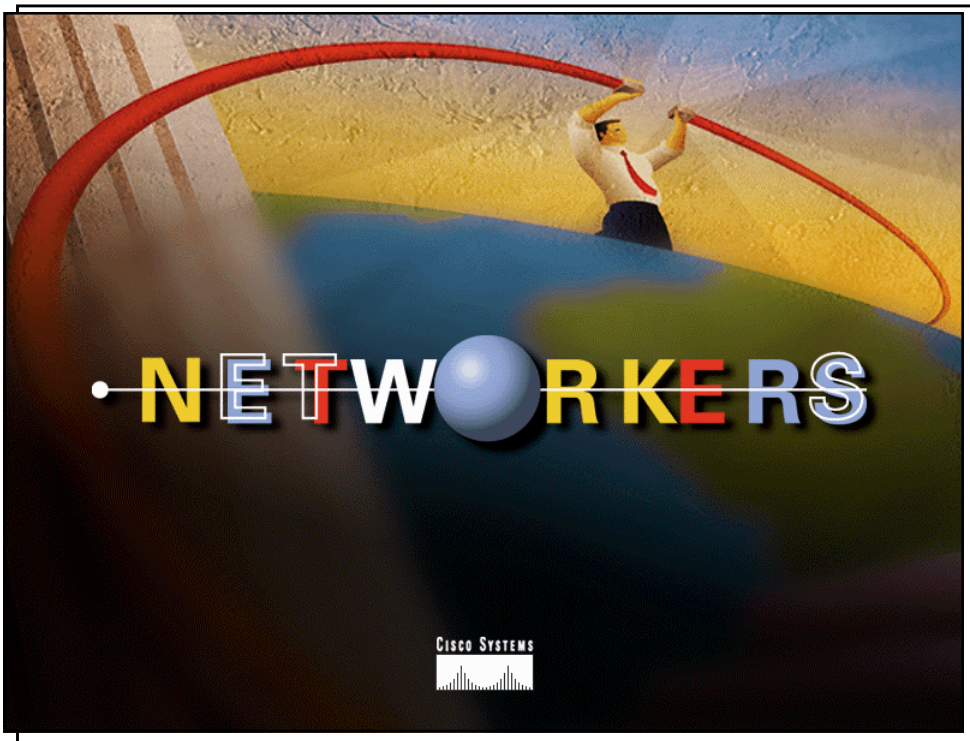

Agenda

- **Why Invest in QoS?**
- Architectural Approaches
- Application Requirements
- Deployment Scenarios
  - Access
  - Distribution
  - Core

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Why Invest in QoS?

"To accelerate the deployment of network services, by enabling predictable response for application traffic and service requirements"

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Multiservice IP Applications

VoIP ERP Multimedia VPN Web/URL

Low Latency
Low Bandwidth

Latency Tolerant
Bursty Bandwidth

Non-Uniform Network Traffic Demands QoS

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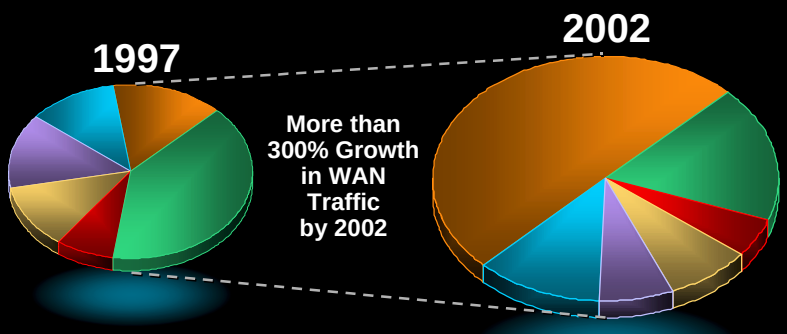
Networked Application Growth



- Voice
- Video Teleconference
- Office Applications
- Client to Server
- Server to Server
- Internet/Intranet

Source: Gartner Group

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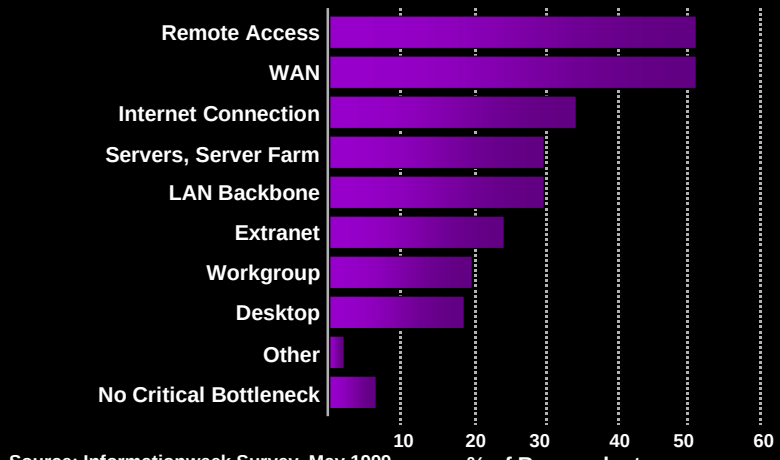
Network Choke Points

Where Are Your Company's Most Critical Network-Bandwidth Bottlenecks?



Source: Informationweek Survey, May 1999

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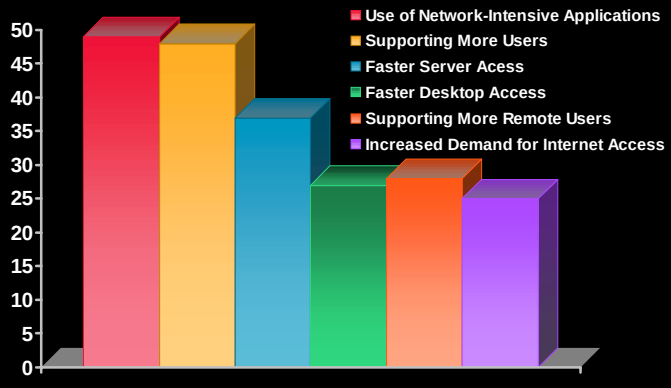
Bandwidth-Hungry Applications

What Issues Are Causing Network Bottlenecks?



- Networked PC growth
  - 46% of business PCs networked in 1997
  - 91% of business PCs networked by 2002

Source: IDC 1998

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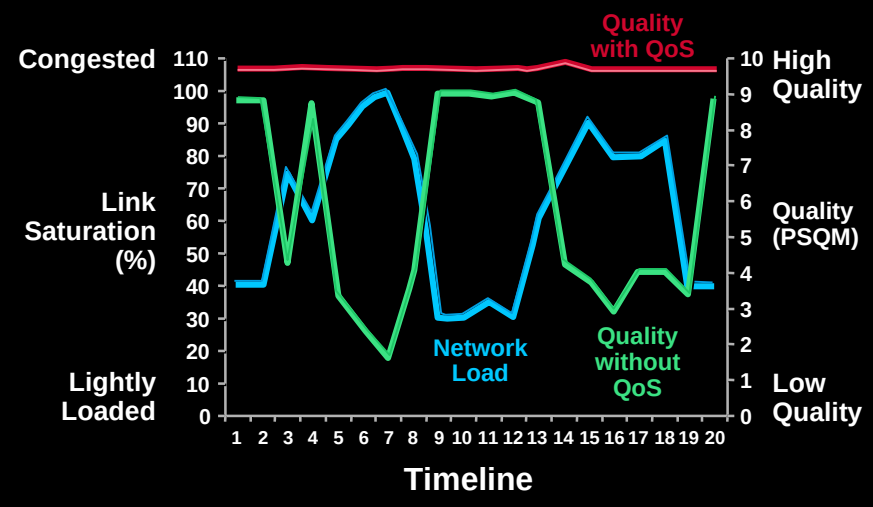
VoIP Traffic—QoS Enabled



Source: Cisco Labs

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Agenda

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Implementation Options

- Integrated services
- Differentiated services
- MPLS/constraint-based routing
- Policy networking

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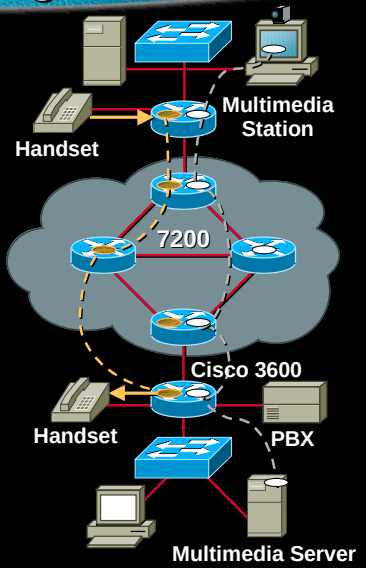
Integrated Services/RSVP: Signaling

- Integrated services model builds upon RSVP
- Signaled request for network resources along path, eg., call admission
- Applications:
  - VoIP
  - Multimedia
  - RRR tunnel establishment
- Platforms supported
  - Cisco 2600/3600
  - Cisco 4X00/5X00
  - Cisco 7200



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RSVP Status

- RSVP supported since ’95
- VoIP creates strong RSVP requirement
- RSVP offers:
  - Explicit resource admission control (end to end)
  - Per-request policy admission control (auth obj, policy obj)
  - Signalling of dynamic port numbers

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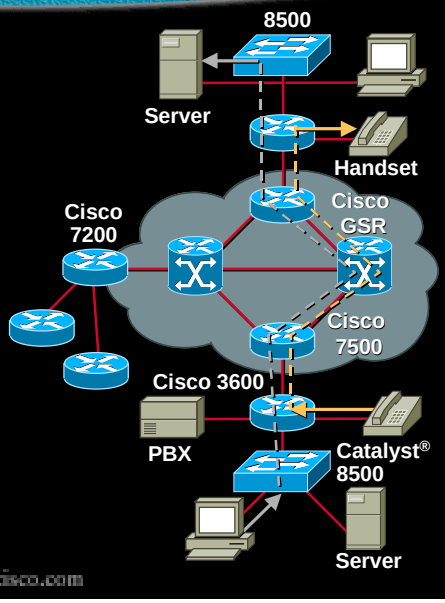
Differentiated Services/IP Precedence: Packet

