supports 1P2Q2T)
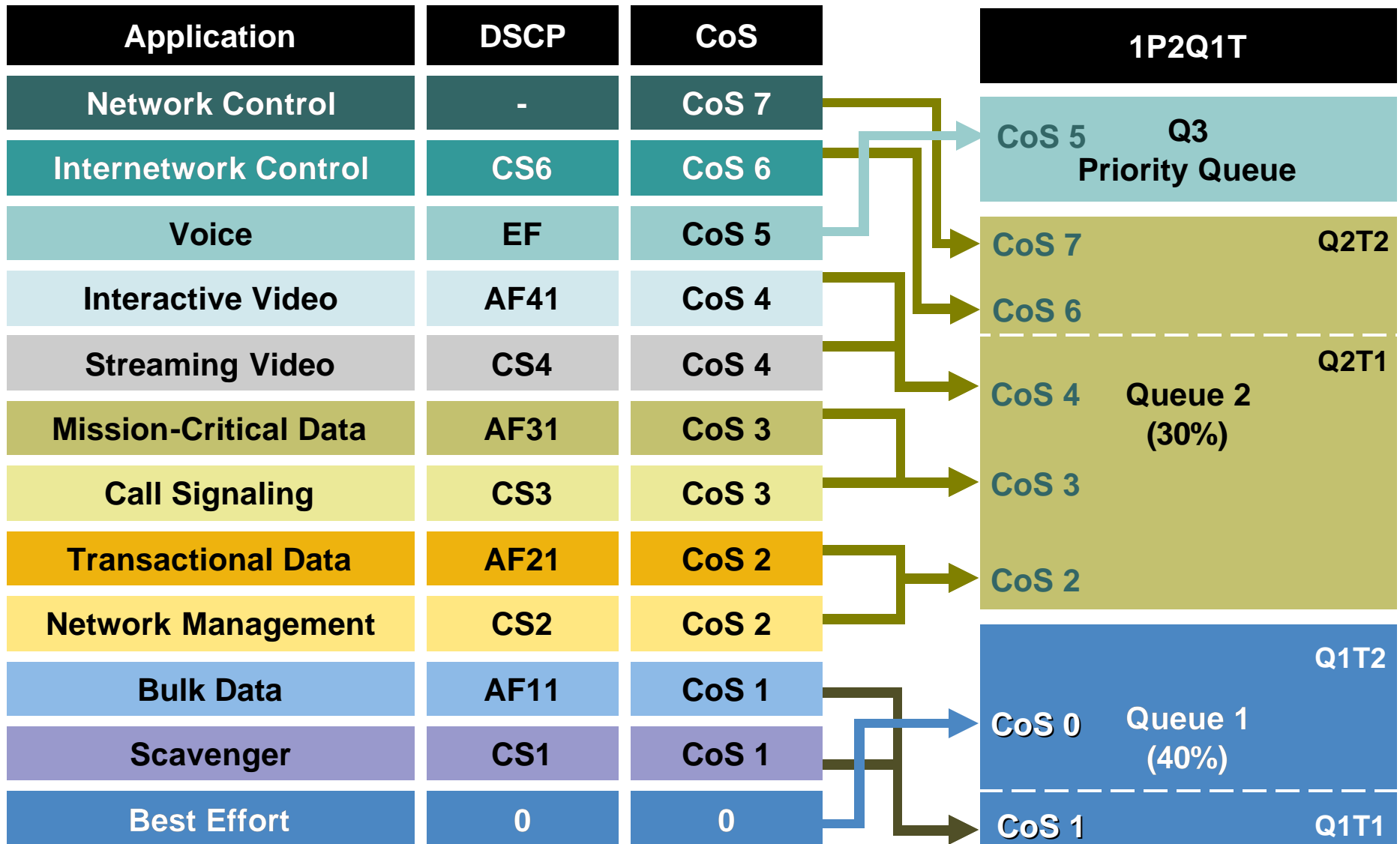
Application	DSCP	CoS	1P2Q1T
Network Control	-	CoS 7	
Internetwork Control	CS6	CoS 6	CoS 5 — Q3 Priority Queue
Voice	EF	CoS 5	
Interactive Video	AF41	CoS 4	CoS 7 — Q2T2
Streaming Video	CS4	CoS 4	CoS 6
Mission-Critical Data	AF31	CoS 3	CoS 4 — Q2T1, Queue 2 (30%)
Call Signaling	CS3	CoS 3	CoS 3
Transactional Data	AF21	CoS 2	CoS 2
Network Management	CS2	CoS 2	
Bulk Data	AF11	CoS 1	CoS 0 — Q1T2, Queue 1 (40%)
Scavenger	CS1	CoS 1	
Best Effort	0	0	CoS 1 — Q1T1

Cisco Catalyst 6500 QoS Design
Queuing Design (1P2Q1T: Cisco Catalyst OS)

```
CAT6500-PFC2-CATOS> (enable) set qos txq-ratio 1p2q1t 40 30 30
          ! Allocates buffers: 40% for Q1, 30% for Q2, 30% for Q3 (PQ)
CAT6500-PFC2-CATOS> (enable) set qos wrr 1p2q1t 30 70
          ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos wred 1p2q1t tx queue 1 40:80
          ! Sets Q1 WRED Threshold to 40:80 to limit Scavenger/Bulk within Q1
CAT6500-PFC2-CATOS> (enable) set qos wred 1p2q1t tx queue 2 70:80
          ! Sets Q2 WRED Threshold to 70:80 to force room for Network Control traffic
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos map 1p2q1t tx 1 1 cos 1
          ! Maps Scavenger/Bulk to Q1 WRED Threshold
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q1t tx 1 cos 0
          ! Maps Best Effort to Q1 tail (100%) threshold
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q1t tx 2 1 cos 2,3,4
          ! Maps CoS 2,3,4 to Q2 WRED Threshold
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q1t tx 2 cos 6,7
          ! Maps Network/Internetwork Control to Q2 tail (100%) threshold
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q1t tx 3 cos 5
          ! Maps VoIP to PQ (Q3)
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P2Q1T: Cisco 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(config-if)#
```

CISCO CATALYST 6500 (PFC3) PER-USER MICROFLOW POLICING & CONTROL PLANE POLICING

C6500 (PFC3) QoS Design
PFC3 Per-User Microflow Policing: Part 1

```
CAT6500-PFC3-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-PFC3-IOS(config)#class-map match-all VOIP
CAT6500-PFC3-IOS(config-cmap)#  match ip dscp ef
CAT6500-PFC3-IOS(config-cmap)#class-map match-all INTERACTIVE-VIDEO
CAT6500-PFC3-IOS(config-cmap)#  match ip dscp af41 af42
CAT6500-PFC3-IOS(config-cmap)#class-map match-all CALL-SIGNALING
CAT6500-PFC3-IOS(config-cmap)#  match ip dscp cs3 af31
CAT6500-PFC3-IOS(config-cmap)#class-map match-all BEST-EFFORT
CAT6500-PFC3-IOS(config-cmap)#  match ip dscp 0
```
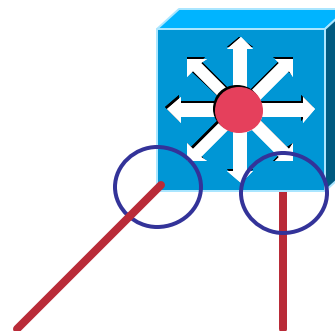
**Distribution-Layer
Catalyst 6500 Sup720**

C6500 (PFC3) QoS Design
PFC3 Per-User Microflow Policing: Part 2

```
CAT6500-PFC3-IOS(config-cmap)#policy-map PER-USER-POLICING
CAT6500-PFC3-IOS(config-pmap)#  class VOIP
CAT6500-PFC3-I(config-pmap-c)# police flow mask src-only 128000 8000
        conform-action transmit exceed-action drop
        ! No source can send more than 128k worth of DSCP EF traffic
CAT6500-PFC3-I(config-pmap-c)#  class INTERACTIVE-VIDEO
CAT6500-PFC3-I(config-pmap-c)# police flow mask src-only 500000 8000
        conform-action transmit exceed-action policed-dscp-transmit
        ! Excess IP/VC traffic from any source is marked down to CS1
CAT6500-PFC3-I(config-pmap-c)#  class CALL-SIGNALING
CAT6500-PFC3-I(config-pmap-c)# police flow mask src-only 32000 8000
        conform-action transmit exceed-action policed-dscp-transmit
        ! Excess Call-Signaling traffic from any source is marked down to CS1
CAT6500-PFC3-I(config-pmap-c)#  class BEST-EFFORT
CAT6500-PFC3-I(config-pmap-c)# police flow mask src-only 5000000 8000
        conform-action transmit exceed-action policed-dscp-transmit
        ! Excess PC Data traffic from any source is marked down to CS1
CAT6500-PFC3-I(config-pmap-c)#  exit
```
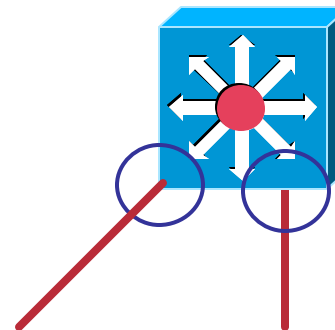
**Distribution-Layer
Catalyst 6500 Sup720**

C6500 (PFC3) QoS Design
PFC3 Per-User Microflow Policing: Part 3

```
CAT6500-PFC3-IOS(config)#
CAT6500-PFC3-IOS(config)#interface range GigabitEthernet4/1 - 4
CAT6500-PFC3(config-if-range)# mls qos trust dscp
CAT6500-PFC3(config-if-range)# service-policy input PER-USER-POLICING
        ! Attaches Per-User Microflow policing policy to Uplinks from Access
CAT6500-PFC3(config-if-range)#end
CAT6500-PFC3-IOS#
```
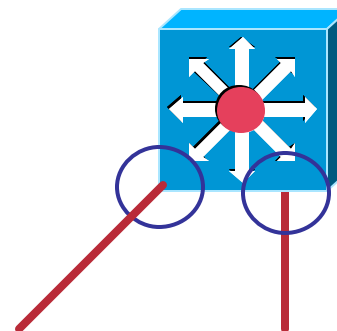
**Distribution-Layer
Catalyst 6500 Sup720**

C6500 (PFC3) QoS Design
C6500 Control Plane Policing Implementation – Part 1

Traffic to CPU

hardware "control-plane"

PFC3

Traffic to CPU

FABRIC

Traffic to CPU

Software "control-plane"

