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Quality of Service (QoS) Essentials

Session PS-560

Power Session Agenda

- QoS Fundamentals
- QoS Main Features
- Network Design and Best Practices
- QoS Network Management

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QoS Fundamentals

Section 1

Two Questions for YOU!

- Any network exists to serve its users and their applications?
- At the end of the day, the boss is happy when the business-critical applications and users have been serviced efficiently?

Agenda

- **What Is QoS?**
- **Why QoS—Isn’t Bandwidth Enough?**
- **The QoS Architectures**
- **The Applications and Their Needs**
- **Q&A**

What Is QoS?
The Application Perspective

- **QoS is the ability of a network to service a given application efficiently, without affecting its function or performance.**

It's ALL about the critical applications!!

What Is QoS?
The Network Perspective

- **Any network is comprised of:**

  Hosts (servers, PCs, etc.)

  Routers/switches

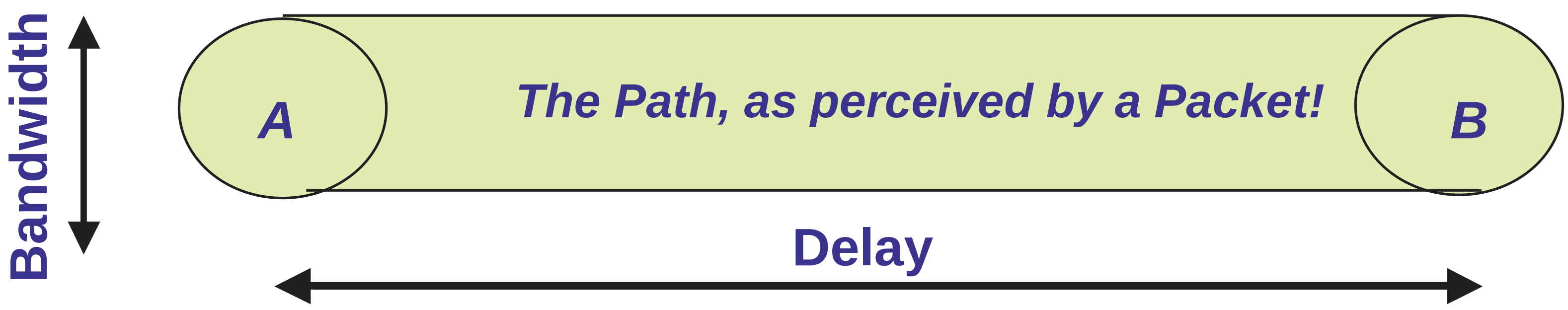
  Links (Ethernet, POS, etc.)

- **True "Quality of Service" depends on ALL of these components working properly!**

→ In this talk, we focus mainly on Routers/Switches, and Links

What Is QoS?
The Network Perspective (Cont.)

- **The definition of a PIPE:**
  - The path from point A to point B, as perceived by a packet
  - Similar to your experience in driving from city A to city B!
- **QoS is the set of techniques to manage:**
  - Bandwidth—The perceived width of the pipe
  - Delay—The perceived length of the pipe
  - Jitter—The perceived variation in the length
  - Packet Loss—The perceived leak in the pipe



What Is QoS?
The Business Perspective

- **Bandwidth, delay, jitter, and packet loss can all be thought of as resources, as you can only guarantee so much of each to a given user/application**
- **QoS is Advanced Resource Management (ARM) of the network, in order to have an application insurance policy, and maximize the ROI on the network infrastructure**

→ ARM Your Network with QoS!

Agenda

- What Is QoS?
- Why QoS—Isn't Bandwidth Enough?
- The QoS Architectures
- The Applications and Their Needs
- Q&A

Why QoS?? Isn't Bandwidth Enough?

- What happens without QoS!
- Why and where congestion occurs
- QoS for accountability and SLAs
- Applications waiting to happen!

Why QoS??
What Happens without QoS—Voice

- **Listen to Sample1: The Little Red Riding Hood Story, With NO Congestion…**
  - » **Very CLEAN!**
- **Listen to Sample2: Sample1 with 142msec delay, and 12% Packet Loss**
  - » **Irritating to Listen TO!**
- **Listen to Sample2: Sample1 with Up to 700msec random delay, and Up to 12% Packet Loss**
  - » **USELESS!**

Sample1 - Good ***Sample2 - Marginal*** ***Sample3 – Useless***

Why QoS??
What Happens without QoS—Data!

- **Interactive traffic suffers freezes, and possible timeouts**
  - Similar to the world-wide wait
- **Non-critical traffic could eat up bandwidth for critical applications**
  - ERP/client-server applications will suffer
- **Goodput of Bulk Transfers affected**
  - E.g. FTP, database sync, etc.
  - SP: Call-record file transfer!

→ **Summary: LOWER OVERALL productivity**

Why QoS??
The Mechanics of Congestion

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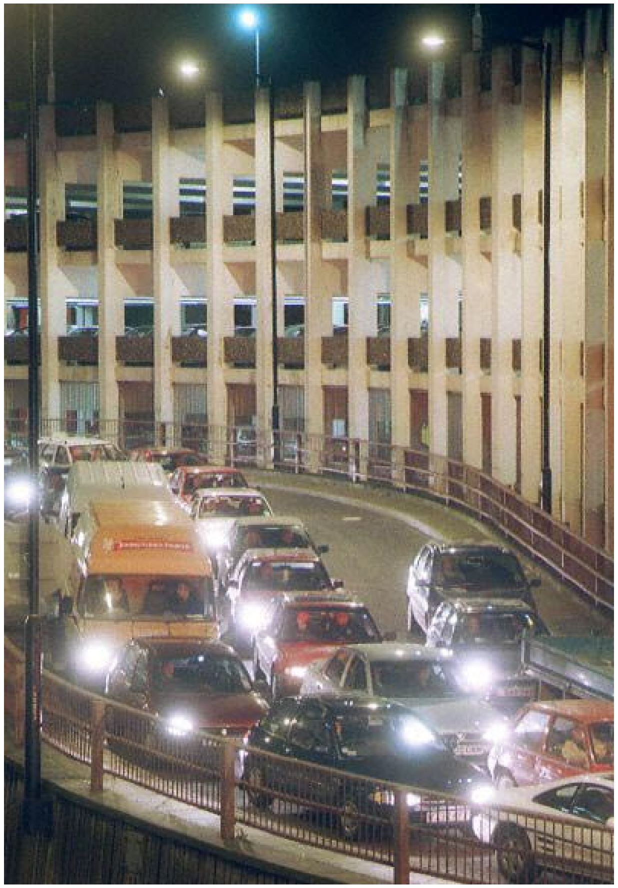
- **The root cause of congestion is LACK of bandwidth**
  - **Demand ≥ capacity**
  - **Un-expected traffic patterns**
- **Congestion examples:**
  - **Rush-hour traffic**
  - **New Year's Eve phone calls!**
  - **Reading electronic mail in the morning!**

→ The Los Angeles Earthquakes!