- IP precedence marks packets into six classes (2 reserved)
- IP precedence (weight) for QoS policy, e.g., WFQ, WRED
- Diff Serv (RFC 2475) framework extends class model, 64 classes (DSCP)
- Applications:
  - Gold/Silver/Bronze
  - VoIP
  - VPNs
  - Tag/MPLS extensions



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Cisco's Diff-Serv Implementation

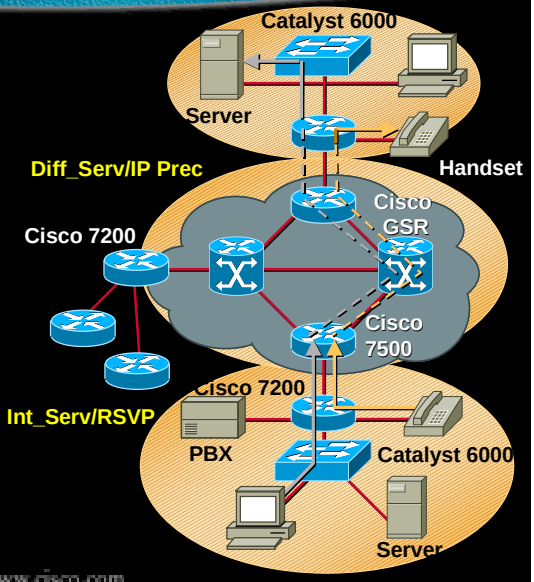
- Pre-Diff-Serv implementation
  - IP precedence
- Compliant with:
  - Diff Serv architecture (RFC 2475)
  - Default forwarding, class selectors, assured forwarding, expedited forwarding
- Not compliant with
  - DS-byte encoding (RFC 2474), uses precedence

Leveraging Diff-Serv PHB and Traffic Conditioning Today

- CAR—set IP precedence (mark, police)
- Class-based WFQ (schedule)
- Cisco's programmable WRED (drop)
- Currently defined Diff-Serv PHBs (Default, EF, AF) supported via combination of CAR, CBWFQ and WRED

One Architectural Direction: Hybrid Int_Serv/Diff_Serv

- Application RSVP/RSVP+ signaled request at edge of network
- Call admission control at the edge
- Mapping RSVP/RSVP+ to IP precedence/ Diff_Serv classes
- Benefits:
  - Scalable network services
  - ISP WAN support
  - Microsoft Win2000
  - Policy aware



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Cisco MPLS Traffic Engineering

- Constraint-based routing for path selection (RRR)
- MPLS tunnel setup via RSVP
- Benefits of IP and L2 ‘consolidation’
- Control of traffic engineering
  - Balance load optimally over existing resources
- Underlying mechanism to achieve IP QoS more efficiently

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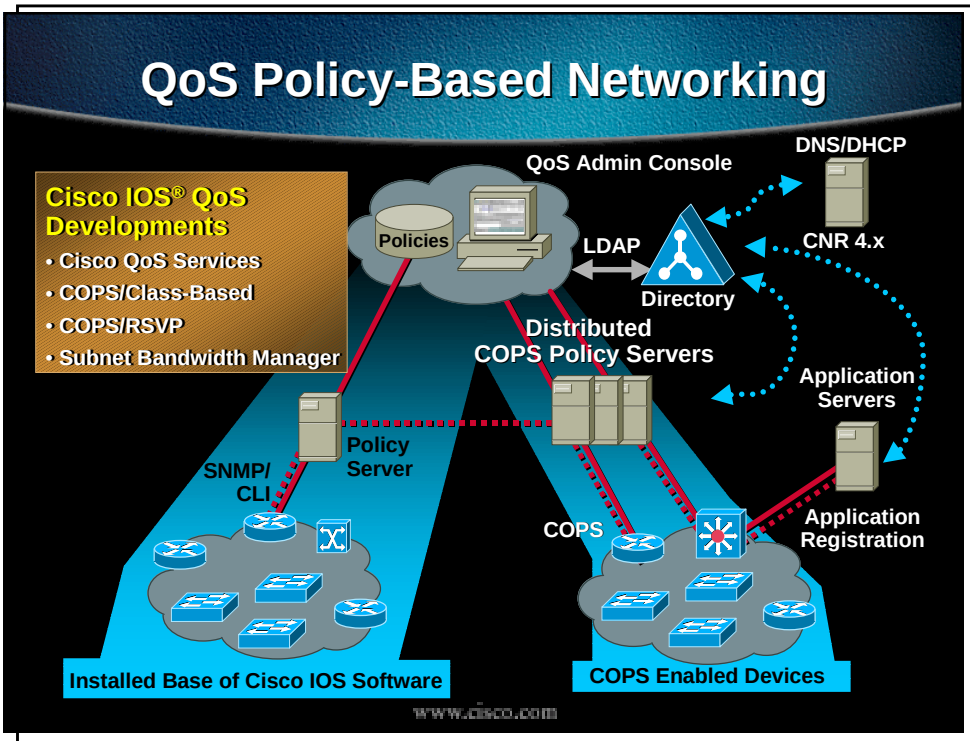
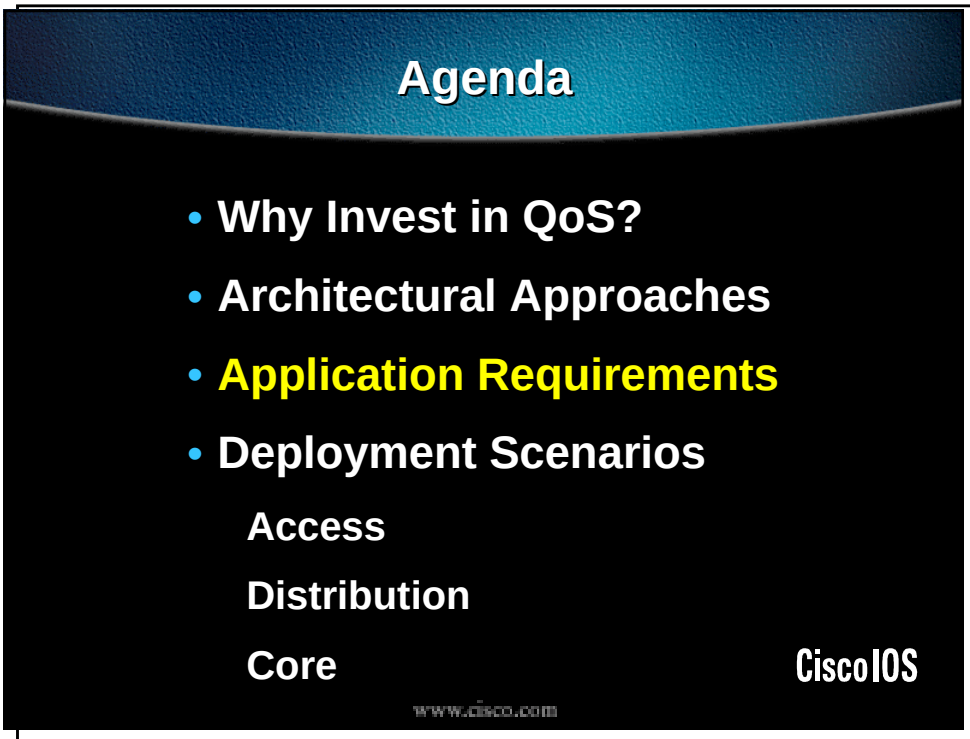
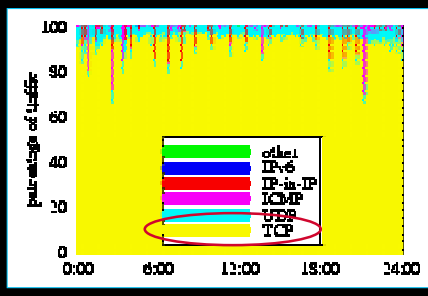


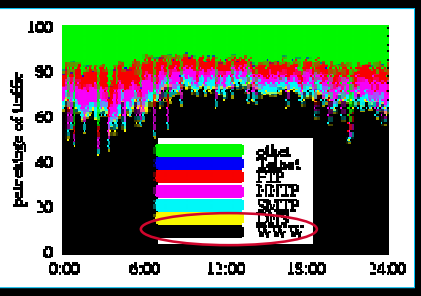


Backbone Traffic Mix

Transport Breakout

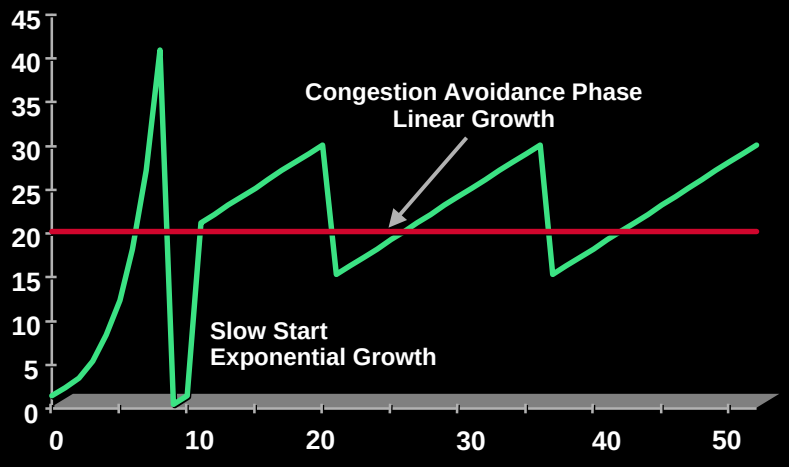


TCP Applications



Source: MCI/NSF OC3MON via http://www.nlanr.net, 1998

Behavior of Long TCP Session



Multiservice IP Application Classification

Application	Protocols	Network Classification
VoIP	RTP H.323 H.245 Control	• TCP-Based Signaling (H.245) • UDP-Based 'Data' • H.245 Port Is User-to-User Specific • Call Signaling Control Channel = TCP1720
SAP	SQLNET	• saprouter Port 3299 • Message Server Port Range 3600-3699 • Application Server 3200+n, 3300+n n=setup
Premium or Best Effort IP	Well Known TCP/UDP	• FTP-cmd/Data Port 21/20 • DNS Port 53 • NFS Port 2049 • Telnet Port 23 • SMTP Port 25 • NTP Port 123 • Kerberos Port 88, 749, 750
Multimedia	UDP	• RealAudio Port 7070 • VDOPhone Ports 7000, 7010, 32496