Traffic to CPU

CPU

Inband channel to RP CPU
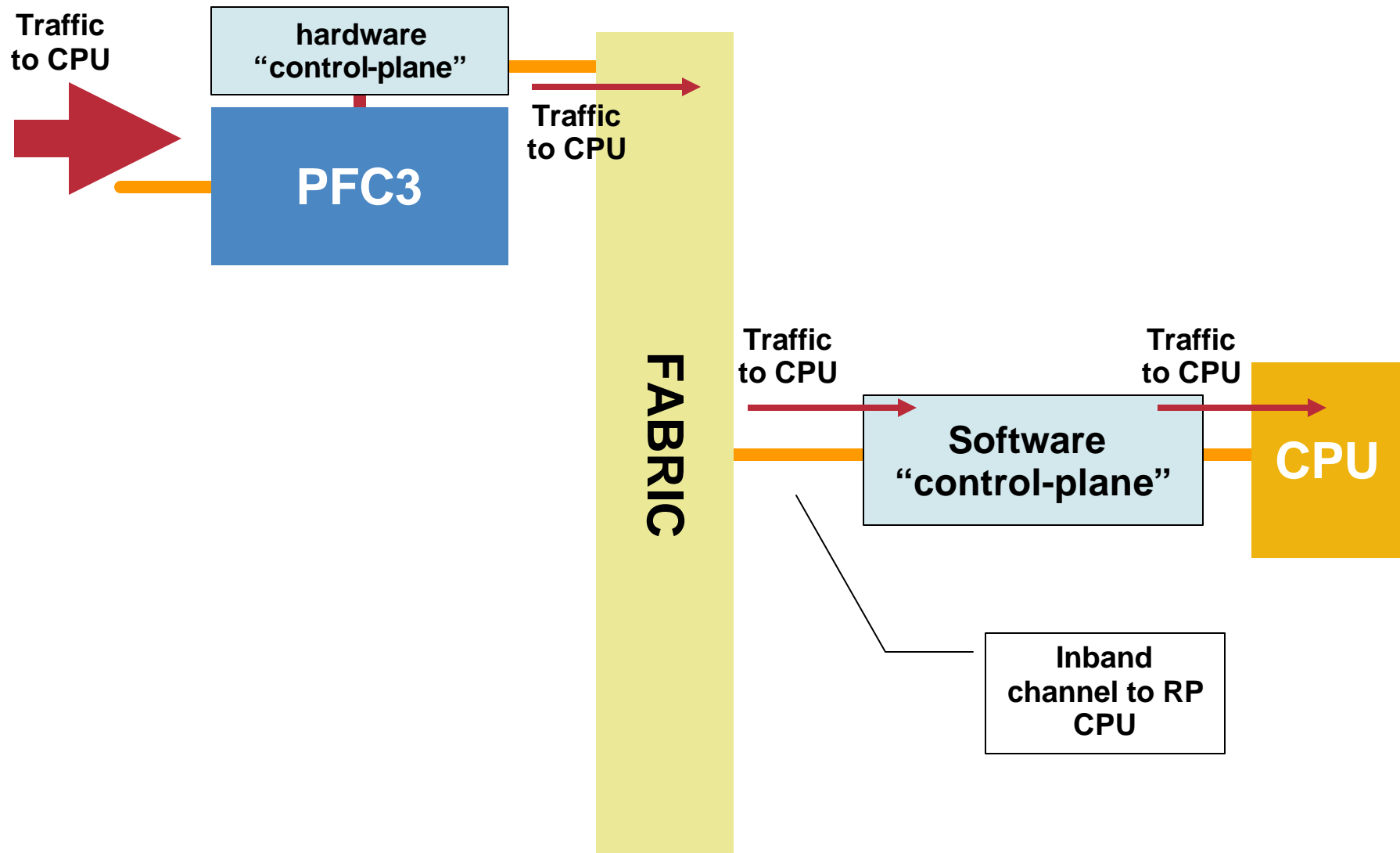
C6500 (PFC3) QoS Design
C6500 Control Plane Policing Implementation – Part 2
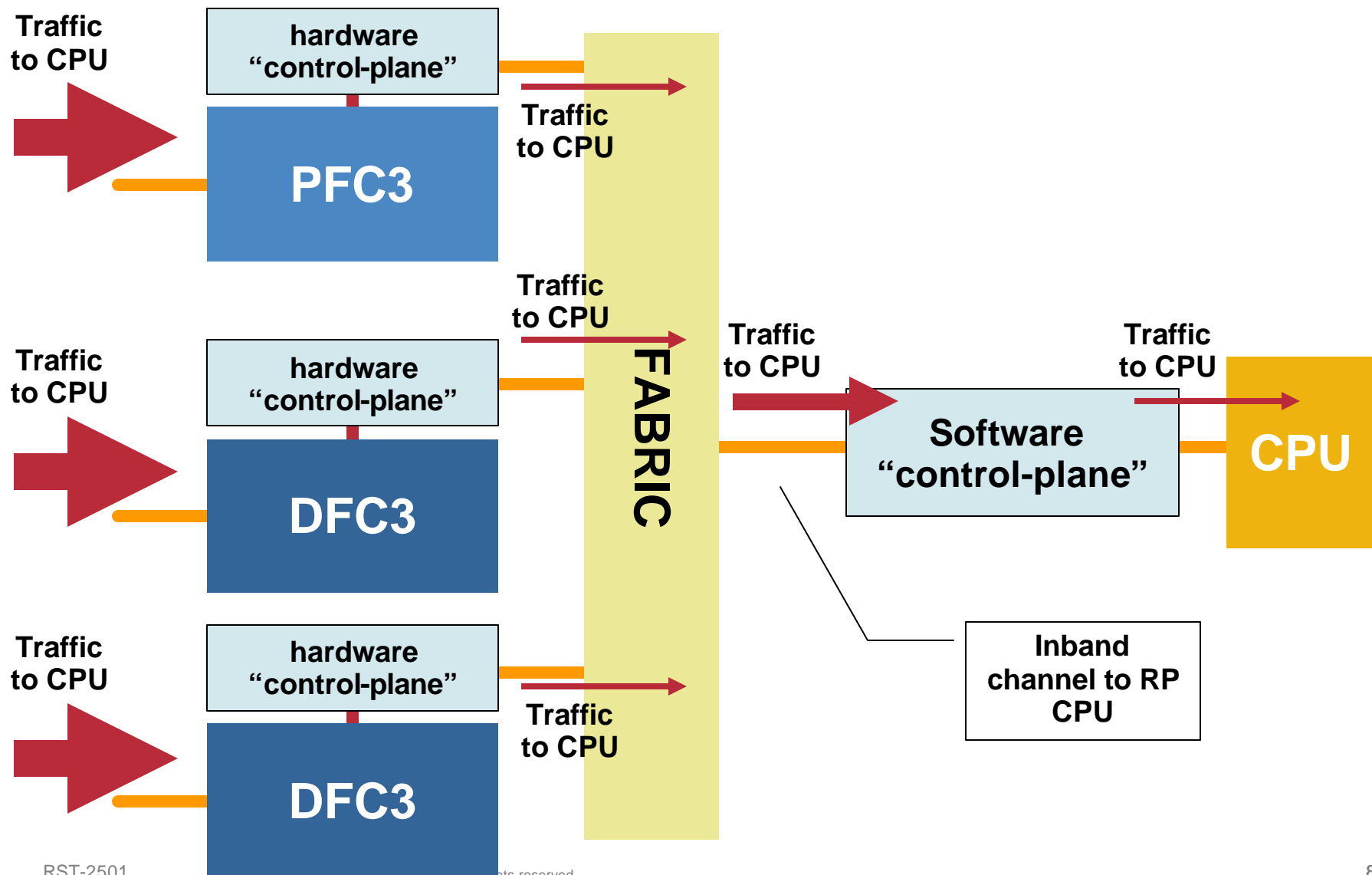
C6500 (PFC3) QoS Design
What CPU Rate Limiters are Available?

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 **B/BXL**
Capture	Used with Optimized ACL Logging

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 **B/BXL**
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

> **Shared across the 10 hardware RL's.**

LAYER 2 RATE LIMITERS

L2PT	L2PT encapsulation/decapsulation
PDU	Layer 2 PDUs

GENERAL RATE LIMITERS

MTU Failure	Packets requiring fragmentation
TTL Failure	Packets with TTL<=1

C6500 (PFC3) QoS Design
Configuring Control Plane Policing

There are 4 steps:

1. Define a packet classification criteria

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

2. Define a service policy

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

3. Enter control-plane configuration mode

    ```
    router(config)# control-plane
    router(config-cp)#
    ```

4. Apply QoS Policy

    ```
    router(config-cp)# service-policy [input| output]
         <service_policy_name>
    ```

C6500 (PFC3) QoS Design
CPP 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, traceroute) – conservative rate limit

   Critical traffic (HSRP, SIP/VoIP, DLSw) – conservative rate limit

   Default traffic – low rate limit

   Undesirable traffic (DoS Attacks) – drop

Summary

QoS TOOLS
AT–A–GLANCE

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.

Delay (Latency)

Delay-Variation (Jitter)

Packet 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 and Marking

Policing and Markdown
STOP

Scheduling (Queuing and Selective-Dropping)

Traffic Shaping

Link-Specific Mechanisms
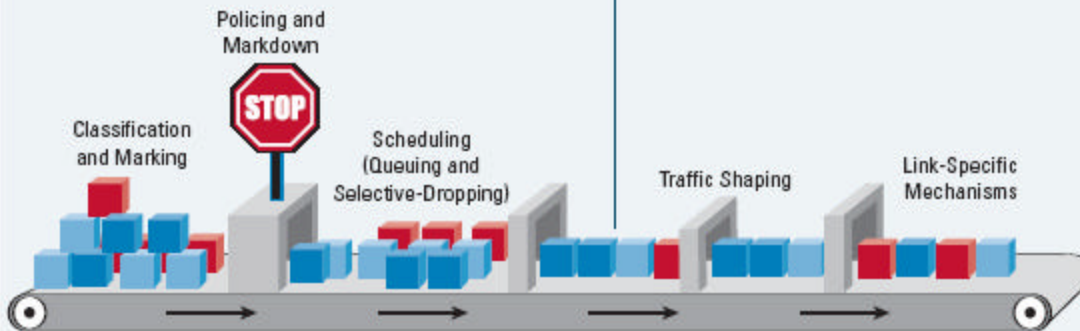
Classification can be Done at Layers 2–7

L2 Frame	L3 IP Packet			L4 TCP/UDP Segment		L7 Data Payload
	ToS/ DSCP	Source IP	Dest IP	Src Port	Dst Port	NBAR PDLM
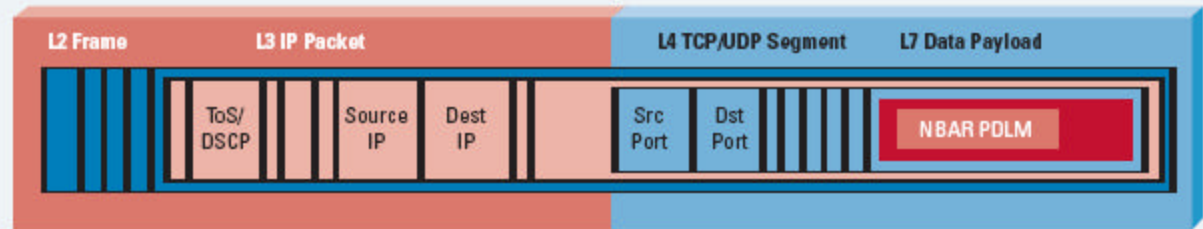
Marking can be done at Layers 2 or Layer 3:

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

Layer 3 (IP ToS Byte) Marking Options

7	6	5	4	3	2	1	0
IP Precedence					Unused		
DiffServ Code Point (DSCP)						IP ECN	

RFC 2474 DiffServ Extensions

RFC 3168 IP ECN Bits
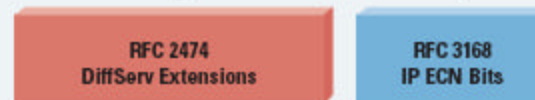
Cisco recommends end-to-end marking at Layer 3 with standards-based DSCP values.