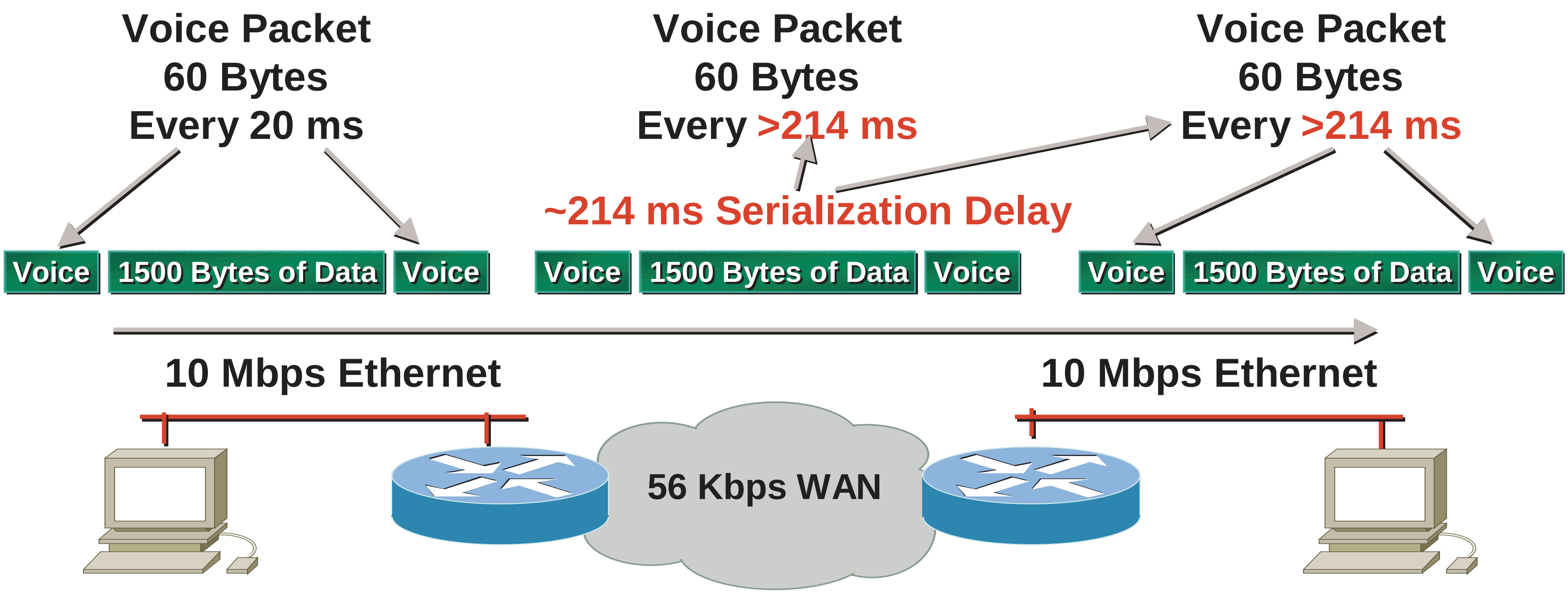


Why QoS??
The Mechanics of Congestion (Cont.)

- **The root cause of delay (also called latency):**
  - **Fixed-delay—delay in switching, propagation, and serialization**
  - **Variable-delay—due to buffering (queuing) of packets during congestion**
  - **The root cause of jitter (delay variation):**
  - **Congestion causes buffering, and results in packets being released onto the link with varying delays**
- **The root cause of packet-loss:**
  - **Buffer exhaustion in routers and switches**

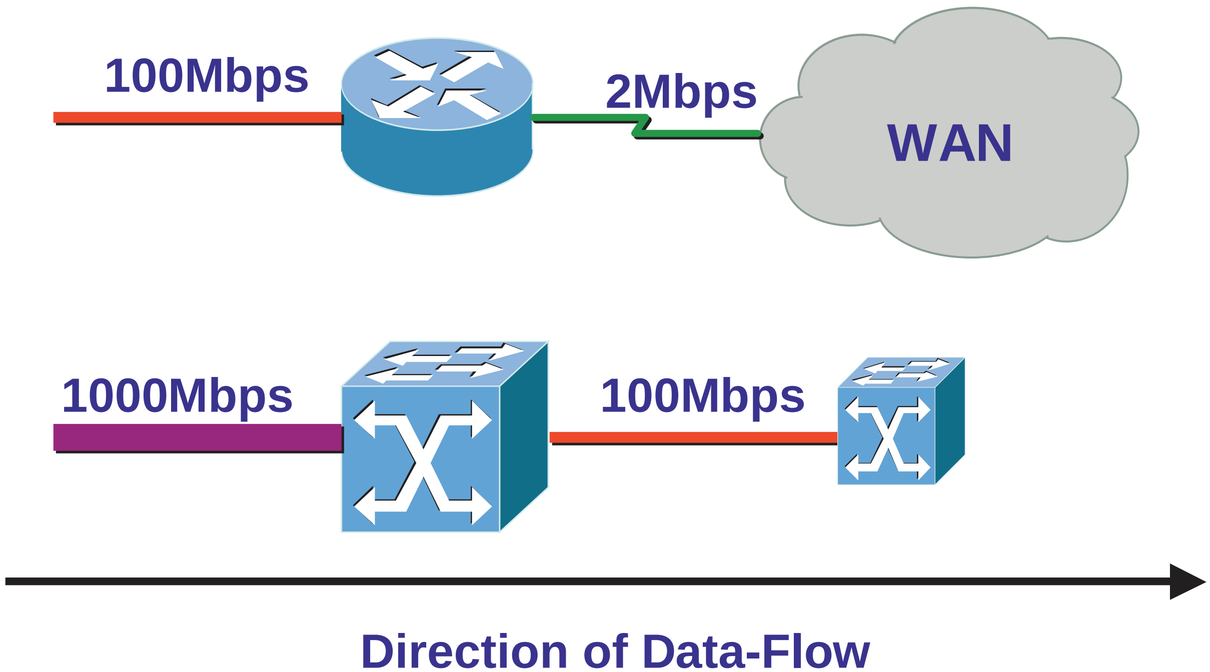
Why QoS??

The Mechanics of Congestion…Serialization Delay Is a Problem!



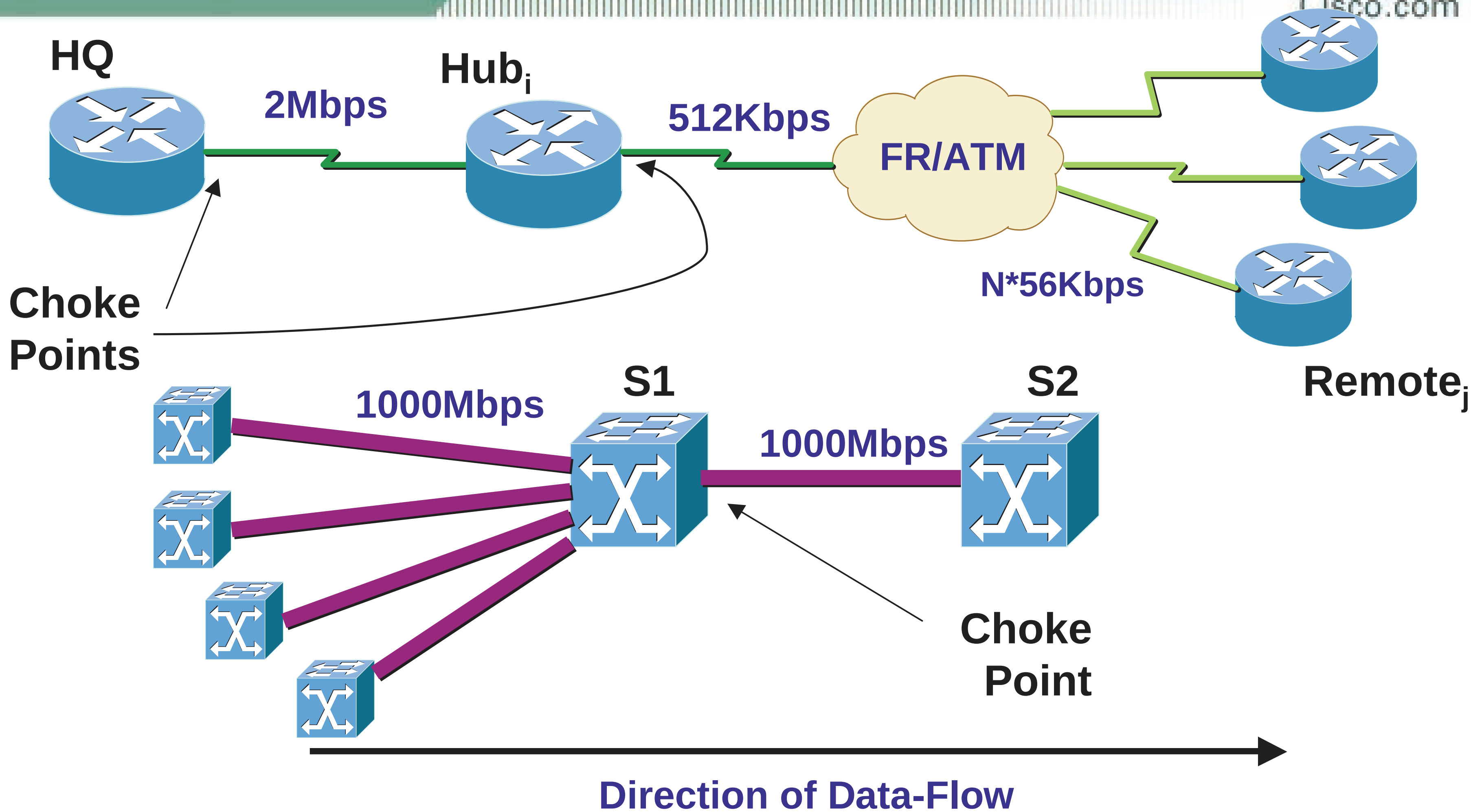
- **Solution to this talked about in the next session—QoS features!**