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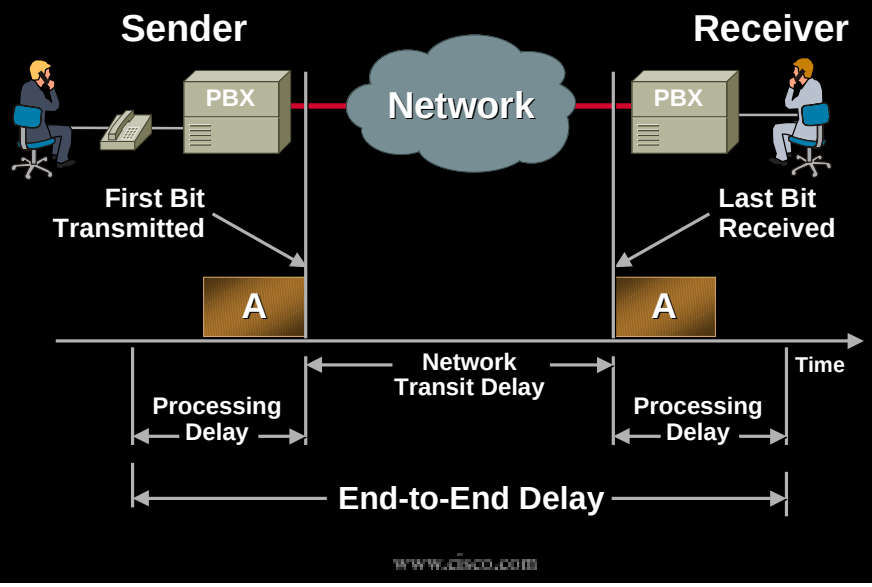
Delay Requires Priority Servicing



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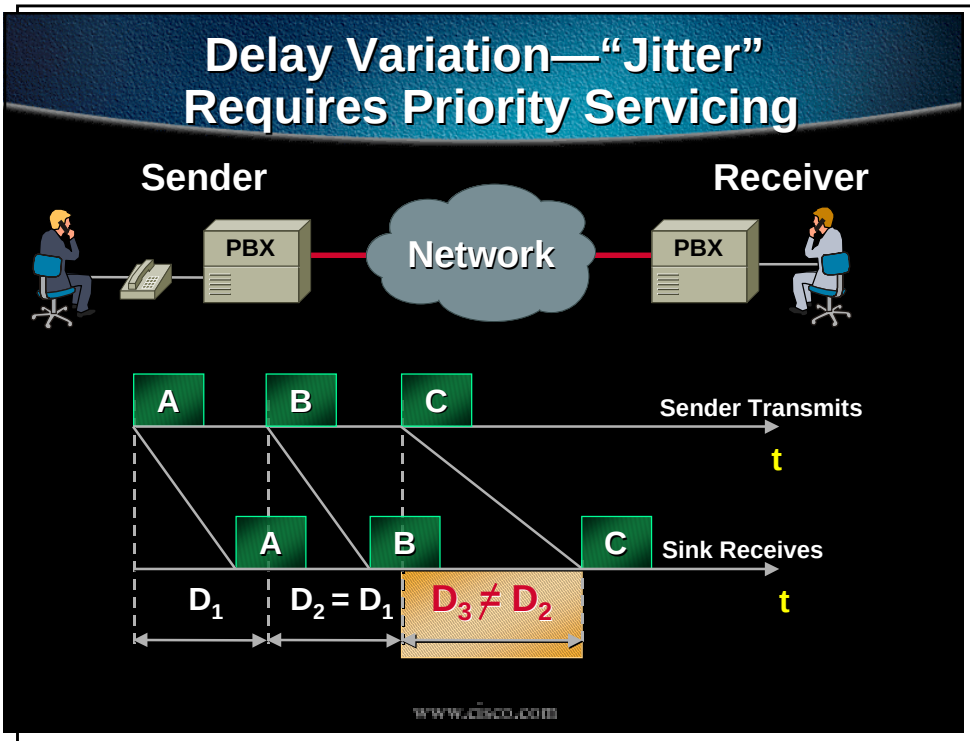
Delay Variation—"Jitter" Requires Priority Servicing



Per Hop Delay

Fixed Frame Serialization Delay Matrix

Link Speed	1 Byte	64 Bytes	128 Bytes	256 Bytes	512 Bytes	1024 Bytes	1500 Bytes
56 kbps	143 us	9 ms	18 ms	36 ms	72 ms	144 ms	214 ms
64 kbps	125 us	8 ms	16 ms	32 ms	64 ms	128 ms	187 ms
128 kbps	62.5 us	4 ms	8 ms	16 ms	32 ms	64 ms	93 ms
256 kbps	31 us	2 ms	4 ms	8 ms	16 ms	32 ms	46 ms
512 kbps	15.5 us	1 ms	2 ms	4 ms	8 ms	16 ms	23 ms
768 kbps	10 us	640 us	1.28 ms	2.56 ms	5.12 ms	10.24 ms	15 ms
153 kbps	5 us	320 us	640 us	1.28 ms	2.56 ms	5.12 ms	7.5 ms

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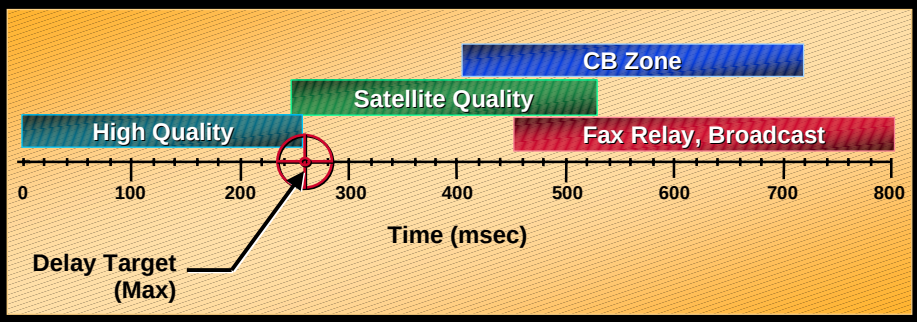
Delay Budget per Class or Application

Cumulative Transmission Path Delay



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Agenda

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What Is a Policy?

"An operational or business decision implemented across your network to meet the application system performance requirements end-to-end"

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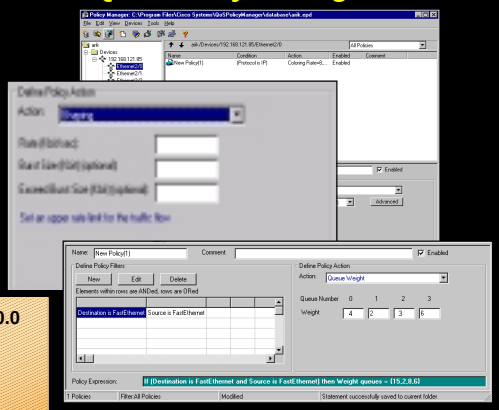
Activate Policy Enforcement Mechanisms

- Granular QoS actions are applied to the flow
- Support for PQ, CQ, WFQ, WRED, GTS, FRTS, CAR limiting, WRR
- User-defined enforcement parameters
- Advanced CAR features

QoS Policy Manager 1.0



Limit all FTP traffic going to subnet 192.0.0.0 to 300 Kbits.

Filter:
protocol=TCP
Source - port=FTP data (20)
Destination - Host Name=192.0.0.0
Mask=255.0.0.0

Action—Shaping
rate=300

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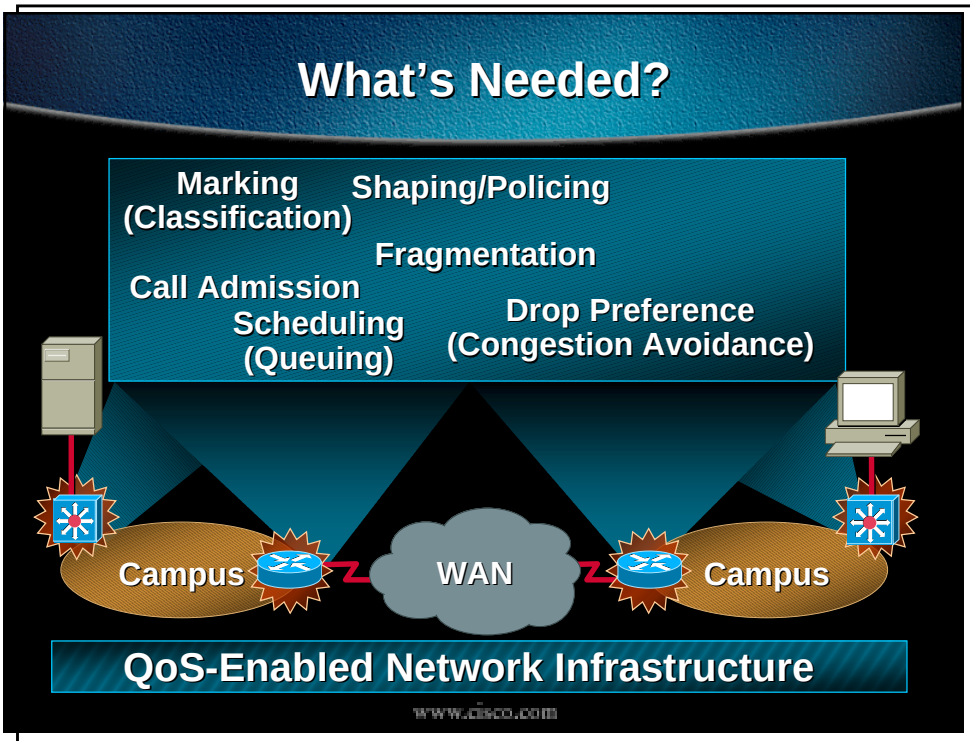