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

Policers Meter Traffic Into Three Categories:

- Violate: No More Traffic is Allowed Beyond This Upper-Limit (Red Light)
- Exceed: Moderate Bursting is Allowed (Yellow Light)
- Conform: Traffic is Within the Defined Rate (Green Light)

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

Voice ① ①
Video ② ②
Data ③ ③
→ ③ ③ ② ① ①
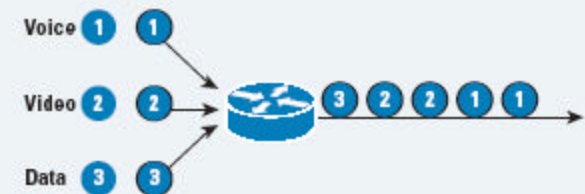
Link-Specific tools are useful on slow-speed WAN/VPN links and include shaping, compression, fragmentation, and interleaving.

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

THE QoS BASELINE
AT–A–GLANCE

CISCO SYSTEMS

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.

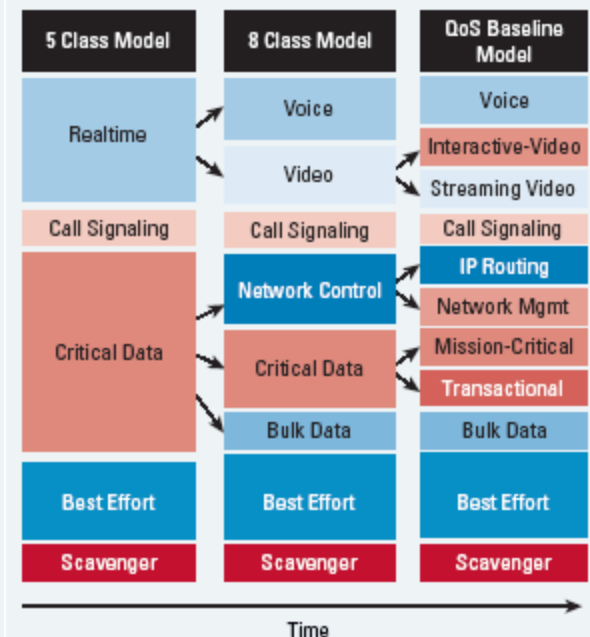| Application	L3 Classification PHB	DSCP	Referencing Standard	Recommended Configuration
IP Routing	CS6	48	RFC 2474-4.2.2	Rate-Based Queuing + RED
Voice	EF	46	RFC 3246	RSVP Admission Control + Priority Queuing
Interactive-Video	AF41	34	RFC 2597	RSVP + Rate-Based Queuing + DSCP-WRED
Streaming Video	CS4	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.

5 Class Model	8 Class Model	QoS Baseline Model
Realtime	Voice	Voice
	Video	Interactive-Video
		Streaming Video
Call Signaling	Call Signaling	Call Signaling
Critical Data	Network Control	IP Routing
		Network Mgmt
	Critical Data	Mission-Critical
		Transactional
	Bulk Data	Bulk Data
Best Effort	Best Effort	Best Effort
Scavenger	Scavenger	Scavenger

Time

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).
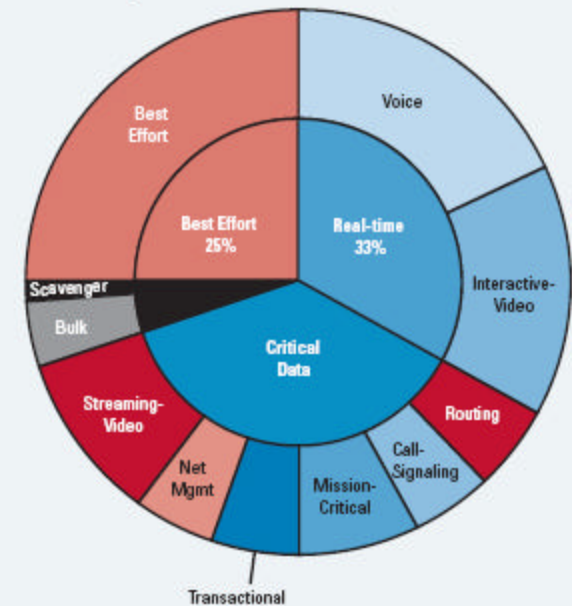
Thoroughly test QoS policies prior to production-network deployment.

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.

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.

Policing Policy

Normal Traffic

Worm

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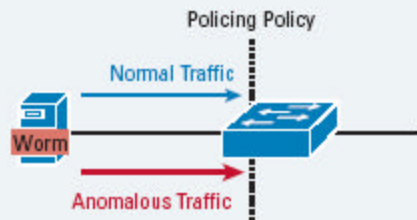
Only traffic in excess of the normal/abnormal threshold is remarked to Scavenger.

Scavenger
DSCP CS1

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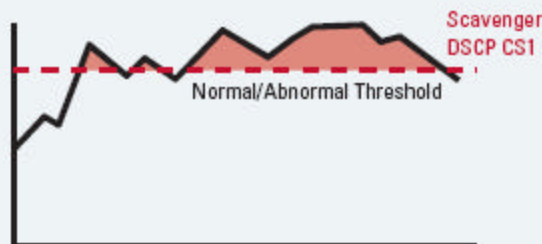
Campus Access-Edge policing policies are coupled with Scavenger-class queuing policies on the uplinks to the Campus Distribution Layer.

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).

Policing Policy

Normal Traffic

Worm

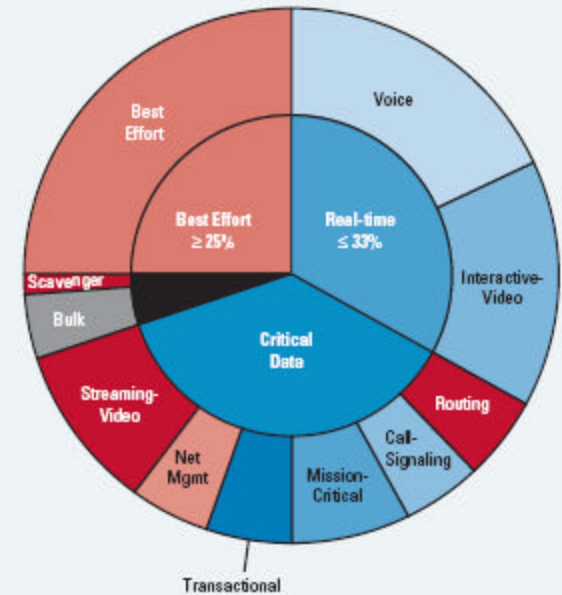Anomalous Traffic

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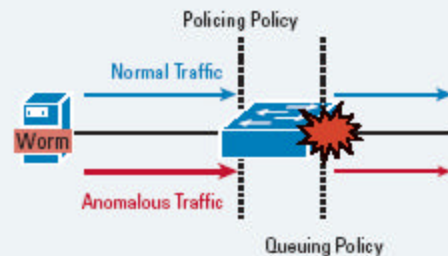
A key point of this strategy is that legitimate traffic flows that temporarily exceed thresholds are not penalized by Scavenger-class QoS.

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 beean 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).

Best Effort

Voice

Best Effort ≥ 25%

Real-time ≤ 33%

Scavenger

Interactive-Video

Bulk

Critical Data

Streaming-Video

Routing

Net Mgmt

Mission-Critical

Call-Signaling

Transactional

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.

CAMPUS QoS DESIGN
AT–A–GLANCE

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

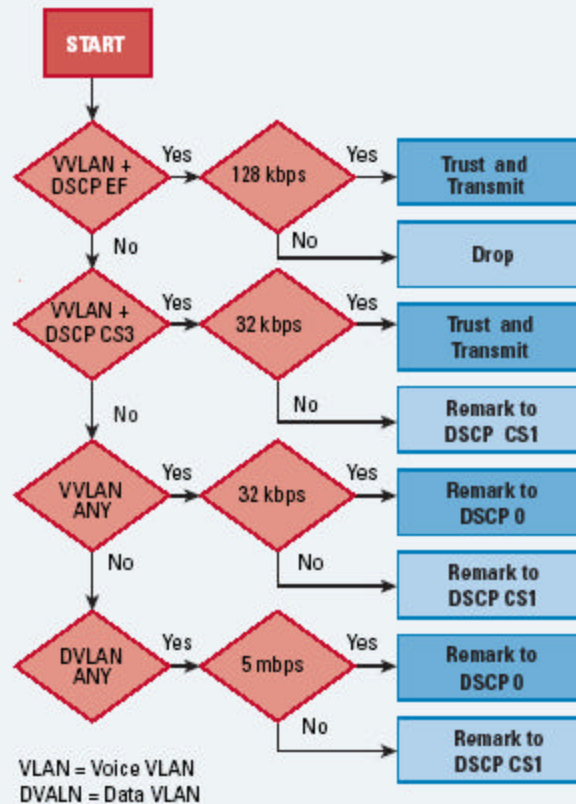Three main types of QoS policies are required within the Campus:

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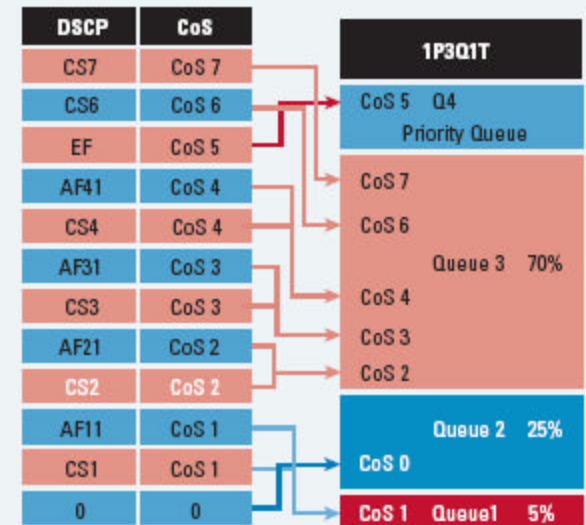
Application	L3 Classification	
	PHB	DSCP
Routing	CS6	48
Voice	EF	46
Interactive-Video	AF41	34
Streaming Video	CS4	32
Mission-Critical	AF31	26
Call-Signaling	CS3	24
Transactional Data	AF21	18
Network Mgmt	CS2	16
Bulk Data	AF11	10
Scavenger	CS1	8
Best Effort	0	0

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

START

VVLAN + DSCP EF — Yes → **128 kbps** — Yes → **Trust and Transmit**
128 kbps — No → **Drop**
VVLAN + DSCP EF — No ↓

VVLAN + DSCP CS3 — Yes → **32 kbps** — Yes → **Trust and Transmit**
32 kbps — No → **Remark to DSCP CS1**
VVLAN + DSCP CS3 — No ↓

VVLAN ANY — Yes → **32 kbps** — Yes → **Remark to DSCP 0**
32 kbps — No → **Remark to DSCP CS1**
VVLAN ANY — No ↓

DVLAN ANY — Yes → **5 mbps** — Yes → **Remark to DSCP 0**
5 mbps — No → **Remark to DSCP CS1**

VLAN = Voice VLAN
DVALN = Data VLAN

Queuing policies will vary by platform:

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

DSCP	CoS
CS7	CoS 7
CS6	CoS 6
EF	CoS 5
AF41	CoS 4
CS4	CoS 4
AF31	CoS 3
CS3	CoS 3
AF21	CoS 2
CS2	CoS 2
AF11	CoS 1
CS1	CoS 1
0	0

1P3Q1T

CoS 5 Q4 Priority Queue

CoS 7
CoS 6
Queue 3 70%
CoS 4
CoS 3
CoS 2

Queue 2 25%
CoS 0

CoS 1 Queue1 5%

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.)

Q and A

REFERENCES

References
DiffServ Standards

- **RFC 2474 "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers"**
  http://www.ietf.org/rfc/rfc2474

- **RFC 2475 "An Architecture for Differentiated Services"**
  http://www.ietf.org/rfc/rfc2475

- **RFC 2597 "Assured Forwarding PHB Group"**
  http://www.ietf.org/rfc/rfc2597

- **RFC 2697 "A Single Rate Three Color Marker"**
  http://www.ietf.org/rfc/rfc2697

- **RFC 2698 "A Two Rate Three Color Marker"**
  http://www.ietf.org/rfc/rfc2698

- **RFC 3246 "An Expedited Forwarding PHB (Per-Hop Behavior)"**
  http://www.ietf.org/rfc/rfc3246

References
Cisco Catalyst QoS Documentation

- **Cisco Catalyst 2950 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/12122ea2/2950scg/swqos.htm

- **Cisco Catalyst 2970 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2970/12225sea/2970scg/swqos.ht

- **Cisco Catalyst 3550 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/c3550/12225seb/scg/swqos.htm

- **Cisco Catalyst 3560 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3560/1225sea/3560scg/swqos.htm

- **Cisco Catalyst 3750 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3750/12225sea/3750scg/swqos.htm

- **Cisco Catalyst 4500 QoS Configuration Documentation**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_25a/conf/qos.htm

- **Cisco Catalyst 6500 QoS Configuration Documentation (CatOS)**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw_8_4/confg_gd/qos.htm

- **Cisco Catalyst 6500 QoS Configuration Documentation (IOS)**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/qos.htm

References
Cisco Catalyst AutoQoS Documentation

- **AutoQoS VoIP for the Cisco Catalyst 2950**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/12122ea2/2950scg/swqos.htm#wp1125412

- **AutoQoS VoIP for the Cisco Catalyst 2970**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2970/12225sea/2970scg/swqos.htm#wp1231112

- **AutoQoS VoIP for the Cisco Catalyst 3550**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/c3550/12225seb/scg/swqos.htm#wp1185065

- **AutoQoS VoIP for the Cisco Catalyst 3560**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3560/1225sea/3560scg/swqos.htm#wp1231112

- **AutoQoS VoIP for the Cisco Catalyst 3750**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat3750/12225sea/3750scg/swqos.htm#wp1231112

- **AutoQoS VoIP for the Cisco Catalyst 4550**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_25a/conf/qos.htm#wp1281380

- **AutoQoS VoIP for the Cisco Catalyst 6500 (Cisco Catalyst OS)**
  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sw_8_4/confg_gd/autoqos.htm

References

Cisco User-Based Rate Limiting and Control Plane Policing Links:

- ### User-Based Rate Limiting (Cat4500)

  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_2_25a/conf/qos.htm#wp1327746

- ### Per-User Microflow Policing (C6500 – IOS)

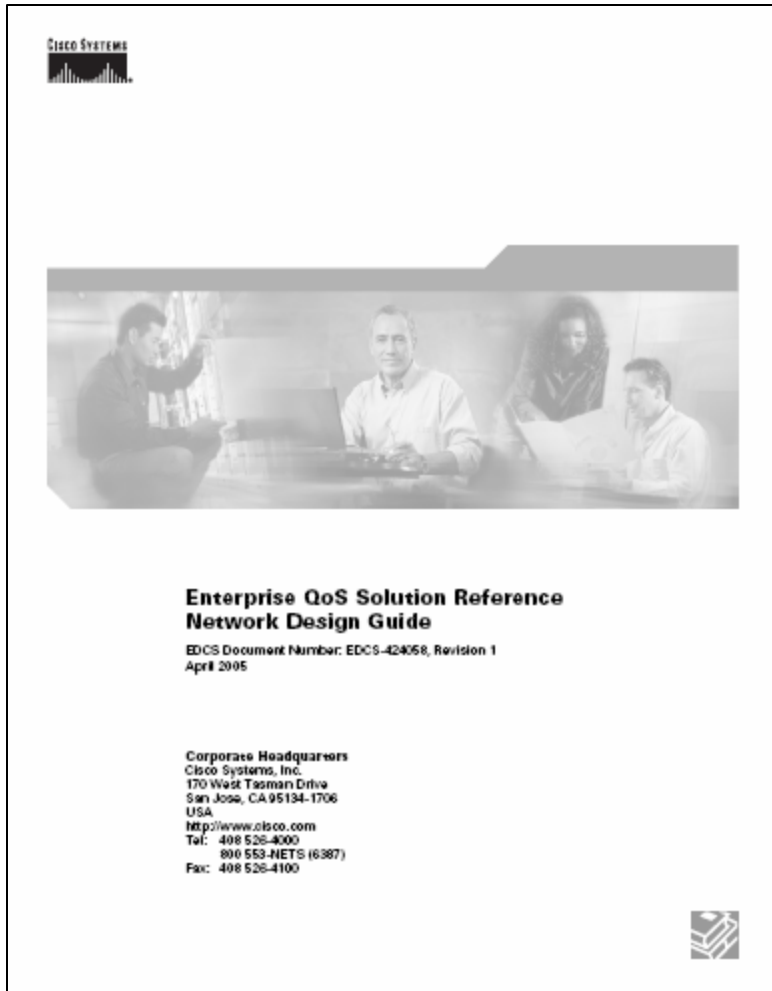 http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/qos.htm#wp1020702

- ### Control Plane Policing (C6500 IOS)

  http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/dos.htm

References

Enterprise QoS Solution Reference Network Design Guide

Enterprise QoS Solution Reference Network Design Guide
EDCS Document Number: EDCS-424058, Revision 1
April 2005

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
    800 553-NETS (6387)
Fax: 408 526-4100

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

QoS Design Overview
Campus QoS Design
WAN QoS Design
Branch QoS Design
MPLS VPN (CE) QoS Design

Recommended Reading

Recommended Reading
Cisco Press Book: End-to-End QoS Design

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

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End-to-End QoS Network Design:
Quality of Service in LANs, WANs, and VPNs

Best-practice QoS designs for protecting voice, video, and critical data while mitigating network denial-of-service attacks

ciscopress.com

Tim Szigeti, CCIE No. 9794
Christina Hattingh
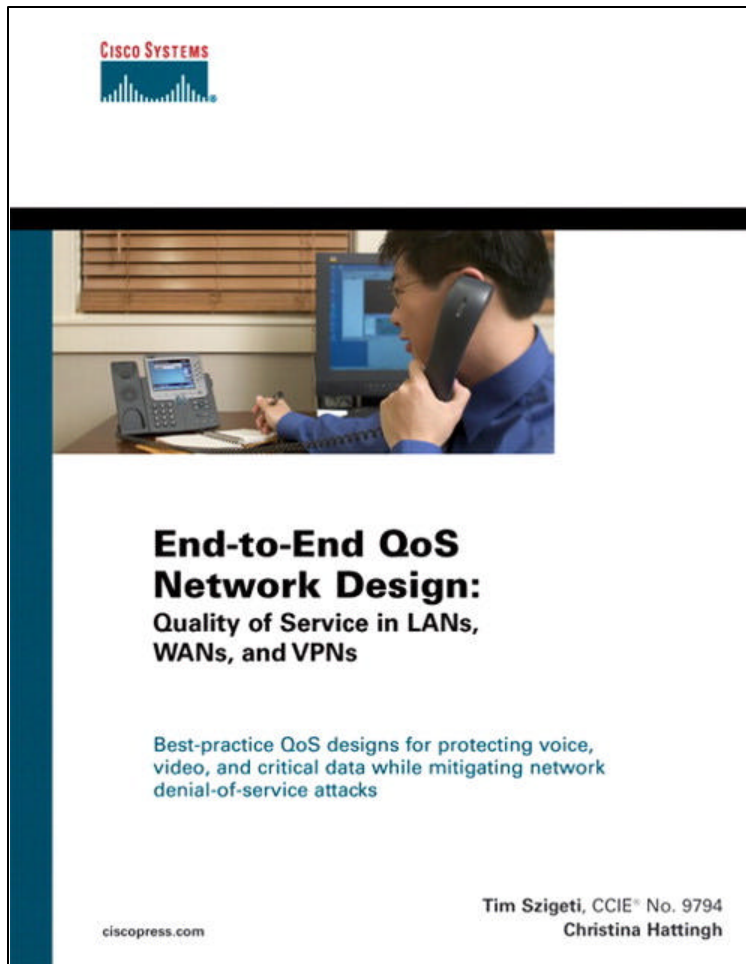
ISBN: 1587051761
Publish Date: Nov 9/04