Why QoS??
Congestion Scenario #1—Speed Mismatch



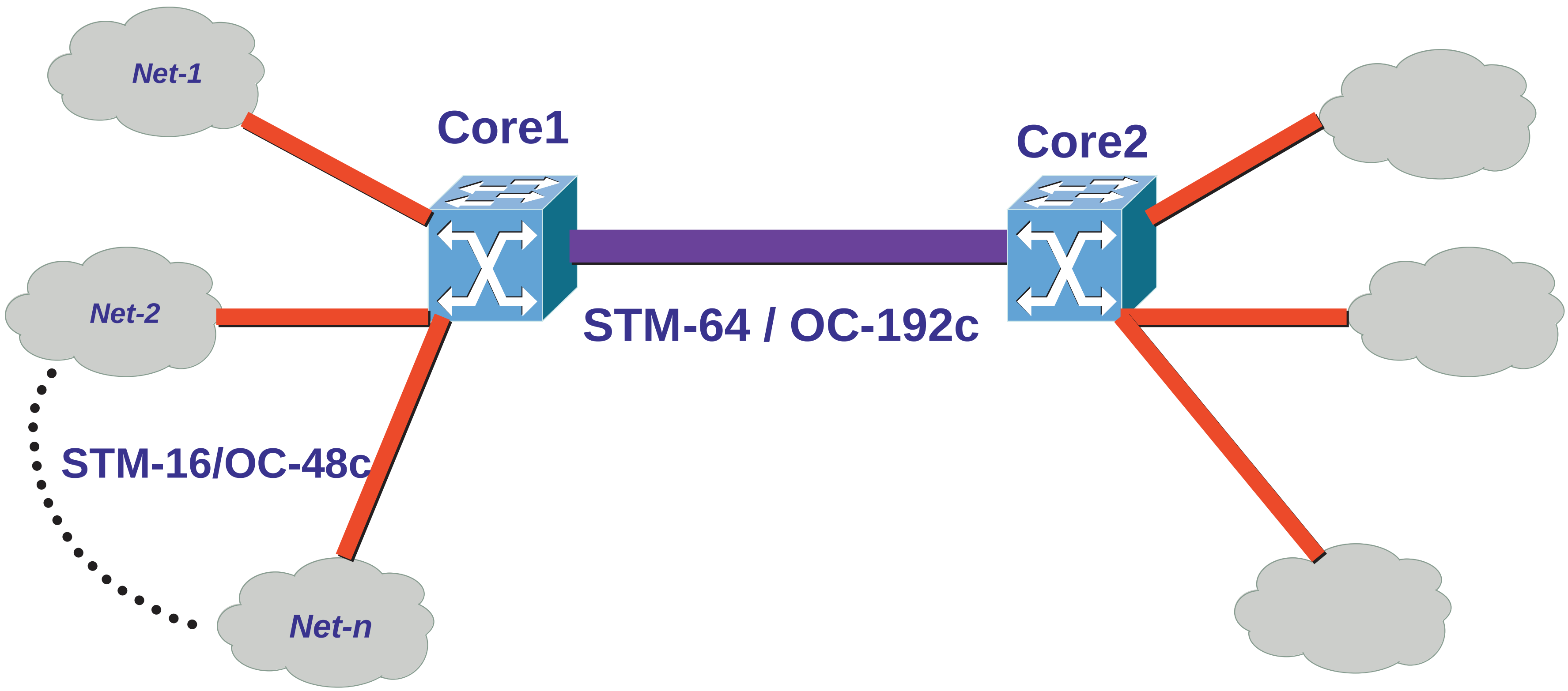
- The #1 reason for congestion!
- Possibly persistent when going from LAN to WAN
- Usually transient when going from LAN to LAN!

Why QoS??
Congestion Scenario #2—Aggregation



- Transient congestion fairly typical!

Why QoS??
Congestion Scenario #3—Confluence



- **Always need mechanisms to provide Guarantees!**
- **Transient Congestion occurs!**

Congestion in Real Networks

It Exists!

24-Hr. Average of Internet Latency
Source: http://average.miq.net

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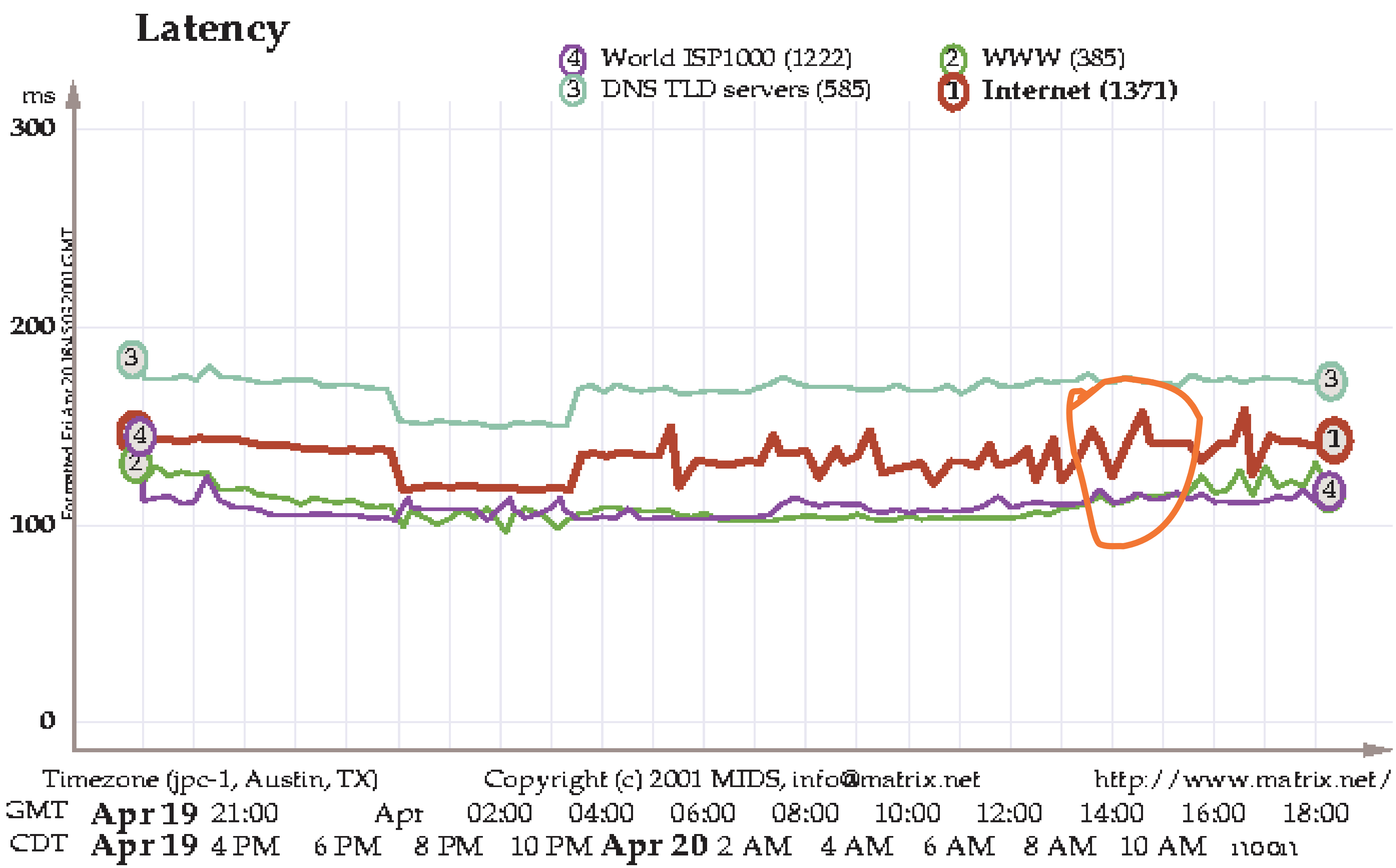