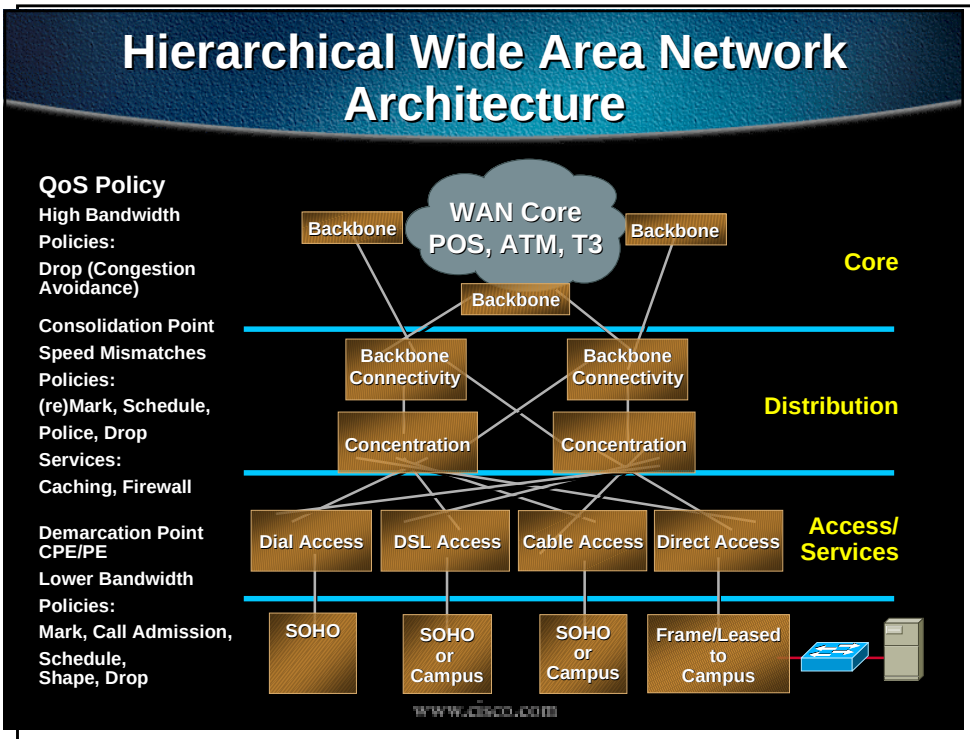

Cisco IOS® QoS Diff Serv Components

PHB/Traffic Conditioner	Mechanism	Network Effect
Drop	RED, WRED, Flow RED	• Avoid Congestion by Notifying Source • Prioritize which Traffic Is Told to Reduce
Scheduling	PQ, CQ, WFQ, CB WFQ, WRR, MDRR	• Bandwidth Management: Traffic Priority • Set Servicing Sequence
Marking	CAR, Policy Routing, DSCP, NFCII	• Sets IP Precedence/DSCP • By Application, Protocol, Address, Etc.
Metering (Policing)	CAR	• Enforce a Maximum Transmission Rate • Conform or Exceed Thresholds
Shaping	GTS, FRTS	• Conforms Traffic to Committed Bandwidth • Interwork with Layer 2 Notification, e.g., BECN
Compress	CRTP	• Reduce the Volume of Traffic Sent
Fragment	LFI, FRF.12	• Reduce Delay on Slower Speed Links • Split, Recombine Larger Frames

Agenda

- Why Invest in QoS?
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  - Access
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One Common Policy

"Policy Required:
Treat Gold traffic with the highest service level over Silver and Bronze traffic"

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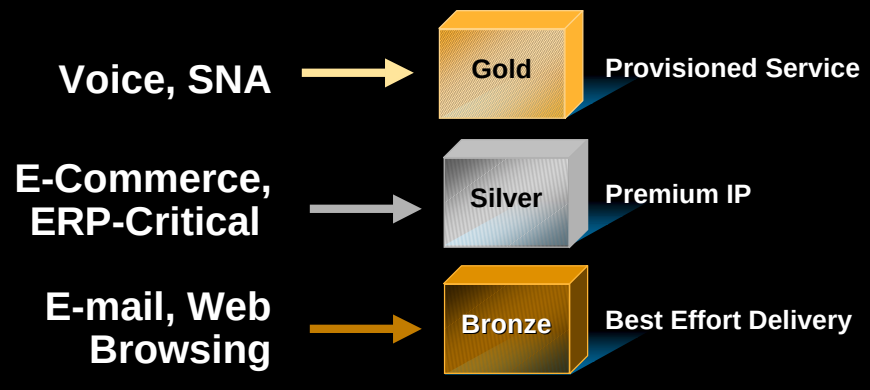
Sample Class Base Service Deployment



Application Audit ⟷ Service Levels

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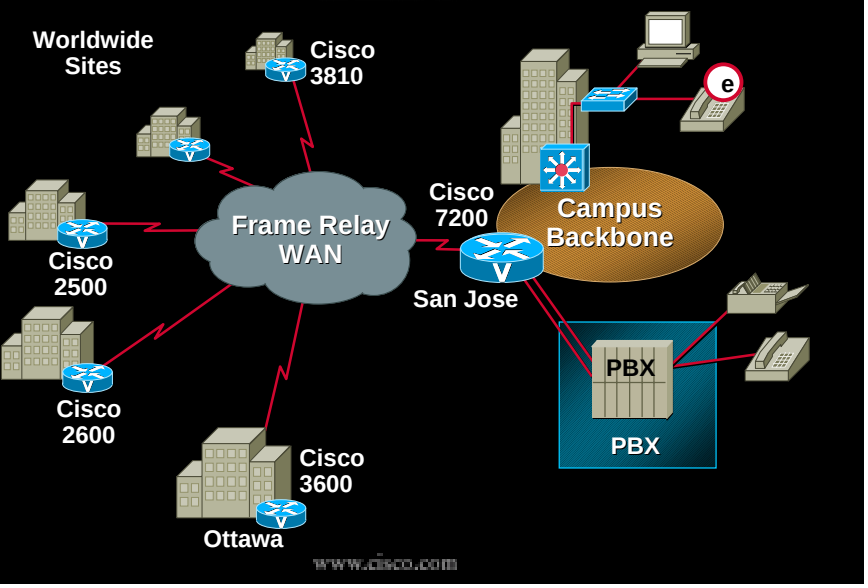
Access Layer: Remote Office Integration over Frame Relay



Features for Servicing Gold Class on a Frame Relay Link

- Mark/classify at the edge
  - Committed Access Rate (CAR)
  - Network Based Application Recognition (NBAR)
- Weighted Fair Queuing (WFQ)*
- Shape traffic to CIR
  - Frame Relay Traffic Shaping (FRTS)
- Fragmentation (optional)
  - FRF.12
- Minimum release required 12.0(4)T
- * or 12.0(5)T for Priority Queue WFQ

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Committed Access Rate (CAR)

- Two functions
  - **Packet classification**—IP precedence and QoS group setting
  - **Access bandwidth management** through rate limiting (policing)

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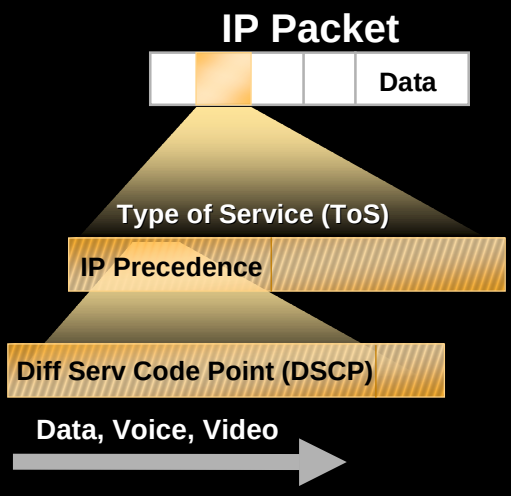
Marking: IP Precedence

- QoS marking
- Inband
- **Differentiated network services across any media or topology**



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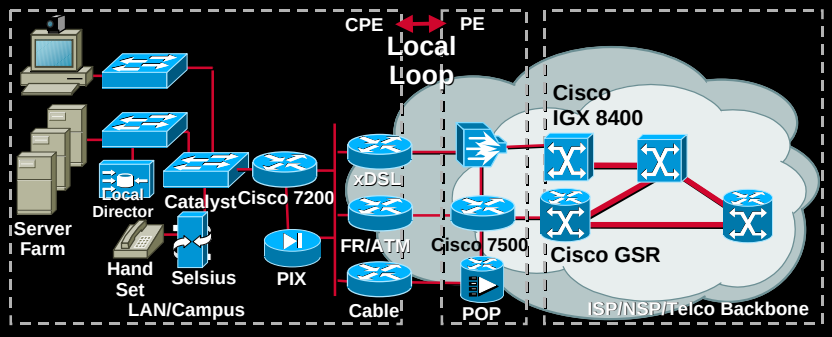
IP Precedence End-to-End Marking



Connectivity:	2900	5500	6000	8500	26/3600	7200	UBR	7500	8400	GSR
IP Prec	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

Services:	QPM	IP/TV	GateKeeper	Selsius	LocalDirector	DD	NetFlow
IP Prec	Y	N*	Y	Y	Y	Y	Y-ToS

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CAR—Traffic Matching Specification

- Identify packets of interest for packet classification or rate limiting or both
- Matching specification
  1) All traffic
  2) IP precedence
  3) MAC address
  4) IP access list—standard and extended (slower)

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CAR—Action Policies

- Configurable actions
  - Transmit
  - Drop
  - Continue (go to the next rate-limit in the list)
  - Set precedence and transmit (rewrite the IP precedence bits and transmit)
  - Set precedence and continue (rewrite the IP precedence bits and go to the next rate-limit in the list)