LAN
- Catalyst 2950
- Catalyst 3550
- Catalyst 2970/3560/3750
- Catalyst 4500
- Catalyst 6500

WAN/Branch
- Leased Lines
- Frame Relay
- ATM
- ATM-to-FR SIW
- ISDN
- NBAR for Worm Policing

VPN
- MPLS (for Enterprise Subscribers)
- MPLS (for Service Providers)
- IPSec (Site-to-Site)
- IPSec (Teleworker)

Recommended Reading
Cisco Press Book: Catalyst QoS Design

http://www.ciscopress.com/title/1587051206

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Cisco Catalyst QoS:
Quality of Service in Campus Networks

End-to-end QoS deployment techniques
for Cisco® Catalyst® series switches

Michael Flannagan, CCIE® No. 7651
Richard Froom, CCIE No. 5102
Kevin Turek, CCIE No. 7284

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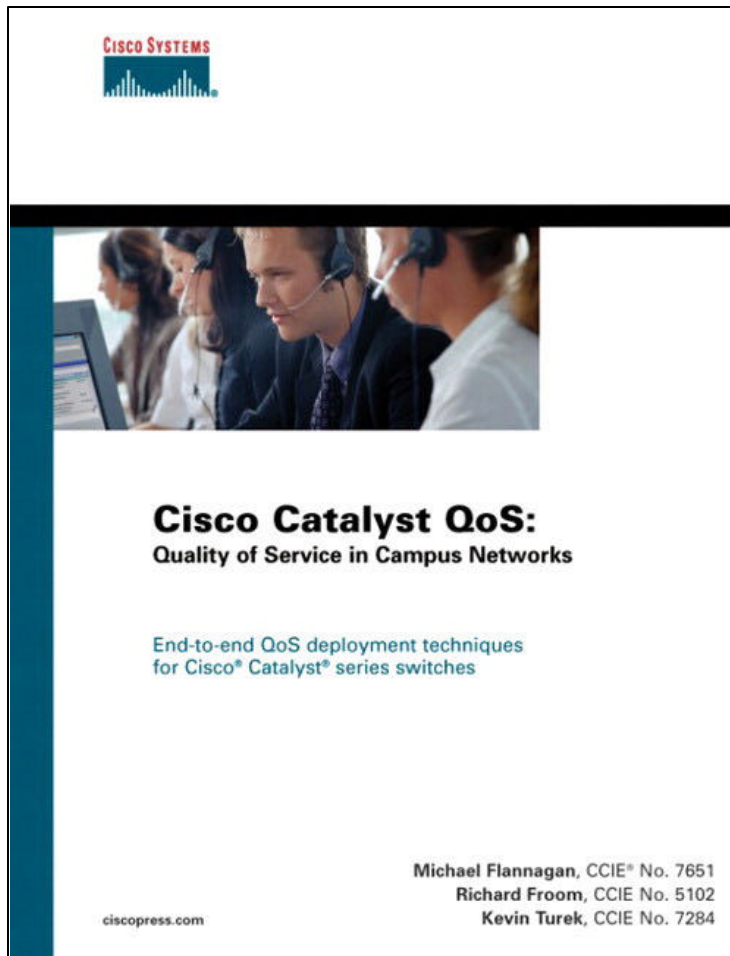
**ISBN: 15870511206
Publish Date: June 2003**

- **Modular QoS CLI**
- **2900XL and 3500XL**
- **4000 Supervisor I and II**
- **2948G and 2980G**
- **5000**
- **2950 and 3550**
- **4500 Supervisor III and IV**
- **2948G-L3 and 4908G-L3**
- **6500 Supervisor I/ IA/ II**
    - **Architecture**
    - **MSFC and FlexWAN QoS**

Complete Your Online Session Evaluation!

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Muchas gracias.

Session ID: RST – 2501

Campus QoS Design

Appendix

Cisco Catalyst 2950 QoS Design
IP Phone + PC + Scavenger (Basic) Model Example

```
CAT2950(config)#mls qos map cos-dscp 0 8 16 24 32 46 48 56        ! Maps CoS 5 to EF
CAT2950(config)#
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)#exit
CAT2950(config)#
CAT2950(config)#policy-map IPPHONE+PC
CAT2950(config-pmap)#  class VVLAN-ANY
CAT2950(config-pmap-c)#    police 1000000 8192 exceed-action drop     ! Excess VoIP dropped
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 remarked
CAT2950(config-pmap-c)#exit
CAT2950(config-pmap)#exit
CAT2950(config)#
CAT2950(config)#
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 CoS from IP Phone
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 3550 QoS Design
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 for the Cat3550
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
```
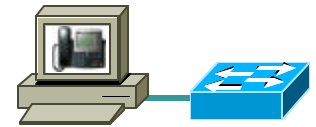
```
CAT3550(config)#mls qos map policed-dscp  0 24 46 to 8
        ! Excess traffic marked 0 or CS3 or EF will be remarked to CS1
CAT3550(config)#
CAT3550(config)#class-map match-all SOFTPHONE-VOICE
CAT3550(config-cmap)#  match access-group name SOFTPHONE-VOICE
CAT3550(config-cmap)#class-map match-all SOFTPHONE-SIGNALING
CAT3550(config-cmap)#  match access-group name SOFTPHONE-SIGNALING
CAT3550(config-cmap)#exit
CAT3550(config)#
CAT3550(config)#policy-map SOFTPHONE-PC
CAT3550(config-pmap)#class SOFTPHONE-VOICE
CAT3550(config-pmap-c)# set ip dscp 46          ! VoIP is marked to DSCP EF
CAT3550(config-pmap-c)# police 128000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile SoftPhone VoIP is marked down to Scavenger (CS1)
CAT3550(config-pmap-c)#class SOFTPHONE-SIGNALING
CAT3550(config-pmap-c)# set ip dscp 24          ! Signaling is marked to DSCP CS3
CAT3550(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile Signaling is marked down to Scavenger (CS1)
CAT3550(config-pmap-c)#class class-default
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-pmap)#exit
CAT3550(config)#
```

Cisco Catalyst 3550 QoS Design
PC + SoftPhone + Scavenger Model Example: Part 2
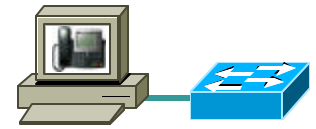
```
CAT3550(config)#interface range FastEthernet0/1 - 48
CAT3550(config-if)# service-policy input SOFTPHONE-PC
CAT3550(config-if)#exit
CAT3550(config)#
CAT3550(config)#ip access-list extended SOFTPHONE-VOICE
CAT3550(config-ext-nacl)# permit udp any any range 16384 32767 ! VoIP ports
CAT3550(config-ext-nacl)#
CAT3550(config-ext-nacl)#ip access-list extended SOFTPHONE-SIGNALING
CAT3550(config-ext-nacl)# permit tcp any any range 2000 2002    ! SCCP ports
CAT3550(config-ext-nacl)#end
CAT3550#
```

```
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)#
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 (new)
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 AF31/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
```

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```
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)#
CAT3550(config)#ip access-list standard ANY                     ! Workaround ACL
CAT3550(config-std-nacl)# permit any
CAT3550(config-std-nacl)#end
CAT3550#
```

Cisco Catalyst 2970/3560/3750 QoS Design
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 for
Cat2970/3560/3750
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
```
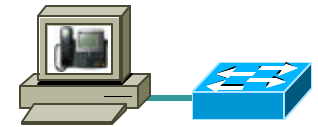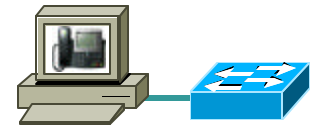
```
CAT2970(config)#mls qos map policed-dscp  0 24 46 to 8
        ! Excess traffic marked 0 or CS3 or EF will be remarked to CS1
CAT2970(config)#
CAT2970(config)#class-map match-all SOFTPHONE-VOICE
CAT2970(config-cmap)#  match access-group name SOFTPHONE-VOICE
CAT2970(config-cmap)#class-map match-all SOFTPHONE-SIGNALING
CAT2970(config-cmap)#  match access-group name SOFTPHONE-SIGNALING
CAT2970(config-cmap)#exit
CAT2970(config)#
CAT2970(config)#policy-map SOFTPHONE-PC
CAT2970(config-pmap)#class SOFTPHONE-VOICE
CAT2970(config-pmap-c)# set ip dscp 46     ! Softphone VoIP is marked DSCP EF
CAT2970(config-pmap-c)# police 128000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile SoftPhone VoIP is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)#class SOFTPHONE-SIGNALING
CAT2970(config-pmap-c)# set ip dscp 24      ! Call-Signaling is marked DSCP CS3
CAT2970(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile SoftPhone Signaling is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)#class class-default
CAT2970(config-pmap-c)# set ip dscp 0
CAT2970(config-pmap-c)# police 5000000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)# exit
CAT2970(config-pmap)#exit
CAT2970(config)#
```

```
CAT2970(config)#interface GigabitEthernet0/1
CAT2970(config-if)# service-policy input SOFTPHONE-PC
CAT2970(config-if)#exit
CAT2970(config)#
CAT2970(config)#ip access-list extended SOFTPHONE-VOICE
CAT2970(config-ext-nacl)# permit udp any any range 16384 32767 ! VoIP ports
CAT2970(config-ext-nacl)#
CAT2970(config-ext-nacl)#ip access-list extended SOFTPHONE-SIGNALING
CAT2970(config-ext-nacl)# permit tcp any any range 2000 2002   ! SCCP ports
CAT2970(config-ext-nacl)#end
CAT2970#
```