Round-Trip Times on the Net…
Source: http://www-iepm.slac.stanford.edu/

OK

White 0-64ms

Green 64-128ms

Yellow 128-256ms

NOT OK

Pink 256-512ms

Red > 512ms

WORLD	Australasia	East Europe	North America	West Europe	South America	Asia
Australasia	3.95	714.74	300.68	454.68	389.69	373.59
East Europe		359.03	235.66	87.37	278.01	319.64
North America		244.24	69.44	153.23	223.06	203.83
West Europe		385.14	163.32	42.97	260.47	290.68
South America		626.39	421.45	590.69	18.93	780.00
Asia		472.57	327.85	321.99	447.02	24.00
Africa		770.90	804.67	804.15		
Aria			772.00	416.88		
null			501.30			
Middle East			1108.97			
Central America			436.00			

OK within regions, N. America OK with Europe, Japan

The Facts of a 1% Packet-Drop!

Link	Link-Speed	Kilobits Dropped every second if 1% Packet Drop experienced
T-1	1.544Mbps	15.81
T-3	45Mbps	460.8
OC-3	155Mbps	1587.2 ⇨ 1.4Mbits
OC-12	622Mbps	6369.3 ⇨ 6.2Mbits
OC-48	2.4Gbps	25165.8 ⇨ 24Mbits
OC-192	9.6Gbps	100663.3 ⇨ 100Mbits
10GE	10Gbps	104857.6 ⇨ 103Mbits

Why QoS??
QoS for Accountability…

- **In an enterprise network:**
  - **Ensures that real-time traffic gets priority**
  - **Ensures that ERP/business-critical traffic is serviced appropriately**
  - **Ensures that non-critical traffic (Napster, Gnotella, etc.) does NOT consume valuable bandwidth**
  - **Protects against denial of service attacks!**

Why QoS??
The Icing on the High-Availability Cake: QoS!

- **The Service Provider perspective:**

  QoS is a key IP service to offer

  Application-level SLAs is a premium service

  Inter-SP QoS via static agreements

  Enterprise QoS + SP-QoS = end-to-end QoS!

The Bandwidth Pie Is Being Eaten!

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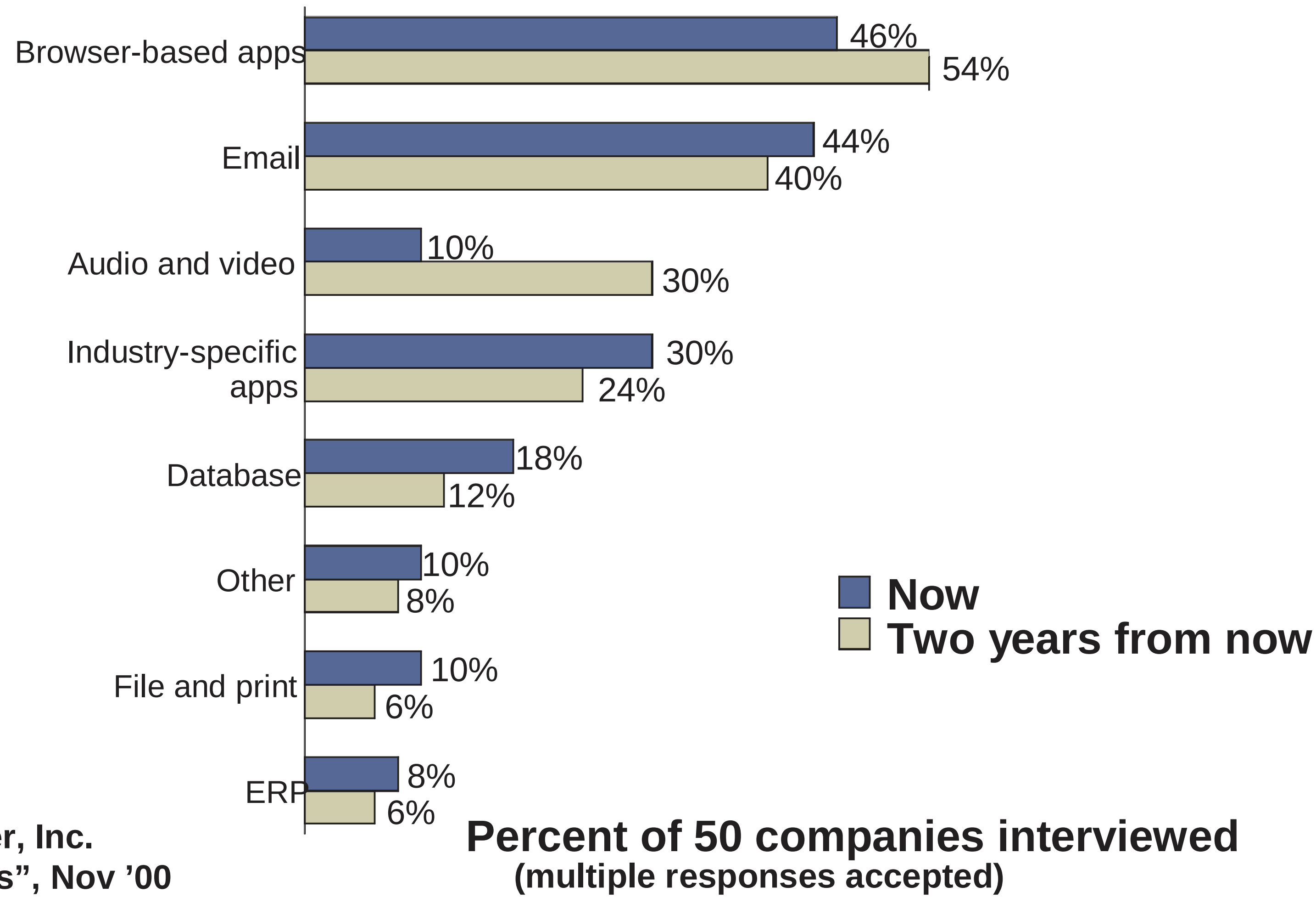
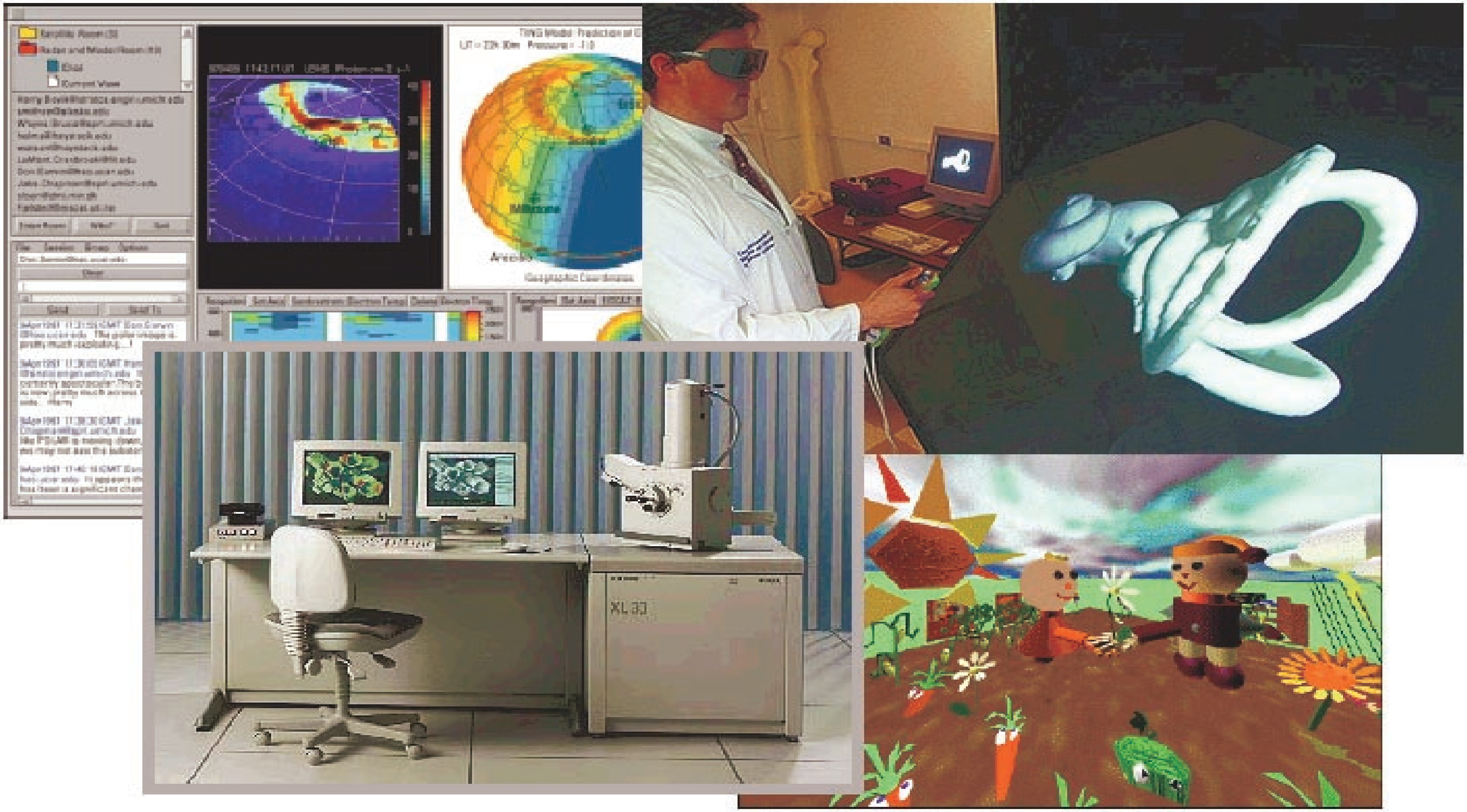
What Applications Dominate Your Bandwidth Needs Now and What Will in Two Years?