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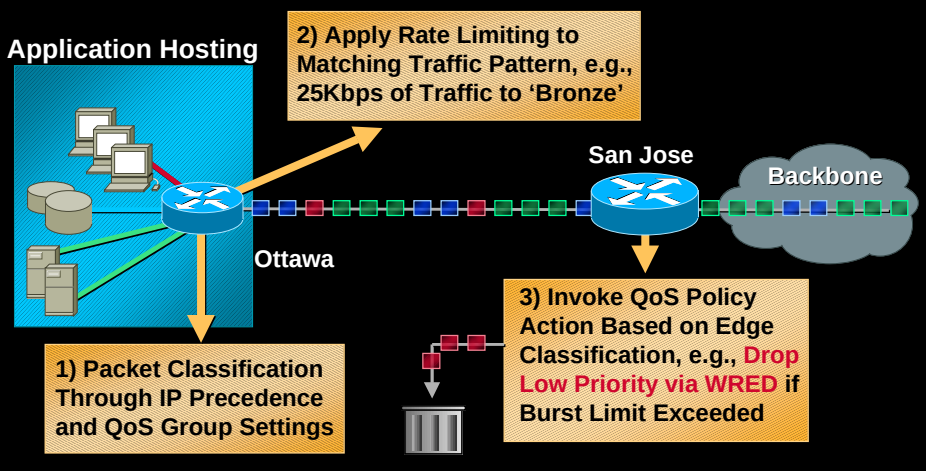
Committed Access Rate (CAR) Bandwidth Management



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Marking at the Edge: IP Precedence

- CAR access-list

  [no] access-list rate-limit <1–99> <ip_precedence>

  [no] access-list rate-limit <100–199> <mac_address>

- CAR show command

  Show interface [interface] rate-limit

Marking IP Precedence: CAR


```
R1#write term
....
!
interface S0
 description 128Kbps to R2
 rate-limit input access-group 101 128000 8000 16000
  conform-action set-prec-transmit 5 exceed-action set-prec-transmit 3
 rate-limit input access-group 102 64000 8000 16000
  conform-action set-prec-transmit 3 exceed-action set-prec-transmit 1
ip address 200.200.14.250 255.255.255.252
!
access-list 101 permit tcp any any eq www
access-list 102 permit tcp any any eq ftp
!
```

NBAR: Application Classification

- Network-based application recognition
- A new IP packet classifier capable of matching:
  - Dynamic/negotiated port numbers (stateful inspection)
  - URL/sub-URL addresses
  - Sub-port, transaction types

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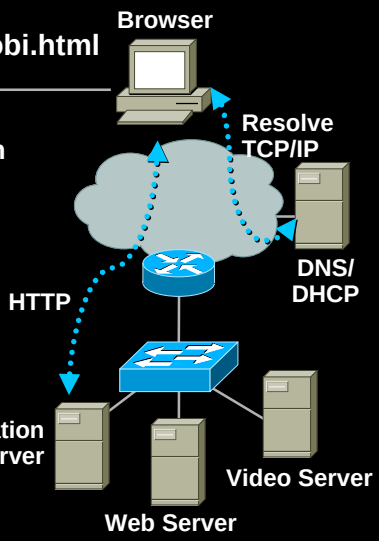
NBAR URL Classification

- http://www.nhl.com:8080/gretzky/kobi.html

protocol | host name | port | path

- HTTP communications:
  - Virtual hosts (Local Director)
  - Proxy services (caching)
  - ACL (NBAR, CAR)



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NBAR Classification

class-map Greatest_game_on_earth

match protocol http url
'www.nhl.com:8080/gretzky/kobi.html'

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Ways to Limit Throughput

- Policing
  - Committed Access Rate (CAR)
- Traffic shaping
  - Generic Traffic Shaping(GTS)
  - Frame Relay Traffic Shaping (FRTS)

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Bandwidth Management: Traffic Shaping

- Shaping highly beneficial if downstream device is policing
- Packet bursts are queued instead of being dropped
- Resulting packet stream is "smoothed" and net throughput for bursty traffic is higher

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Difference Between CAR and FRTS

CAR	FRTS
Policer	Shaper
Policy Based on IP	Policy Based on DLCI
Input and Output Interfaces	Output Interfaces
Marking	No Marking
Runs in Distributed Mode	Does Not Run in Distributed Mode
Does Not Act on FECN/BECN	Understands BECN/FECN

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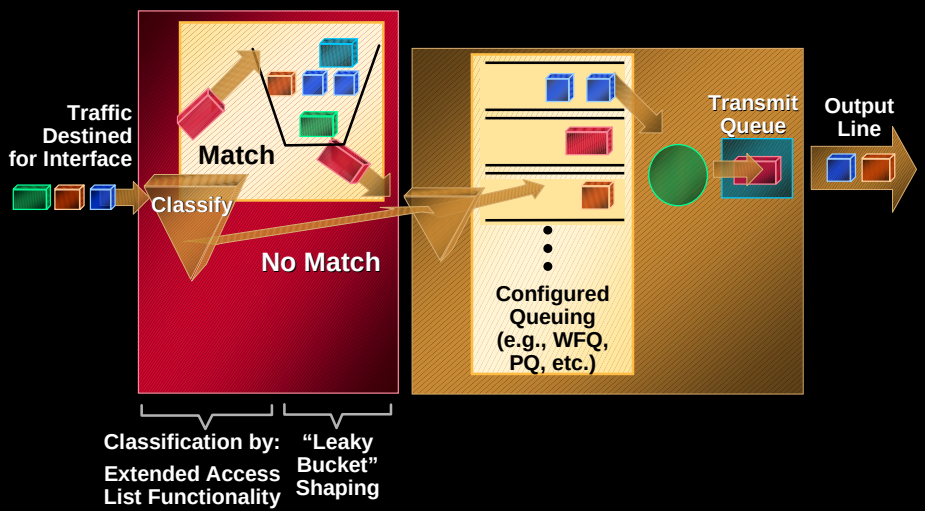
Traffic Shaping



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Difference Between FRTS and GTS

FRTS	GTS
Shaper FR Only	Shaper
Per DLCI	Interface Level or Group-Based
Shaping Queue PQ,CQ and WFQ(12.0(4)T)	Shaping Queue WFQ
Interface Queue 2 Level Priority	Can Be Anything
Supports FRF.12	No Support for FRF.12
Understands FECN/BECN	Understands BECN/FECN

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Configuring FRTS + FRF.12

```
! interface Serial 0
  no ip address
  encap frame-relay ietf
  frame relay lmi-type ansi
  frame-relay traffic shaping
  frame-relay class gold
! map-class  gold
 frame-relay cir 128000
 frame-relay bc 8000
 frame-relay mincir 32000
 no frame-relay adaptive-shaping
 frame-relay fair-queue
 frame-relay fragment 70
```

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Show Commands

```
panama#show frame-relay fragment
interface       dlci   frag-type      frag-size  in-frag    out-frag   dropped frag
Serial0/1.2     110   end-to-end    70          0          0             0

ottawa#show frame-relay fragment  interface serial0/1.2 110

 fragment size 70                    fragment type end-to-end
 in fragmented pkts 0                 out fragmented pkts 0
 in fragmented bytes 0                out fragmented bytes 0
 in un-fragmented pkts 0               out un-fragmented pkts 2
 in un-fragmented bytes 0              out un-fragmented bytes 60
 in assembled pkts 0                  out pre-fragmented pkts 2
 in assembled bytes 0                 out pre-fragmented bytes 60
 in dropped reassembling pkts 0      out dropped fragmenting pkts 0
 in timeouts 0
 in out-of-sequence fragments 0
 in fragments with unexpected B bit set 0
 out interleaved packets 0
```

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Show Commands

```
ottawa#show frame-relay pvc interface s0/1.2 110

PVC Statistics for interface Serial0/1.2 (Frame Relay DTE)

DLCI = 110, DLCI USAGE = LOCAL, PVC STATUS = STATIC, INTERFACE = Serial0/1.2

  input pkts 0            output pkts 0          in bytes 0
  out bytes 0             dropped pkts 0          in FECN pkts 0
  in BECN pkts 0          out FECN pkts 0         out BECN pkts 0
  in DE pkts 0            out DE pkts 0
  out bcast pkts 0        out bcast bytes 0
  pvc create time 00:02:53, last time pvc status changed 00:02:54
  fragment type end-to-end          fragment size 70
  cir 128000      bc 8000      be 0         limit 125   interval 15
  mincir 32000     byte increment 125  BECN response no
  pkts 0          bytes 0         pkts delayed 0         bytes delayed 0
  shaping inactive
 shaping drops 0
  Current fair queue configuration:
   Discard      Dynamic       Reserved
   threshold    queue count   queue count
   64           16            2
  Output queue size 0/max total 600/drops 0
```

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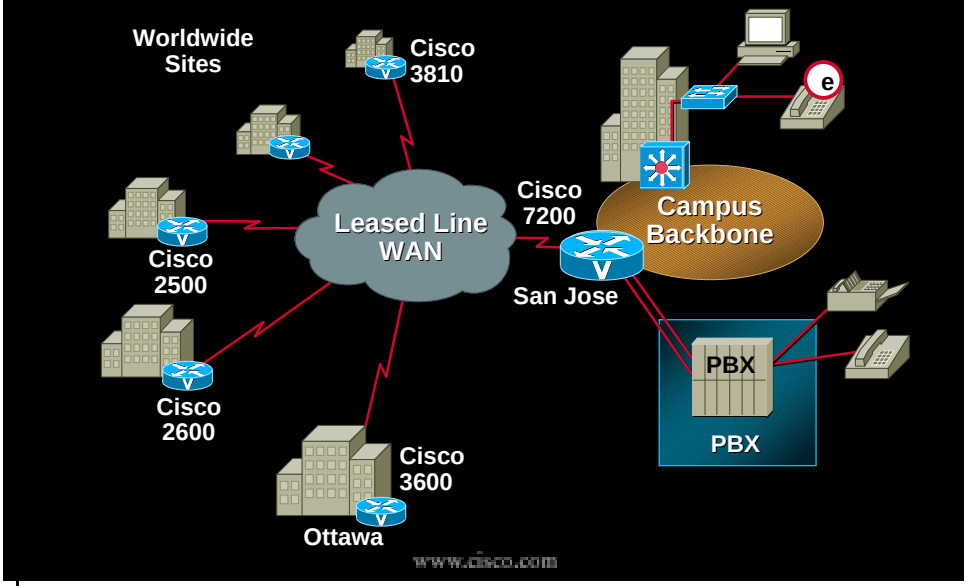
Access Layer: Remote Office Integration over Fractional T1



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Features for Servicing Gold Class on a Fractional T1PPP Link

- CAR to mark and police
- Class Based WFQ (CB WFQ)
- Multilink PPP—MLPPP
- IP RTP reserve or CRTP for voice (optional)
- Minimum release required 12.0(5)T