IP Phone + PC + Scavenger (Basic) Model Example: Part 1

```
CAT2970(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
CAT2970(config)#mls qos map policed-dscp 0 24 to 8
         ! Excess VVLAN & DVLAN traffic will be remarked to Scavenger (CS1)


CAT2970(config)#
CAT2970(config)#
CAT2970(config)#class-map match-all VVLAN-VOICE
CAT2970(config-cmap)#  match access-group name VVLAN-VOICE
CAT2970(config-cmap)#
CAT2970(config-cmap)#class-map match-all VVLAN-CALL-SIGNALING
CAT2970(config-cmap)#  match access-group name VVLAN-CALL-SIGNALING
CAT2970(config-cmap)#
CAT2970(config-cmap)#class-map match-all VVLAN-ANY
CAT2970(config-cmap)#  match access-group name VVLAN-ANY
CAT2970(config-cmap)#
CAT2970(config-cmap)#
```

```
CAT2970(config-cmap)#policy-map IPPHONE+PC-BASIC
CAT2970(config-pmap)#class VVLAN-VOICE
CAT2970(config-pmap-c)# set ip dscp 46                    ! DSCP EF (Voice)
CAT2970(config-pmap-c)# police 128000 8000 exceed-action drop
        ! Only one voice call is permitted per switchport VVLAN
CAT2970(config-pmap-c)#class VVLAN-CALL-SIGNALING
CAT2970(config-pmap-c)# set ip dscp 24                    ! DSCP CS3 (Call-Signaling)
CAT2970(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile Call-Signaling is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)#class VVLAN-ANY
CAT2970(config-pmap-c)# set ip dscp 0
CAT2970(config-pmap-c)# police 32000 8000 exceed-action policed-dscp-transmit
        ! Unauthorized VVLAN traffic is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)#class class-default
CAT2970(config-pmap-c)# set ip dscp 0
CAT2970(config-pmap-c)# police 5000000 8000 exceed-action policed-dscp-transmit
        ! Out-of-profile data traffic is marked down to Scavenger (CS1)
CAT2970(config-pmap-c)# exit
CAT2970(config-pmap)#exit
CAT2970(config)#
```

Cisco Catalyst 2970/3560/3750
IP Phone + PC + Scavenger (Basic) Model Example: Part 3

```
CAT2970(config)#interface GigabitEthernet0/1
CAT2970(config-if)# switchport access vlan 10                ! DVLAN
CAT2970(config-if)# switchport voice vlan 110               ! VVLAN
CAT2970(config-if)# mls qos trust device cisco-phone        ! Conditional Trust
CAT2970(config-if)# service-policy input IPPHONE+PC-BASIC
CAT2970(config-if)#exit
CAT2970(config)#
CAT2970(config)#
CAT2970(config)#ip access-list extended VVLAN-VOICE
CAT2970(config-ext-nacl)#permit udp 10.1.110.0 0.0.0.255
        any range 16384 32767 dscp ef
        ! Voice is matched by VVLAN subnet and DSCP EF
CAT2970(config-ext-nacl)#exit
CAT2970(config)#
CAT2970(config)#ip access-list extended VVLAN-CALL-SIGNALING
CAT2970(config-ext-nacl)#permit tcp 10.1.110.0 0.0.0.255
        any range 2000 2002 dscp cs3
        ! Call-Signaling is matched by VVLAN subnet and DSCP CS3
CAT2970(config-ext-nacl)#exit
CAT2970(config)#
CAT2970(config)#ip access-list extended VVLAN-ANY
CAT2970(config-ext-nacl)# permit ip 10.1.110.0 0.0.0.255 any
        ! Matches all other traffic sourced from the VVLAN subnet
CAT2970(config-ext-nacl)#end
CAT2970#
```

Cisco Catalyst 4500 QoS Design
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#
```
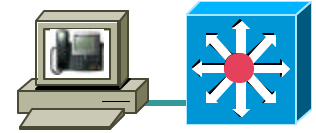
```
CAT4500-SUP4(config)#qos map dscp policed 0 24 46 to dscp 8
        ! Excess traffic marked 0 or CS3 or EF will be remarked to CS1
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#class-map match-all SOFTPHONE-SIGNALING
CAT4500-SUP4(config-cmap)#  match access-group name SOFTPHONE-SIGNALING
CAT4500-SUP4(config-cmap)#class-map match-all SOFTPHONE-VOICE
CAT4500-SUP4(config-cmap)#  match access-group name SOFTPHONE-VOICE
CAT4500-SUP4(config-cmap)#exit
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#policy-map SOFTPHONE-PC
CAT4500-SUP4(config-pmap)# class SOFTPHONE-VOICE
CAT4500-SUP4(config-pmap-c)# set ip dscp ef               ! VoIP is marked to DSCP EF
CAT4500-SUP4(config-pmap-c)# police 128 kbps 8000 byte exceed-action
        policed-dscp-transmit
        ! Out-of-profile SoftPhone VoIP is marked down to Scavenger (CS1)
CAT4500-SUP4(config-pmap-c)#class SOFTPHONE-SIGNALING
CAT4500-SUP4(config-pmap-c)# set ip dscp cs3             ! Signaling is marked DSCP CS3
        ! SoftPhone Call-Signaling is marked to DSCP CS3
CAT4500-SUP4(config-pmap-c)# police 32 kbps 8000 byte exceed-action
        policed-dscp-transmit
        ! Out-of-profile Signaling traffic is marked down to Scavenger (CS1)
CAT4500-SUP4(config-pmap-c)#class class-default
CAT4500-SUP4(config-pmap-c)# set ip dscp default
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
```

Cisco Catalyst 4500 QoS Design
PC + SoftPhone + Scavenger Model Example: Part 2
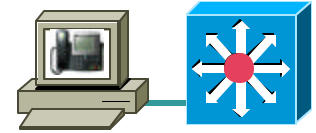
```
CAT4500-SUP4(config)#interface FastEthernet2/1
CAT4500-SUP4(config-if)# service-policy input SOFTPHONE-PC
CAT4500-SUP4(config-if)#exit
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#ip access-list extended SOFTPHONE-VOICE
CAT4500-SUP4(config-ext-nacl)# permit udp any any range 16384 32767    ! VoIP
CAT4500-SUP4(config-ext-nacl)#
CAT4500-SUP4(config-ext-nacl)#ip access-list extended SOFTPHONE-SIGNALING
CAT4500-SUP4(config-ext-nacl)# permit tcp any any range 2000 2002      ! SCCP
CAT4500-SUP4(config-ext-nacl)#end
CAT4500-SUP4#
```

```
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)#
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#class-map match-all VVLAN-VOICE
CAT4500-SUP4(config-cmap)#  match access-group name VVLAN-VOICE
CAT4500-SUP4(config-cmap)#
CAT4500-SUP4(config-cmap)#class-map match-all VVLAN-CALL-SIGNALING
CAT4500-SUP4(config-cmap)#  match access-group name VVLAN-CALL-SIGNALING
CAT4500-SUP4(config-cmap)#
CAT4500-SUP4(config-cmap)#class-map match-all VVLAN-ANY
CAT4500-SUP4(config-cmap)#  match access-group name VVLAN-ANY
CAT4500-SUP4(config-cmap)#
```

```
CAT4500-SUP4(config-cmap)#policy-map IPPHONE+PC-BASIC
CAT4500-SUP4(config-pmap)#class VVLAN-VOICE
CAT4500-SUP4(config-pmap-c)# set ip dscp 46              ! DSCP EF (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)# set ip dscp 24              ! DSCP CS3 (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 VVLAN-ANY
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)
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 access vlan 10              ! DVLAN
CAT4500-SUP4(config-if)# switchport voice vlan 110              ! VVLAN
CAT4500-SUP4(config-if)# qos trust device cisco-phone           ! Conditional Trust
CAT4500-SUP4(config-if)# service-policy input IPPHONE+PC-BASIC
CAT4500-SUP4(config-if)#exit
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#ip access-list extended VVLAN-VOICE
CAT4500-SUP4(config-ext-nacl)# permit udp 10.1.110.0 0.0.0.255 any
        range 16384 32767
        ! Voice is matched by VVLAN subnet and UDP port-range
CAT4500-SUP4(config-ext-nacl)#exit
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#ip access-list extended VVLAN-CALL-SIGNALING
CAT4500-SUP4(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
CAT4500-SUP4(config-ext-nacl)#exit
CAT4500-SUP4(config)#
CAT4500-SUP4(config)#ip access-list extended VVLAN-ANY
CAT4500-SUP4(config-ext-nacl)# permit ip 10.1.110.0 0.0.0.255 any
        ! Matches all other traffic sourced from the VVLAN subnet
CAT4500-SUP4(config-ext-nacl)#end
CAT4500-SUP4#
```

Cisco Catalyst 6500 QoS Design
Globally Enabling QoS in Cisco Catalyst OS and Cisco IOS

```
CAT6500-PFC2-CATOS> (enable) set qos enable
QoS is enabled.
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) show qos status
QoS is enabled on this switch.
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-IOS(config)# mls qos
CAT6500-PFC2-IOS(config)#end
CAT6500-PFC2-IOS#
CAT6500-PFC2-IOS# show mls qos
  QoS is enabled globally
  Microflow policing is enabled globally
  Vlan or Portchannel(Multi-Earl) policies supported: Yes
  ----- Module [2] -----
  QoS global counters:
    Total packets: 65
    IP shortcut packets: 0
    Packets dropped by policing: 0
    IP packets with TOS changed by policing: 0
    IP packets with COS changed by policing: 0
    Non-IP packets with COS changed by policing: 0
CAT6500-PFC2-IOS#
```

Cisco Catalyst 6500 QoS Design
Trusted Endpoint Examples (Cisco Catalyst OS and Cisco IOS)

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**

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

Cisco Catalyst 6500 QoS Design
PC + SoftPhone + Scavenger Model – CatOS Example
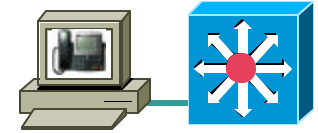
```
CAT6500-PFC2-CATOS> (enable) set qos policed-dscp-map 0,24,46:8
          ! Excess traffic marked DSCP 0 or CS3 or EF will be remarked to CS1
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate SOFTPHONE-VOICE
          rate 128 burst 8000 policed-dscp
          ! Defines the policer for SoftPhone VoIP traffic
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate SOFTPHONE-SIGNALING
          rate 32 burst 8000 policed-dscp
          ! Defines the policer for SoftPhone Call-Signaling traffic
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate PC-DATA
          rate 5000 burst 8000 policed-dscp
          ! Defines the policer for PC Data traffic
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) set qos acl ip SOFTPHONE-PC dscp 46
          aggregate SOFTPHONE-VOICE udp any any range 16384 32767
          ! Binds ACL to policer and marks in-profile SoftPhone VoIP to DSCP EF
CAT6500-PFC2-CATOS> (enable) set qos acl ip SOFTPHONE-PC dscp 24
          aggregate SOFTPHONE-SIGNALING tcp any any range 2000 2002
          ! Binds ACL to policer marks in-profile Call-Signaling to DSCP CS3
CAT6500-PFC2-CATOS> (enable) set qos acl ip SOFTPHONE-PC dscp 0
          aggregate PC-DATA any
          ! Binds ACL to policer and marks in-profile PC Data traffic to DSCP 0
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) commit qos acl SOFTPHONE-PC
          ! Commits ACL to PFC memory
CAT6500-PFC2-CATOS> (enable) set port qos 3/1 trust untrusted
          ! Sets the port trust state to untrusted
CAT6500-PFC2-CATOS> (enable) set qos acl map SOFTPHONE-PC 3/1
          ! Attaches ACL to switch port
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
IP Phone + PC + Scavenger (Basic) Model - CatOS Ex: Part 1

```
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
        rate 128 burst 8000 drop
        ! Defines the policer for IP Phone VoIP traffic
CAT6500-PFC2-CATOS> (enable) set qos policer aggregate VVLAN-SIGNALING
        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
        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
        rate 5000 burst 8000 policed-dscp
        ! Defines the policer for PC Data traffic
CAT6500-PFC2-CATOS> (enable)
```