Source: Forrester, Inc.
"Where Fiber Fits", Nov '00

Applications Waiting to Happen!



Source: Internet2 QBone WG

Agenda

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QoS Architecture Analogy…

- **Think of the your postal system!**

  A packet ~ letter/package

  A router ~ mail-hub/post-office

  A link ~ land/sea/air routes

Evolution of the QoS Architectures…..

- **Best-Effort IP Service: 1981, RFC-791**

  Compare to Regular Mail Service

- **Integrated Services (IntServ)/RSVP: 1997**

  Imagine a Custom Mail Service

- **Differentiated Services (DiffServ): 1998/99**

  Compare to Mail Service Classes (Express,Priority,Registered,Regular,etc..)

- **DiffServ-Aware Traffic Engineering (DS-TE):**

  Imagine a Custom, Point-to-Point Mail Service

  Technology Is Still Evolving!

Differentiated Services
(DiffServ)

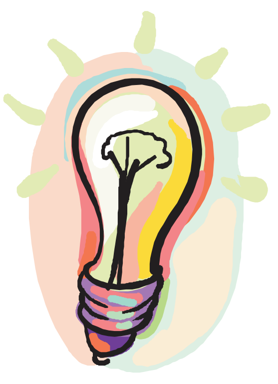
The Formula for Scalable QoS

The IETF DiffServ Model (RFC-2474,2475,2597,2598)

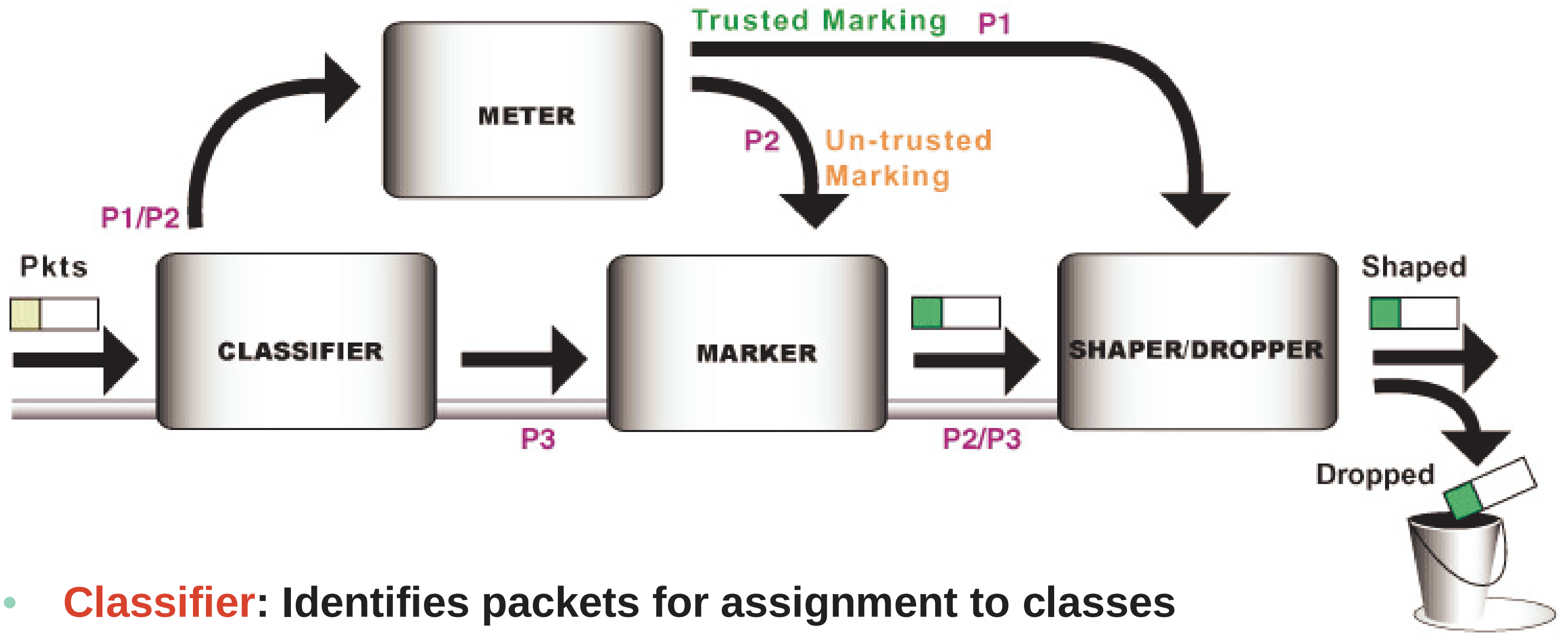
- The idea is VERY simple—Offer service levels for packets: Gold, silver, bronze, etc.
- What is a service?