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RTP Header Compression (RTP-HC~CRTP)

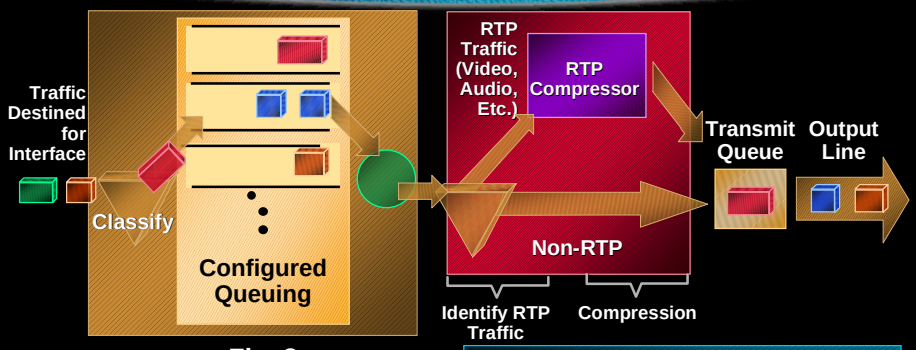
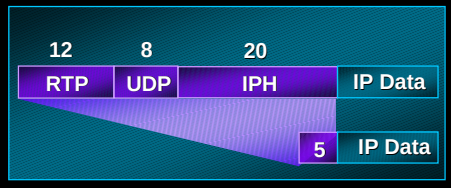


Fig. 8



Efficiencies	Payload	Packet Size Reduction*
VOIP	20 Byte	~ 240%
SQL	256 Byte	~ 13%
FTP	1,500 Byte	~ 2.3%

*Also ~5ms Reduction in Serialization Delay at 64 Kbps

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CRTP Example

Leased line

```
!
interface serial 0
 ip address 192.168.121.18 255.255.255.248
 no ip mroute-cache
 ip rtp header-compression
 encapsulation ppp
!
```

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Minimum Bandwidth Guarantee

"Policy Required: Gold Traffic will always receive a minimum bandwidth of 512 Kbps available at all times"

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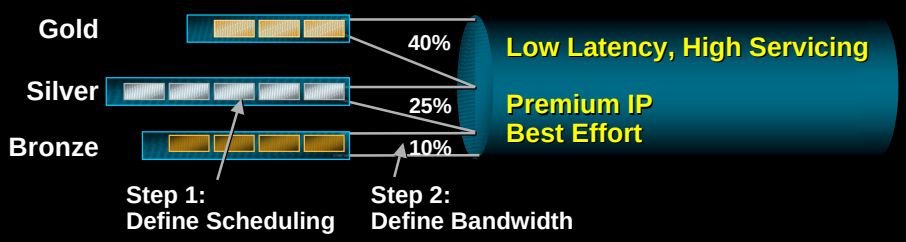
Class-Based WFQ



- Class definition sets minimum bandwidth
- Queue servicing (metering) controls latency
- Unused capacity is shared amongst the other classes
- Each class can be separately configured for QoS

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Modular CLI

- Same across all main Cisco IOS-based platforms
- Separates classification engine from the policy
- Template-based
- Initial release 12.0(5)T

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Modular CLI

- Class maps
  - Access lists, input interface, protocol
  - Class-default
- Policy maps
  - Bandwidth, random-detect, queue-limit
- Service maps
  - Input, output

Class Maps Example

```
Router(config)# classmap gold
Router(config-cmap)# match access-group 101
Router(config-cmap)# exit
Router(config)# classmap silver
Router(config-cmap)# match access-group 102
Router(config-cmap)# exit
```

Policy Maps Example

```
Router(config)# policymap premium_policy
Router(config-pmap)# class Gold
Router(config-pmap-c)# bandwidth 512
Router(config-pmap-c)# queue-limit 64
Router(config-pmap-c)# random-detect
Router(config-pmap)# exit
```

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Policy Maps Example

```
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth 256
Router(config-pmap)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue 10
Router(config-pmap)# exit
```

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Service Map Example

```
Router(config)# interface s1/1
Router(config-if)# service output premium_policy
Router(config-if)# exit
Router(config)# interface s/0/0
Router(config-if)# service output premium_policy
Router(config-if)# exit
```

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Minimum Bandwidth Guarantee

“Policy Required: Reserve BW for my application which is RSVP enabled and can signal to the network for it’s requirements”

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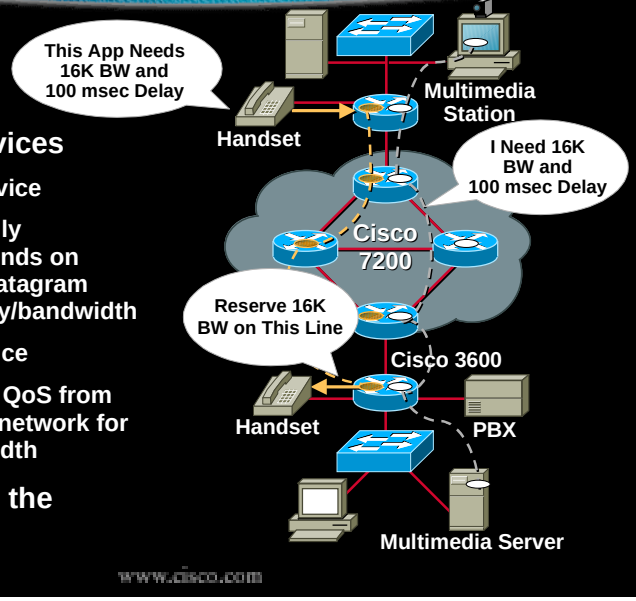
Access Layer: RSVP Signaled Applications

- RSVP QoS services
  - Guaranteed service
    - Mathematically provable bounds on end-to-end datagram queuing delay/bandwidth
  - Controlled service
    - Approximate QoS from an unloaded network for delay/bandwidth
- RSVP provides the policy to WFQ



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RSVP Policy

- RSVP admission control
  - Accept or deny RSVP requests
  - Preempt existing reservations based on policy
  - Policy objects (future)
- Configure RSVP parameters such as:
  - Queuing parameters
  - Traffic shaping parameters

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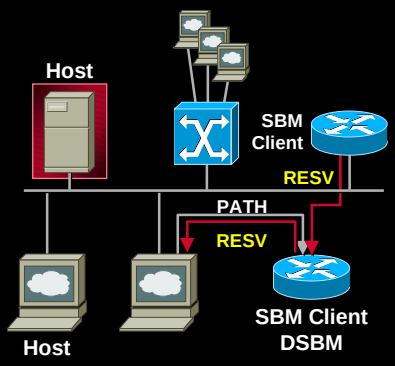
RSVP for Ethernet LANs Subnet Bandwidth Manager (SBM)

- Shared/switched L2 devices
- RSVP in switch or router controlling LAN segment
- Controls rate promises made on a shared/ switched LAN

  DSBM (Designated SBM)
- Works with IEEE 802.1p
- DSBM does admission control for segment bandwidth



Configuring RSVP

ip rsvp bandwidth [interface-kbps] [single-flow-kbps]

```
!
interface Serial0/0
 ip address 10.1.1.2 255.255.0.0
 ip rsvp bandwidth 96 96
 bandwidth 128
 fair-queue 64 256 1000
!
```

Verifying Reservation Accepted

```
bottom#sho ip rsvp installed
BPS       To            From          Protoc  DPort  Sport  Weight Conversation
24K       10.1.1.1      10.1.1.2      UDP     16384  16384  4      264
```


Displaying WFQ with RSVP

Sho Interface

```
HUB#sho int se 0/0

Queueing strategy: weighted fair
  Output queue: 64/1000/64/109548 (size/max total/threshold/drops)
     Conversations  1/4 (active/max active/threshold)
     Reserved Conversations 1/1/64 (allocated/max allocated)
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 120000 bits/sec, 89 packets/sec
```

1. Note reserved flow and weight
2. 0 drops for reserved flow

Sho Queue

```
HUB#sho queu se 0/0

(depth/weight/discards/tail drops/interleaves) 1/4/0/0/0
  Conversation 190, linktype: ip, length: 64
  source: 10.1.1.1, destination: 10.1.1.2, id: 0x8DF7, ttl: 254,
  TOS: 0 prot: 17, source port 16390, destination port 16396

  (depth/weight/discards/tail drops/interleaves) 63/4096/144854/0/0
  Conversation 32, linktype: ip, length: 1500
  source: 10.1.2.2, destination: 10.1.3.2, id: 0xC278, ttl: 254, prot: 1
```

Agenda

- Why Invest in QoS?
- Architectural Approaches
- Application Requirements
- Deployment Scenarios
  - Access
  - Distribution
  - Core

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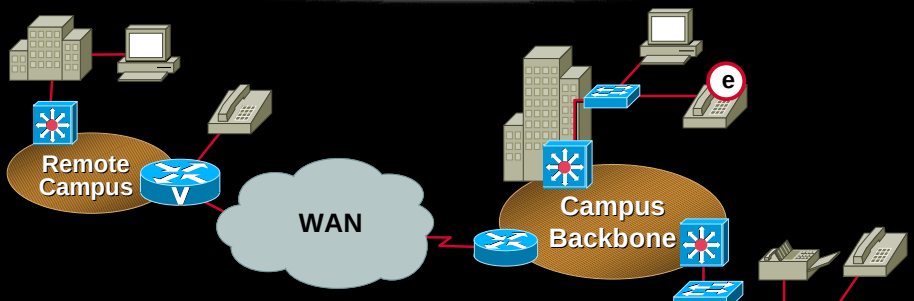
Distribution or Core Layer: Campus to Campus DS3/ATM



- DS1-DS3 bandwidth
- PPP link encapsulation
- Multiservice IP
  - Gold → VoIP
  - Silver → E-Commerce
  - Bronze → E-Mail

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Distribution Layer: Features for Gold on Cisco 7500/VIP for DS-3 Trunking

- CAR to mark and police
- Queuing
  - ToS-based DWFQ (2 bits-4 classes)
  - Class Based WFQ (QoS Group)
- Minimum release required 12.0(3)T, 11.1cc for 7500/VIP