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```
CAT6500-PFC2-CATOS> (enable) set qos acl ip IPPHONE-PC-BASIC dscp 46
        aggregate VVLAN-VOICE 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 dscp 24
        aggregate VVLAN-SIGNALING 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 dscp 0
        aggregate VVLAN-ANY 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 dscp 0
        aggregate PC-DATA any
        ! Binds ACL to policer and marks in-profile PC Data traffic to DSCP 0
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) commit qos acl IPPHONE-PC-BASIC
        ! Commits ACL to PFC memory
CAT6500-PFC2-CATOS> (enable)
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
        ! Attaches ACL to switch port
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P2Q2T)

Application	DSCP	CoS	1P2Q2T
Network Control	-	CoS 7	
Internetwork Control	CS6	CoS 6	CoS 5 Q3 (30%) Priority Queue
Voice	EF	CoS 5	
Interactive Video	AF41	CoS 4	CoS 7 Q2T2
Streaming Video	CS4	CoS 4	CoS 6
Mission-Critical Data	AF31	CoS 3	CoS 4 Queue 2 Q2T1
Call Signaling	CS3	CoS 3	CoS 3 (30%)
Transactional Data	AF21	CoS 2	CoS 2
Network Management	CS2	CoS 2	
Bulk Data	AF11	CoS 1	CoS 0 Q1T2
Scavenger	CS1	CoS 1	Queue 1 (40%)
Best Effort	0	0	CoS 1 Q1T1

Cisco Catalyst 6500 QoS Design
Queuing Design (1P2Q2T Cisco Catalyst OS)

```
CAT6500-PFC2-CATOS> (enable) set qos txq-ratio 1p2q2t 40 30 30
        ! Allocates buffers: 40% for Q1, 30% for Q2, 30% for Q3 (PQ)
CAT6500-PFC2-CATOS> (enable) set qos wrr 1p2q2t 30 70
        ! Sets the WRR weights for 30:70 (Q1:Q2) bandwidth servicing
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos wred 1p2q2t tx queue 1 40:80 80:100
        ! Sets Q1 WRED T1 to 40:80 to limit Scavenger/Bulk within Q1
        ! Sets Q1 WRED T2 to 80:100 for congestion-avoidance for Best Effort
CAT6500-PFC2-CATOS> (enable) set qos wred 1p2q2t tx queue 2 70:80 80:100
        ! Sets Q2 WRED T1 to 70:80 to provide congestion-avoidance
        ! Sets Q2 WRED T2 to 80:100 to force room for Network Control traffic
CAT6500-PFC2-CATOS> (enable)


CAT6500-PFC2-CATOS> (enable) set qos map 1p2q2t tx 1 1 cos 1
        ! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q2t tx 1 2 cos 0
        ! Maps Best Effort to Q1 WRED Threshold 2
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q2t tx 2 1 cos 2,3,4
        ! Maps CoS 2,3,4 to Q2 WRED Threshold 1
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q2t tx 2 2 cos 6,7
        ! Maps Network/Internetwork Control to Q2 WRED Threshold 2
CAT6500-PFC2-CATOS> (enable) set qos map 1p2q2t tx 3 1 cos 5
        ! Maps VoIP to PQ
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P2Q2T: Cisco IOS): Part 1

```
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 QoS Design
Queuing Design (1P2Q2T: Cisco IOS): Part 2

```
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 QoS Design

Queuing Design (1P3Q1T: Cisco Catalyst OS Supports 1P3Q2T)
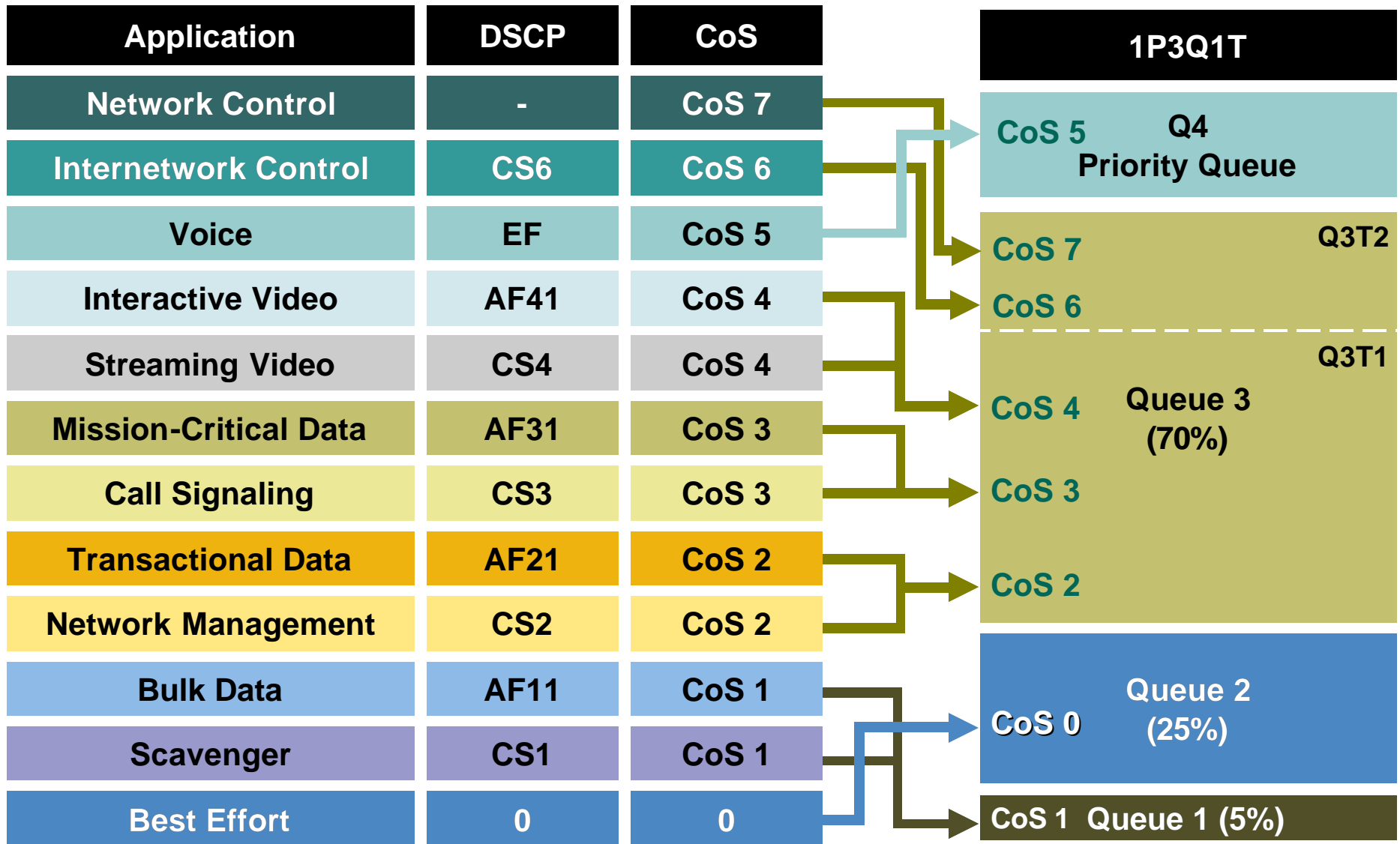
Application	DSCP	CoS	1P3Q1T
Network Control	-	CoS 7	**CoS 5** Q4 Priority Queue
Internetwork Control	CS6	CoS 6	
Voice	EF	CoS 5	CoS 7 Q3T2
Interactive Video	AF41	CoS 4	CoS 6
Streaming Video	CS4	CoS 4	Q3T1
Mission-Critical Data	AF31	CoS 3	CoS 4 Queue 3 (70%)
Call Signaling	CS3	CoS 3	CoS 3
Transactional Data	AF21	CoS 2	CoS 2
Network Management	CS2	CoS 2	
Bulk Data	AF11	CoS 1	CoS 0 Queue 2 (25%)
Scavenger	CS1	CoS 1	
Best Effort	0	0	CoS 1 Queue 1 (5%)

Cisco Catalyst 6500 QoS Design
Queuing Design (1P3Q1T: Cisco Catalyst OS)

```
CAT6500-PFC2-CATOS> (enable) set qos wrr 1p3q1t 5 25 70
        ! Sets the WRR weights for 5:25:70 (Q1:Q2:Q3) bandwidth servicing
CAT6500-PFC2-CATOS> (enable)
CAT6500-PFC2-CATOS> (enable) set qos wred 1p3q1t tx queue 1 80:100
        ! Sets Q1 WRED T1 to 80:100 for Scavenger/Bulk queue
CAT6500-PFC2-CATOS> (enable) set qos wred 1p3q1t tx queue 2 80:100
        ! Sets Q2 WRED T1 to 80:100 for Best Effort queue
CAT6500-PFC2-CATOS> (enable) set qos wred 1p3q1t tx queue 3 70:80
        ! Sets Q3 WRED T1 to 70:80 for congestion-avoidance for CoS 2,3,4
        ! and to force room (via tail-drop) for Network Control traffic
CAT6500-PFC2-CATOS> (enable)



CAT6500-PFC2-CATOS> (enable) set qos map 1p3q1t tx 1 1 cos 1
        ! Maps Scavenger/Bulk to Q1 WRED Threshold 1 (80:100)
CAT6500-PFC2-CATOS> (enable) set qos map 1p3q1t tx 2 1 cos 0
        ! Maps Best Effort to Q2 WRED Threshold 1 (80:100)
CAT6500-PFC2-CATOS> (enable) set qos map 1p3q1t tx 3 1 cos 2,3,4
        ! Maps CoS 2,3,4 to Q3 WRED Threshold 1 (70:80)
CAT6500-PFC2-CATOS> (enable) set qos map 1p3q1t tx 3 cos 6,7
        ! Maps Network/Internetwork Control to Q3 Tail (100%)
CAT6500-PFC2-CATOS> (enable) set qos map 1p3q1t tx 4 cos 5
        ! Maps VoIP to PQ (Q4)
CAT6500-PFC2-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P3Q1T: Cisco IOS): Part 1

```
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 QoS Design
Queuing Design (1P3Q1T: Cisco IOS): Part 2