  “Some significant characteristics of packet transmission in one direction across a set of one or more paths within a network. (E.g. Bandwidth, latency,etc.)”…RFC-2475

- Packets of a particular service are referred to as packets of a particular “class”
- Meaningful services constructed using Per-Hop Behaviors (PHB)



The DiffServ
Traffic Conditioner Block (TCB)

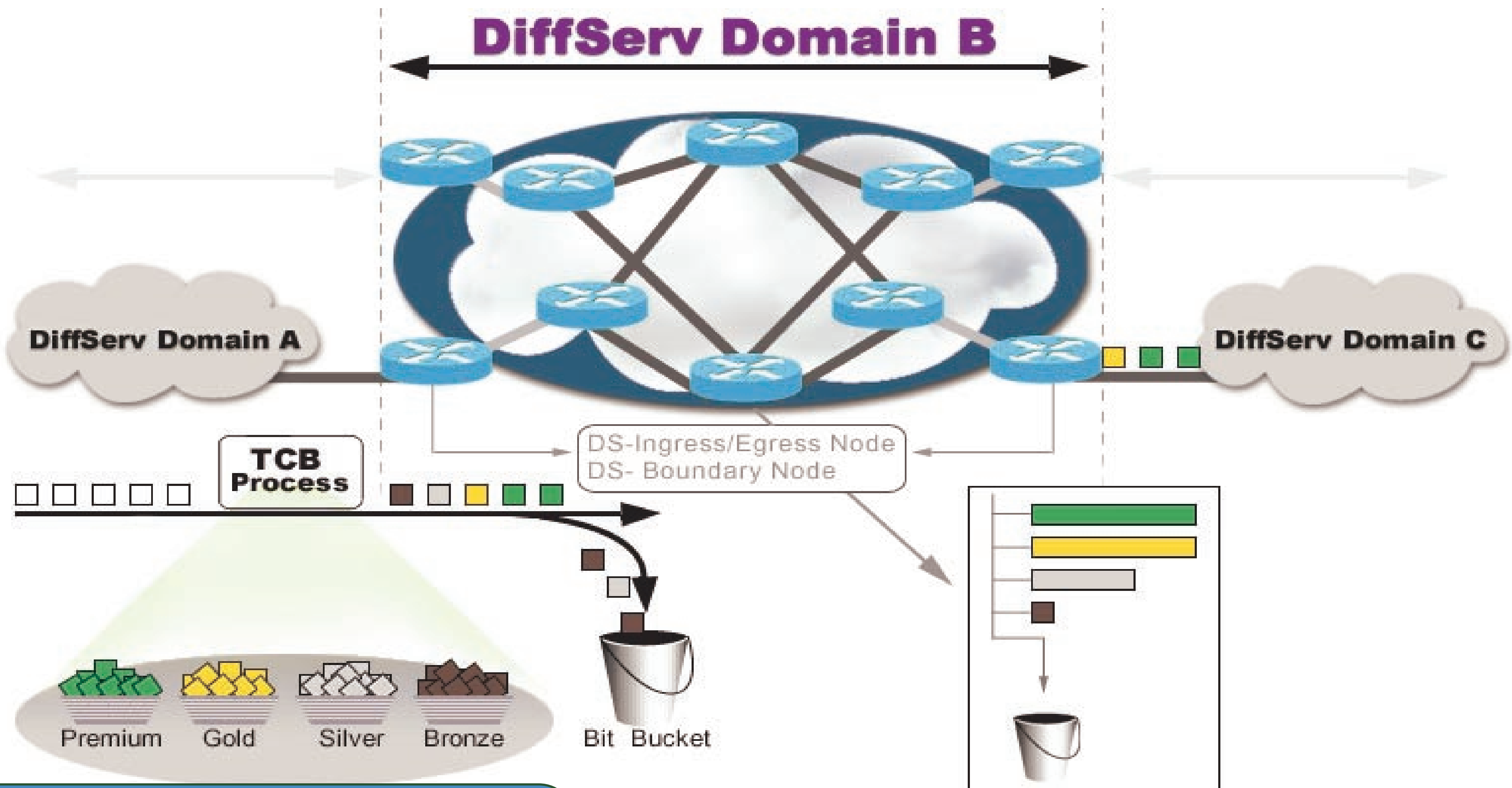


- **Classifier**: Identifies packets for assignment to classes
- **Meter**: Checks compliance to traffic parameters (Token Bucket) and passes result to Marker and Shaper/Dropper to trigger particular action for in/out-of-profile packets
- **Marker**: Writes/rewrites the DSCP value
- **Shaper**: Delays some packets for them to be compliant with the profile
- **Dropper**: Drops packets that exceed the profile (Bc or Be)

The DiffServ Recipe for Constructing Services

- At the ingress network-edge: (Traffic Conditioning Block—TCB)
  1) Classify the packets into ‘classes’
  2) Mark (color) the packets for purposes of classification in the core
  3) Optionally meter a class
  4) If performing (3), police or shape the class (at network ingress and/or egress)
  5) Queue and/or drop packets toward the core
- In the network core: (implementing the PHB)
  6) Queue and/or drop packets

The DiffServ Architecture (RFC-2475)



TCB in Cisco IOS

Class-Based Policing and Shaping

MQC-Based Classification and Marking

Packet "color" in **DSCP**

PHB in Cisco IOS

LLQ and WRED

How DiffServ Works
Step 1: Classifying Packets into Classes

- **The most popular techniques:**
  - Incoming/outgoing interface
  - All/any IP traffic
  - Standard or Extended Access Control List
  - IP RTP Ports (Real-Time Traffic)
  - Source/Destination MAC address
  - DSCP or IP precedence value (If trusted and marked appropriately)
  - MPLS EXP (Experimental Bits) (If trusted and marked appropriately)
  - Network Based Application Recognition (NBAR)
- **E.g.: All VoIP (RTP) packets between UDP ports 16384 and 16484 belong to the “Premium Class”**

The Hook for Scalable IPv4 Packet-Marking and Classification

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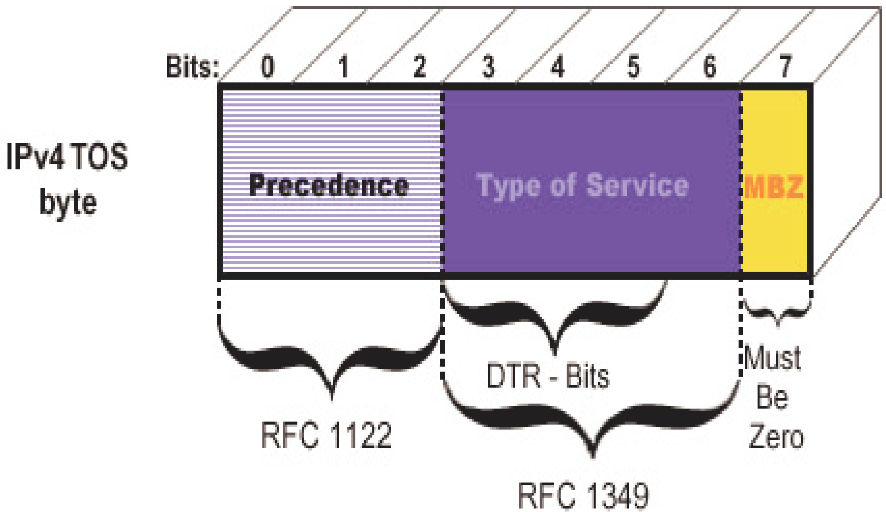
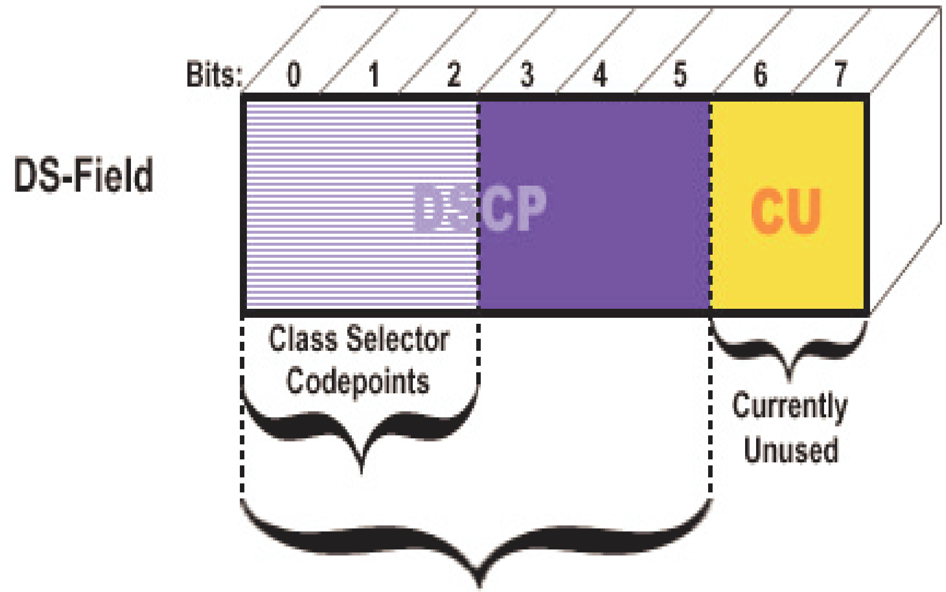
Packets are Marked @ The Edge, for Purposes of Classification in the Core