Distributed Weight Fair Queuing

- The user has the option to set aggregate queue depth and also individual queue depth
- During periods of congestion the individual queue depth limits is enforced
- With ToS and QoS group-based WFQ the user also has the option to set queue depth for each ToS or QoS group queues

Configuring DWFQ

- Enabling flow-based WFQ

  [no] fair-queue

- Enabling ToS-based WFQ

  [no] fair-queue tos-based

- Enabling class-based WFQ

  [no] fair-queue qos-group

Must Enable DCEF First

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ToS-Based DWFQ

- Packets are classified into four queues based on IP precedence

  Follows directly from the precedence value

- Each queue is weighted

  Expressed in percentage (%)

- The weight determines the amount of bandwidth that each active queue is allowed to consume during periods of congestion

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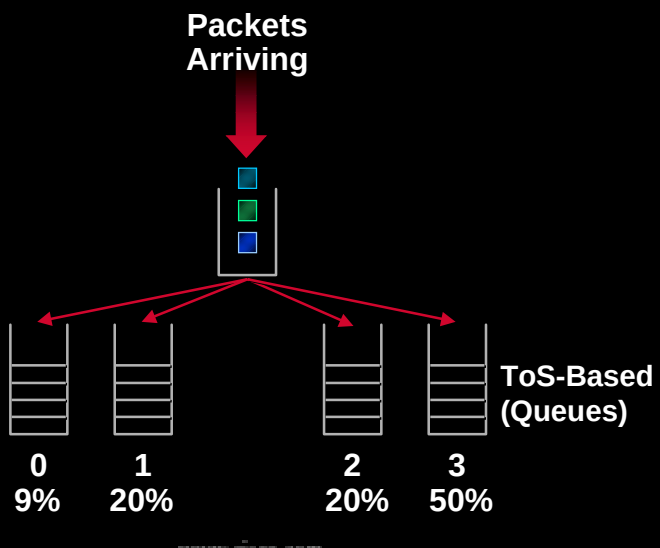
ToS-Based DWFQ



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Configuring DWFQ

- Setting queue depth (flow, ToS, and class-based WFQ)
  - Fair-queue aggregate-limit <aggregate-limit>
  - Fair-queue individual-limit <individual-limit>
- Setting queue depth for a particular queue (ToS- and class-based WFQ only)
  - Fair-queue qos-group <n> limit <queue-limit>
    - For ToS-based WFQ <n>–0..3
    - For class-based WFQ <n>–0..99

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Configuring DWFQ

- Changing the weights for ToS and class-based WFQ
  - Fair-queue qos-group <n> weight <weight>
    - For ToS-based WFQ <n> - 0..3
    - For class-based WFQ <n> - 1..99
- Show command
  - Show interface [interface] fair-queue

Configuration Example

```
interface HSSI0/0/0
description DS-3 to New Orleans
 ip address 188.1.3.70 255.255.255.0
 rate-limit output access-group rate-limit 6 45000000 10000 350000
    conform-action set-qos-transmit 6 exceed-action drop
 rate-limit output access-group rate-limit 2 45000000 10000 350000
    conform-action set-qos-transmit 2 exceed-action drop
  fair-queue qos-group
 fair-queue qos-group 2 weight 10
 fair-queue qos-group 2 limit 27
 fair-queue qos-group 6 weight 30
 fair-queue qos-group 6 limit 27
!
access-list rate-limit 2 2
access-list rate-limit 6 6
```

Configuration Example TOS-Based DWFQ

```
interface Hssi0/0/0
 ip address 188.1.3.70 255.255.255.0
  fair-queue tos
 fair-queue tos 1 weight 20
 fair-queue tos 1 limit 27
 fair-queue tos 2 weight 30
 fair-queue tos 2 limit 27
 fair-queue tos 3 weight 40
 fair-queue tos 3 limit 27
```


DWFQ Show Commands

```
Router# show interfaces fair-queue

 Hssi0/0/0 queue size 0
       packets output 356232, drops 1
 WFQ: aggregate queue limit 54, individual queue limit 27
   max available buffers 54

    Class 0: weight 60 limit 27 qsize 0 packets output 654 drops 0
    Class 2: weight 10 limit 27 qsize 0 packets output 402789 drops 0
    Class 6: weight 30 limit 27 qsize 0 packets output 402789 drops 1
```

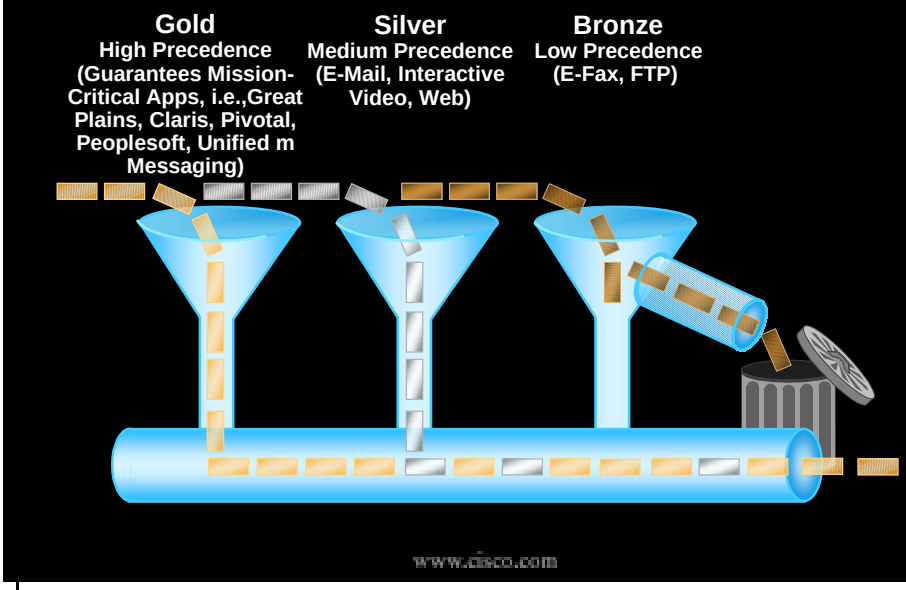
DWFQ Show Command

```
R1#sh int hssi 0/0/0
Hssi0/0/0 is up, line protocol is up
  Hardware is cyBus HSSI
  Description: 45Mbps to R2
  Internet address is 200.200.14.250/30
  MTU 4470 bytes, BW 45045 Kbit, DLY 200 usec, rely 255/255, load 1/255
  Encapsulation HDLC, loopback not set, keepalive set (10 sec)
  Last input 00:00:09, output 00:00:00, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy  VIP-based fair queuing
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    2011 packets input, 133587 bytes, 0 no buffer
    Received 1604 broadcasts, 0 runts, 0 giants
          0 parity
    4 input errors, 4 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    1971 packets output, 133082 bytes, 0 underruns
    0 output errors, 0 applique, 3 interface resets
    0 output buffers copied, 0 interrupts, 0 failures
    1 carrier transitions
```

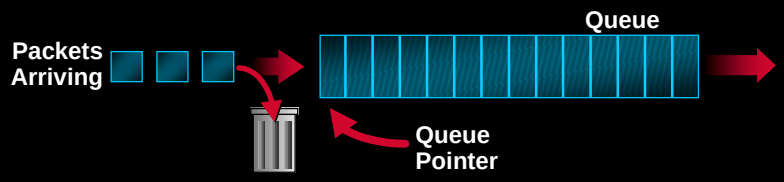

Drop Policy

> **Policy Required: Bronze or Silver traffic will be dropped when there is congestion. Gold traffic will be forwarded unaffected**

Weighted Random Early Detection



Random Early Detect (RED)



- Without **Red**, when the queue fills up, all packets that arrive are dropped—tail drop
- With **Red**, as opposed to doing a tail drop, the router monitors the average queue size and uses randomization to choose connections to notify that a congestion is impending

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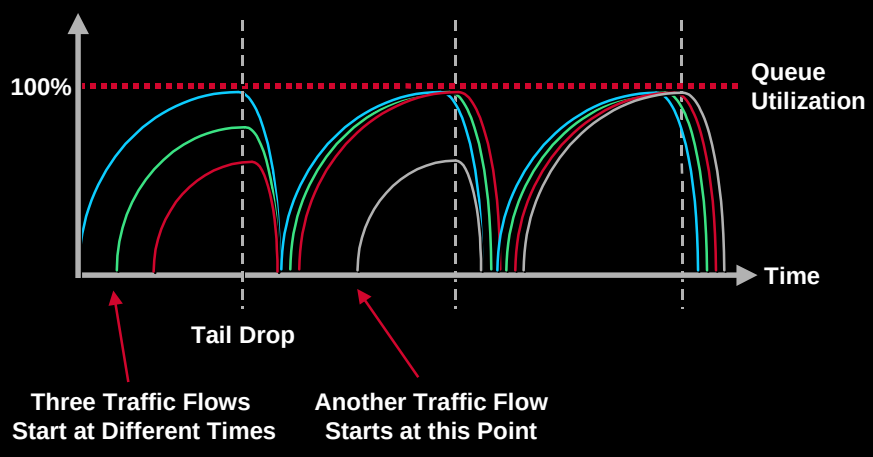
Global Synchronization



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Flow WRED

- Extension of WRED
- Penalize flows that do not respond to drops (e.g., UDP)
- Flow-WRED ensures that no single flow can hog all the buffer resources
- Adaptive flows get fair share of resources
- Minimum release 12.0(3)T…not VIP

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FRED vs. WRED

- **Perception**

  FRED punishes UDP FLOWS => bad for voice

- **Reality**

  FRED only punishes aggressive flows so in case where voice and video share the same class FRED will punish video