```
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 QoS Design
Queuing Design (1P3Q8T)

Application	DSCP	CoS		1P3Q8T
Network Control	-	CoS 7		CoS 5 Q4 Priority Queue
Internetwork Control	CS6	CoS 6		
Voice	EF	CoS 5		CoS 7 Q3T5
Interactive Video	AF41	CoS 4		CoS 6 Q3T4
Streaming Video	CS4	CoS 4		CoS 3 Q3T3
Mission-Critical Data	AF31	CoS 3		CoS 2 Q3T2
Call Signaling	CS3	CoS 3		Queue 3 (70%) Q3T1
Transactional Data	AF21	CoS 2		CoS 4
Network Management	CS2	CoS 2		
Bulk Data	AF11	CoS 1		Queue 2 (25%) Q2T1
Scavenger	CS1	CoS 1		CoS 0
Best Effort	0	0		CoS 1 Queue 1 (5%) Q1T1

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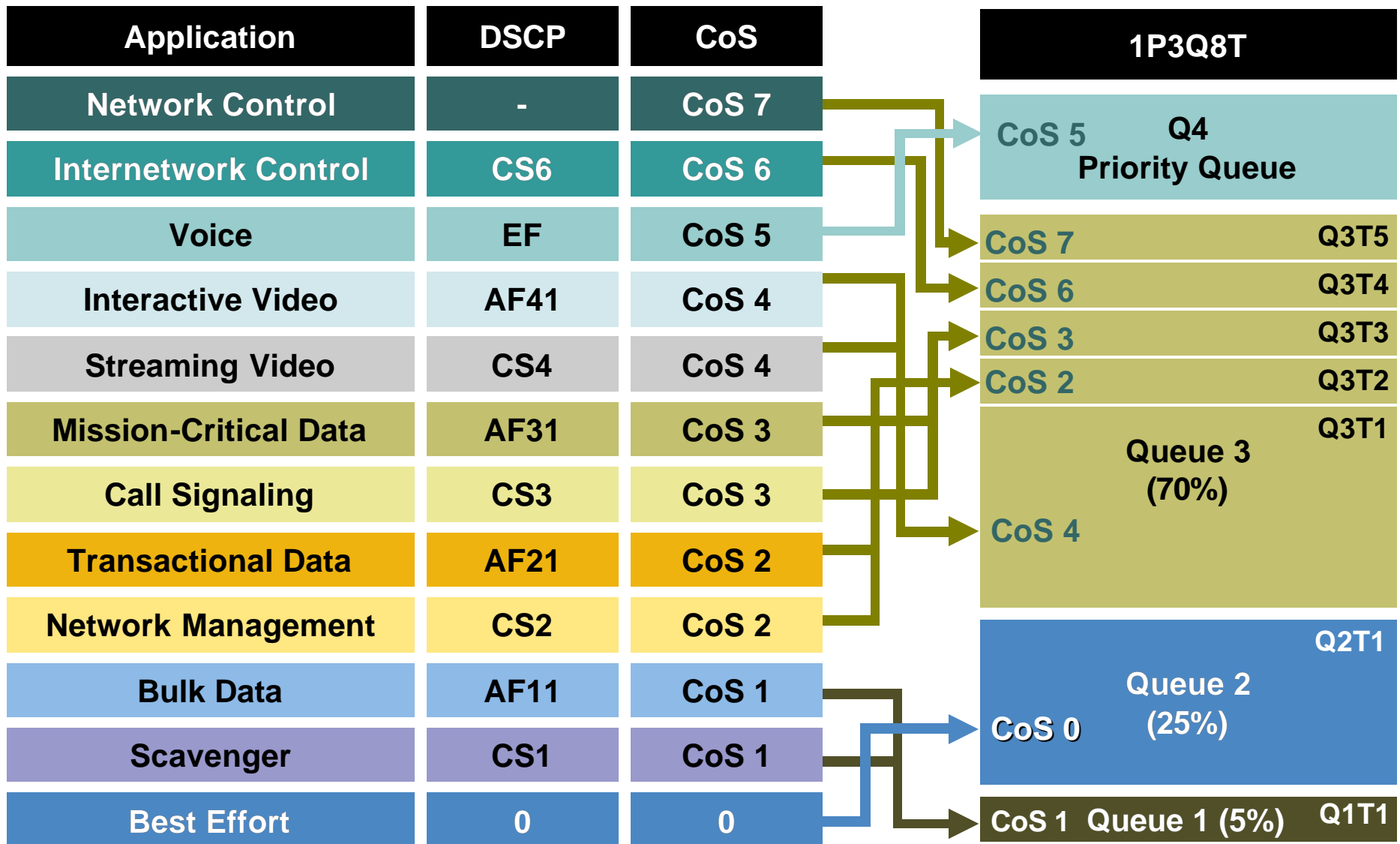
Cisco Catalyst 6500 QoS Design
Queuing Design (1P3Q8T: Cisco Catalyst OS): Part 1

```
CAT6500-PFC3-CATOS> (enable) set qos txq-ratio 1p3q8t 5 25 40 30
        ! Allocates 5% for Q1, 25% for Q2, 40% for Q3 and 30% for Q4 (PQ)
CAT6500-PFC3-CATOS> (enable) set qos wrr 1p3q8t 5 25 70
        ! Sets the WRR weights for 5:25:70 (Q1:Q2:Q3) bandwidth servicing



CAT6500-PFC3-CATOS> (enable) set qos wred 1p3q8t tx queue 1 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q1 WRED T1 to 80:100 and all other Q1 WRED Thresholds to 100:100



CAT6500-PFC3-CATOS> (enable) set qos wred 1p3q8t tx queue 2 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q2 WRED T1 to 80:100 and all other Q2 WRED Thresholds to 100:100



CAT6500-PFC3-CATOS> (enable) set qos wred 1p3q8t tx queue 3 50:60 60:70 70:80
        80:90 90:100 100:100 100:100 100:100
        ! Sets Q3 WRED T1 to 50:60, Q3T2 to 60:70, Q3T3 to 70:80,
        ! Q3T4 to 80:90, Q3T5 to 90:100
        ! and the other two Q3 WRED Thresholds to 100:100
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P3Q8T: Cisco Catalyst OS): Part 2

```
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 1 1 cos 1
        ! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 2 1 cos 0
        ! Maps Best Effort to Q2 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 3 1 cos 4
        ! Maps Video to Q3 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 3 2 cos 2
        ! Maps Net-Mgmt and Transactional Data to Q3 WRED T2
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 3 3 cos 3
        ! Maps Call-Signaling and Mission-Critical Data to Q3 WRED T3
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 3 4 cos 6
        ! Maps Internetwork-Control (IP Routing) to Q3 WRED T4
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 3 5 cos 7
        ! Maps Network-Control (Spanning Tree) to Q3 WRED T5
CAT6500-PFC3-CATOS> (enable) set qos map 1p3q8t tx 4 cos 5
        ! Maps VoIP to the PQ (Q4)
CAT6500-PFC3-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P3Q8T: Cisco IOS): Part 1

```
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 QoS Design
Queuing Design (1P3Q8T: Cisco IOS): Part 2

```
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 QoS Design
Queuing Design (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		
Streaming Video	CS4	CoS 4	CoS 3	Q5 (20%) · Q5T1
Mission-Critical Data	AF31	CoS 3		
Call Signaling	CS3	CoS 3	CoS 2	Q4 (20%) · Q4T1
Transactional Data	AF21	CoS 2	CoS 4	Q3 (20%) · Q3T1
Network Management	CS2	CoS 2		
Bulk Data	AF11	CoS 1	CoS 0	Q2 (25%) · Q2T1
Scavenger	CS1	CoS 1		
Best Effort	0	0	CoS 1	Q1 (5%) · Q1T1

Cisco Catalyst 6500 QoS Design
Queuing Design (1P7Q8T: Cisco Catalyst OS): Part 1

```
CAT6500-PFC3-CATOS> (enable) set qos txq-ratio 1p7q8t 5 25 10 10 10 5 5 30
        ! Allocates 5% to Q1, 25% to Q2, 10% to Q3, 10% to Q4,
        ! Allocates 10% to Q5, 5% to Q6, 5% to Q7 and 30% to the PQ (Q8)
CAT6500-PFC3-CATOS> (enable) set qos wrr 1p7q8t 5 25 20 20 20 5 5
        ! Sets the WRR weights for 5:25:20:20:20:5:5 (Q1 through Q7)

CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 1 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q1 WRED T1 to 80:100 and all other Q1 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 2 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q2 WRED T1 to 80:100 and all other Q2 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 3 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q3 WRED T1 to 80:100 and all other Q3 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 4 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q4 WRED T1 to 80:100 and all other Q4 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 5 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q5 WRED T1 to 80:100 and all other Q5 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 6 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q6 WRED T1 to 80:100 and all other Q6 WRED Thresholds to 100:100
CAT6500-PFC3-CATOS> (enable) set qos wred 1p7q8t tx queue 7 80:100 100:100
        100:100 100:100 100:100 100:100 100:100 100:100
        ! Sets Q7 WRED T1 to 80:100 and all other Q7 WRED Thresholds to 100:100
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P7Q8T: Cisco Catalyst OS): Part 2

```
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 1 1 cos 1
        ! Maps Scavenger/Bulk to Q1 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 2 1 cos 0
        ! Maps Best Effort to Q2 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 3 1 cos 4
        ! Maps Video to Q3 WRED Threshold 1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 4 1 cos 2
        ! Maps Net-Mgmt and Transactional Data to Q4 WRED T1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 5 1 cos 3
        ! Maps Call-Signaling and Mission-Critical Data to Q5 WRED T1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 6 1 cos 6
        ! Maps Internetwork-Control (IP Routing) to Q6 WRED T1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 7 1 cos 7
        ! Maps Network-Control (Spanning Tree) to Q7 WRED T1
CAT6500-PFC3-CATOS> (enable) set qos map 1p7q8t tx 8 cos 5
        ! Maps VoIP to the PQ (Q4)
CAT6500-PFC3-CATOS> (enable)
```

Cisco Catalyst 6500 QoS Design
Queuing Design (1P7Q8T: Cisco IOS): Part 1

```
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 QoS Design
Queuing Design (1P7Q8T: Cisco IOS): Part 2

```
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 QoS Design
Queuing Design (1P7Q8T: Cisco IOS): Part 3

```
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 QoS Design
Queuing Design (1P7Q8T: Cisco IOS): Part 4

```
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#
```