Version Length	ToS 1 Byte	Len	ID	offset	TTL	Proto	FCS	IP-SA	IP-DA	Data

The IPv4 Header and the Type of Service (ToS) Byte

IPv4 ToS vs. DS-Field (The ToS Byte Is Redefined)





Differentiated Services Codepoint (DSCP)
RFC 2474

Bits (0-2): IP- Precedence Defined

111 - Network Control
110 - Internetwork Control
101 - CRITIC/ECP
100 - Flash Override
011 - Flash
010 - Immediate
001 - Priority
000 - Routine

Bits (3-6): The Type of Service Defined

0000 (all normal)
1000 (minimize delay)
0100 (maximize throughput)
0010 (maximize reliability)
0001 (minimize monetary cost)

Just Remember *"DSCP"*

How DiffServ Works
Step 2: Marking Packets of the Defined Classes

- **Remember that Marking can also be in Layer2!**
- **The most popular techniques:**

  IP DSCP -- Layer 3

  MPLS EXP Bits -- Layer 2.5

  ATM CLP-Bit – Layer 2

  Frame-Relay DE-Bit – Layer 2

  IEEE 802.1Q/p User-Priority Bits – Layer 2

- **E.g.: The Premium Class (VoIP) Packets get marked with IP DSCP – ‘101110’**

How DiffServ Works

Optional Step 3: Metering (The Token Bucket)

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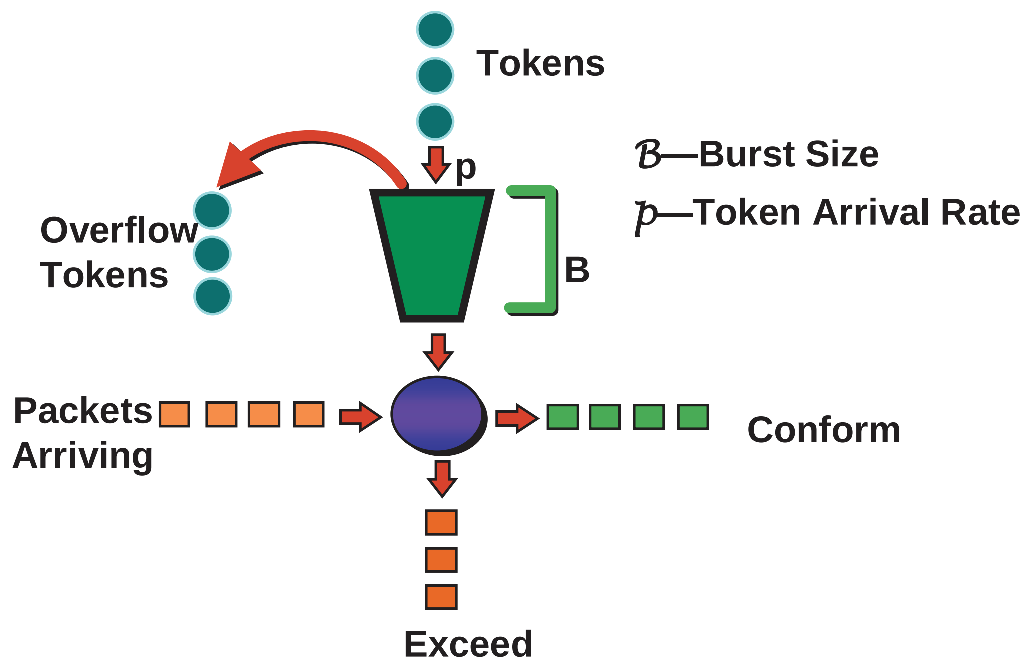
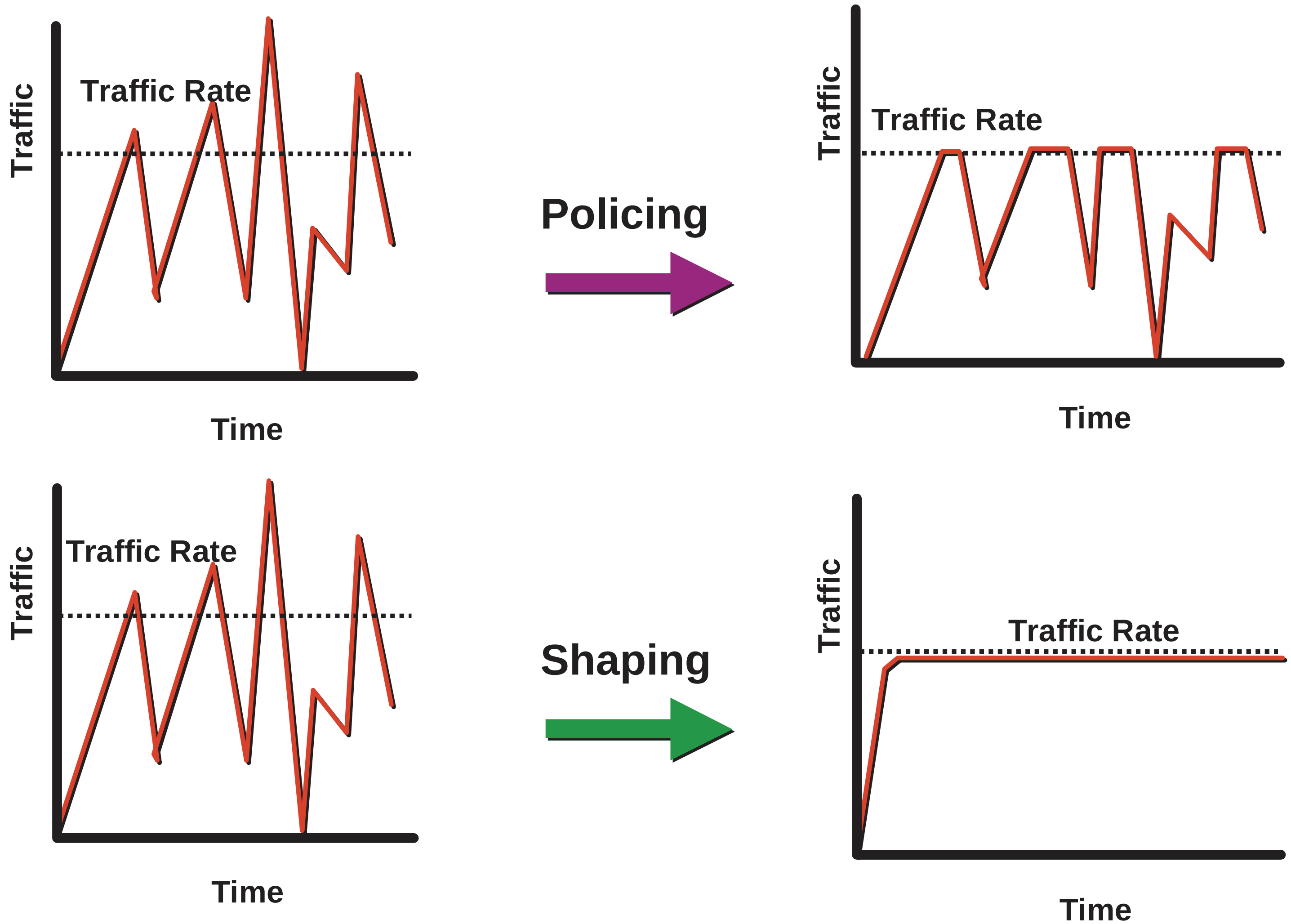
- Tokens Keep Pouring into the Bucket at a Pre-Defined Average-Rate
- If Token Available, Can Transmit a Packet
- Used by Policer and Shaper
- Explained in detail: Next Talk and Sess#: IPS-230