Agenda

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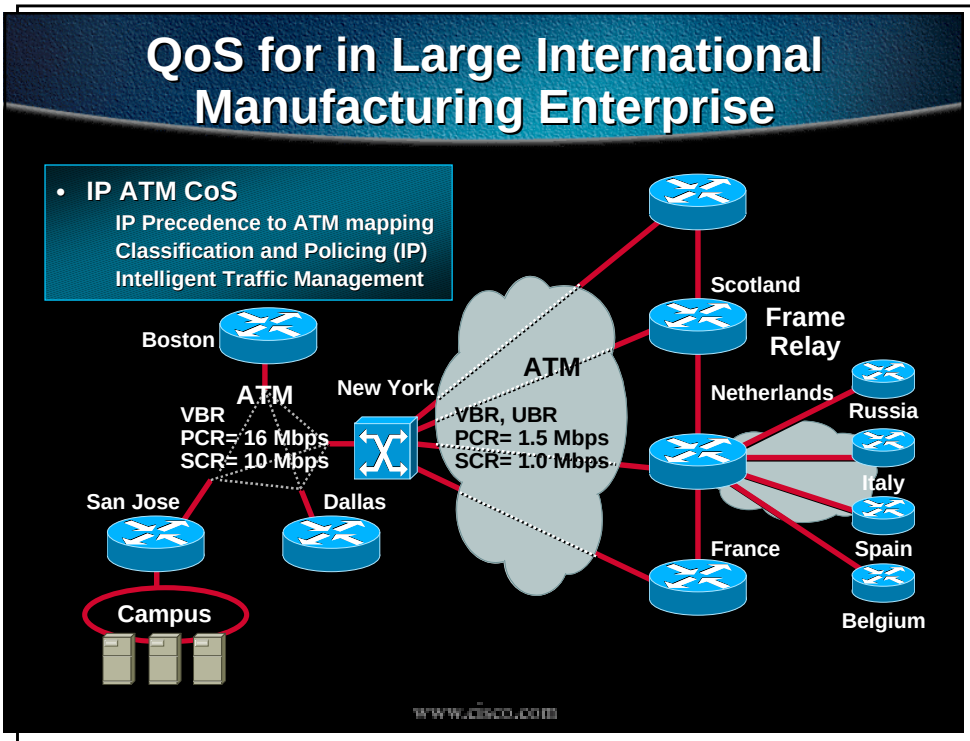
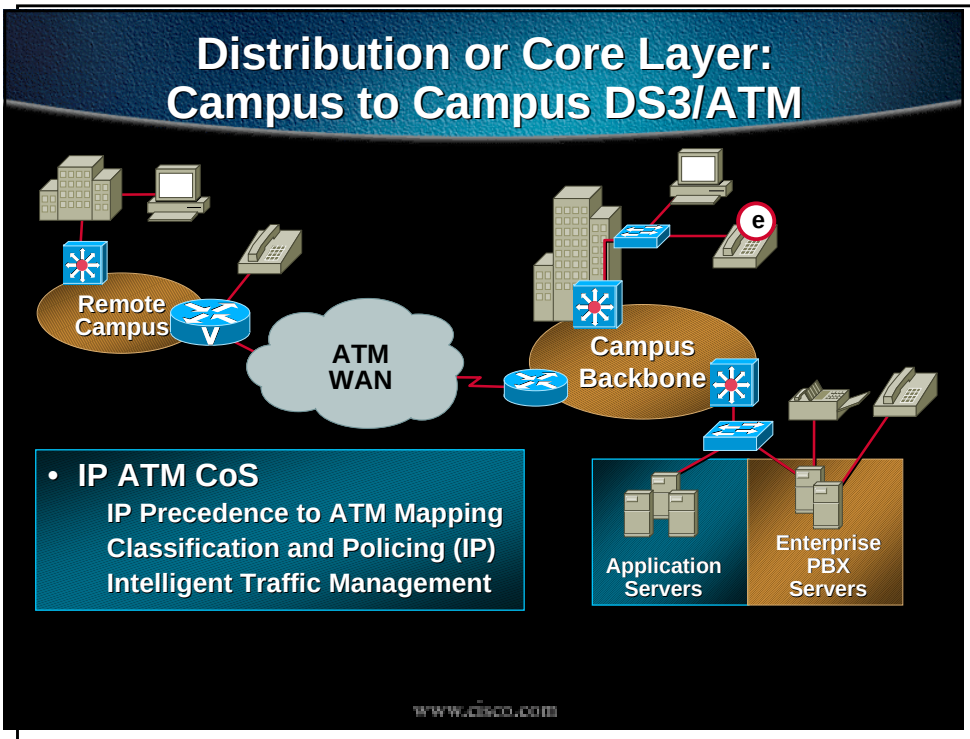




Features for VoIP on Cisco 72xx for a ATM Link

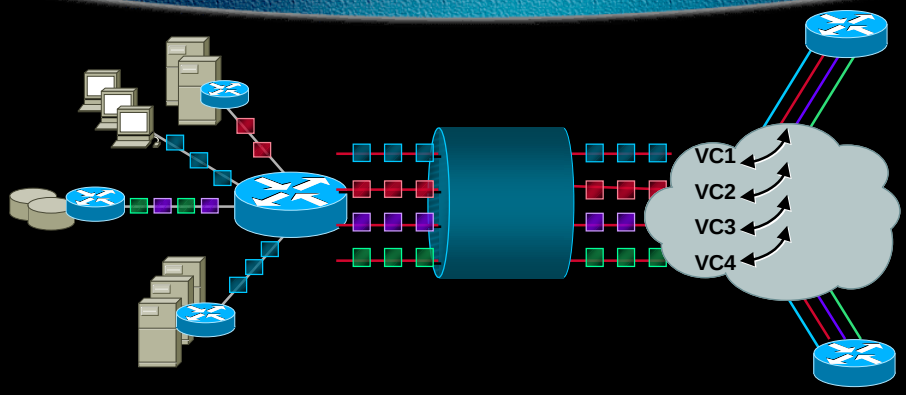
- CAR to mark and police
- Per VC queuing
- IP ATM CoS (Paris)
  - Phase II (VC mapping) or
  - Per VC CBWFQ with WRED*
- Minimum release required 12.0(3)T

* Minimum release 12.0(5)T for 7200 12.1.1T for 7500/VIP

IP ATM CoS Overview

- IP ATM CoS: Differentiated services over standard ATM
- Requires PA-A3/deluxe PA
  - Phase 1: Per VC WRED (in 11.1cc only for Cisco 75xx)
  - Phase 2: IP precedence to ATM CoS mapping
  - (In 12.0(5)T for 72xx and 75xx)
  - Phase 3; per VC CBWFQ

Precedence to VC Mapping



- Multiple VCs for Each Source/Destination
- Separate VC for Each IP CoS
- RED (WRED) Runs on Each VC Queue

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Per-VC WRED

- ATM router interface shapes according to VBR, ABR*, or CBR requirements
- Effect is to develop queue in router
- WRED on that queue ensures low loss for high-precedence traffic
- Low loss on ATM network is essential
  - Good match to ABR
  - Not effective with UBR VCs

* Minimum Release Is 12.0(4)T

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IP Precedence to VC Mapping

```
interface ATM3/1/0.1 multi-point
 ip address 170.100.9.20
    255.255.255.0
 no ip mroute-cache
 no ip route-cache
 bundle test
  oam manage 5
  encapsulation aal5snap
  protocol ip 170.100.9.10 broadcast
 !
  pvc-bundle high 0/34
  precedence 5-7
 !
  pvc-bundle med 0/33
  precedence other
```

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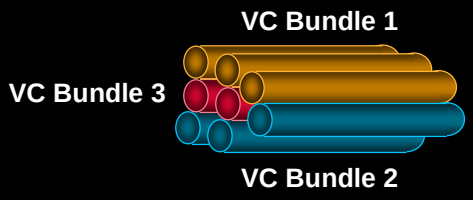
VC Bundling and Bumping

A VC Bundle Is Created when Multiple VCs Are Required between the Same Source/Destination



Only One Routing Adjacency per "Bundle"

If High Precedence VC Fails, It Can "Bump" Traffic to a Lower Precedence VC, or Entire Bundle Can Be Declared down

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QoS/CoS on Core GSR for a OC-3+ Link

- Committed access rate
- Weighted Random Early Detection (WRED)
- Modified Deficit Round Robin (MDRR) GSR

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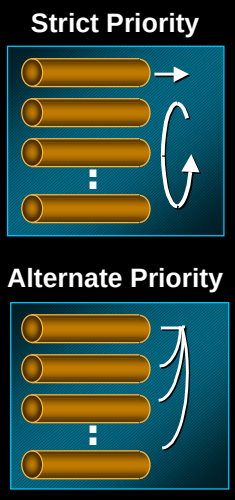
DRR Provides Emission Priority

- IP packets are mapped into different Class of Service (CoS) queues based on precedence bits
- Queues are serviced in round robin fashion except for one
- This one queue can be configured to be in either one of two modes:
  - Strict priority mode
  - Alternate priority mode



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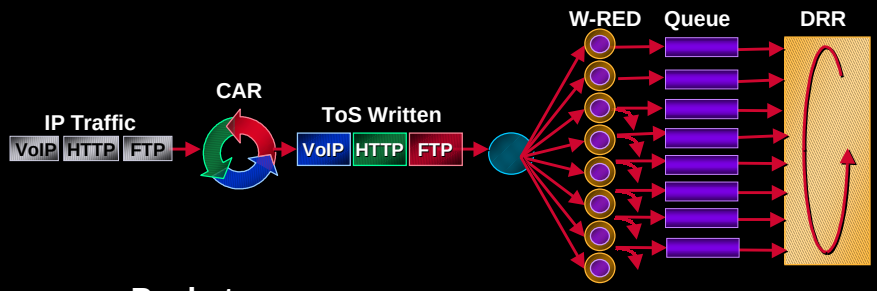
GSR Class of Service Putting it All Together



- Packets are
  - Colored (ToS Set) at Ingress
  - Classified and potentially discarded by W-RED (congestion management)
  - Assigned to the appropriate outgoing queue
  - Scheduled for transmission by DRR

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Reference Pointers

Quality of Service Solutions Configuration Guide
http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/12cgcr/qos_c/index.htm

Quality of Service Solutions Command Reference
http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/12cgcr/qos_r/index.htm

IP to ATM Class of Service Phase 1 Design Guide
http://www.cisco.com/univercd/cc/td/doc/product/software/ios111/cc111/ipatmdg.htm

Quality of Service for Virtual Private Networks
http://cmc/cc/sol/mkt/ent/vpne/qsvpn_wp.htm

Quality of Service for the Cisco 7200/7500
http://wwwin.cisco.com/cmc/cc/cisco/mkt/ios/qos/tech/qos72_wp.htm

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Thank You

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