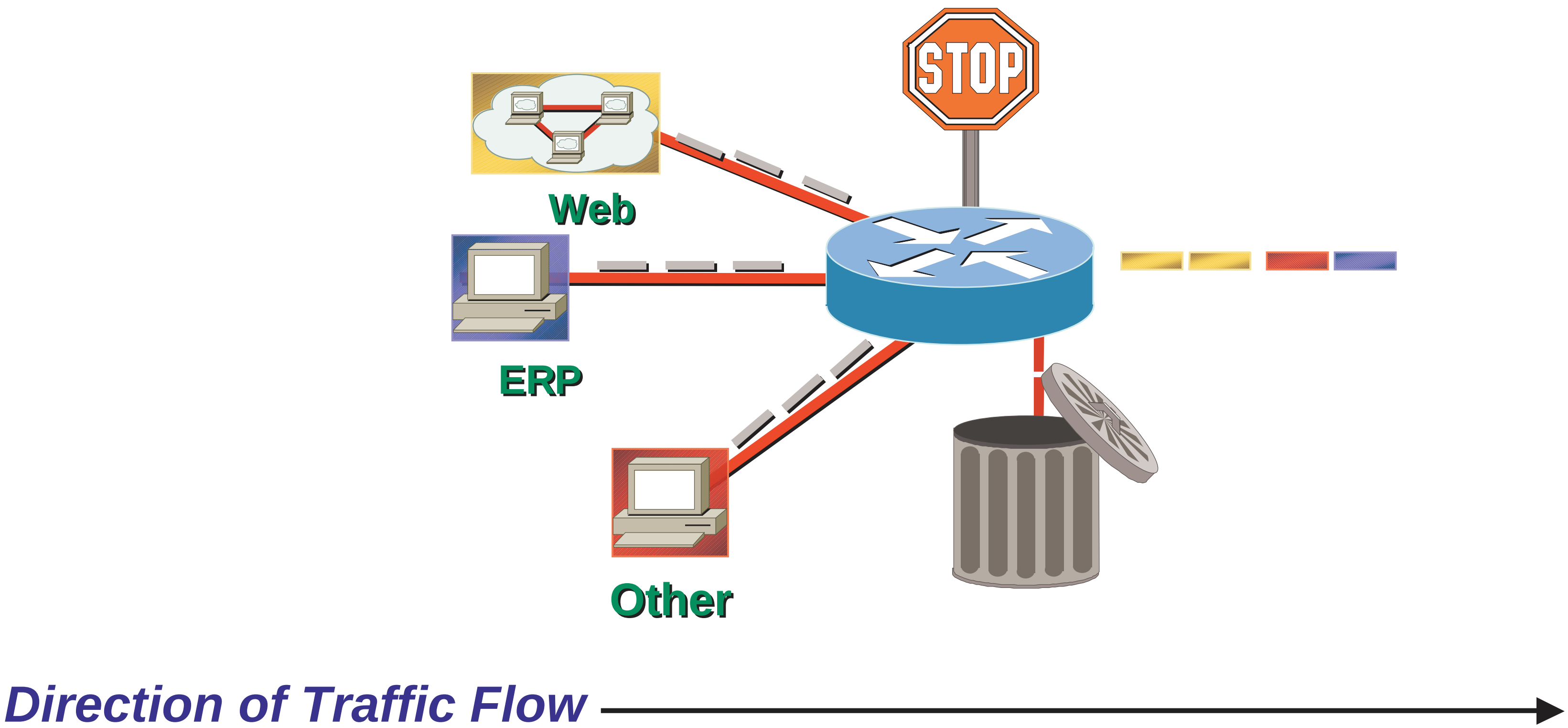


How DiffServ Works
Step 4: Metering ← Policing (Dropping)/Shaping



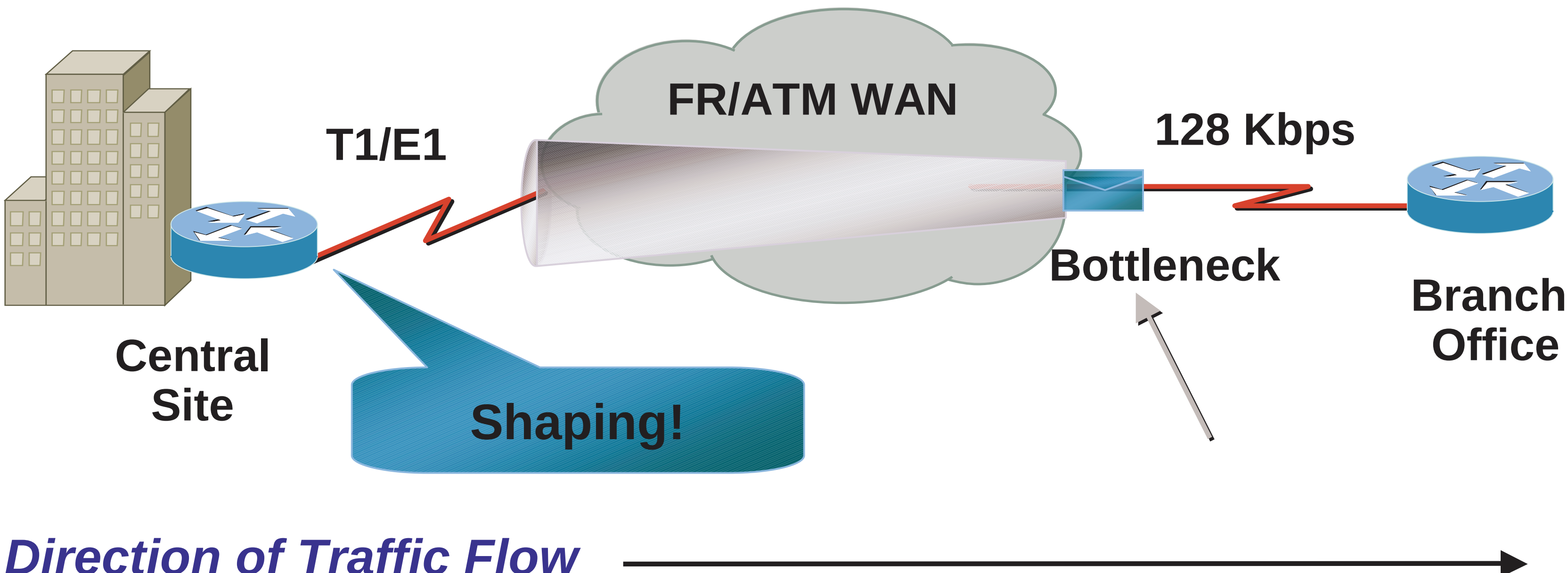
On Policing…

- **Policing is used not only to drop out-of-profile packets, but also to re-mark them, and indicate to dropping mechanisms downstream that they should be dropped ahead of the in-profile packets!**



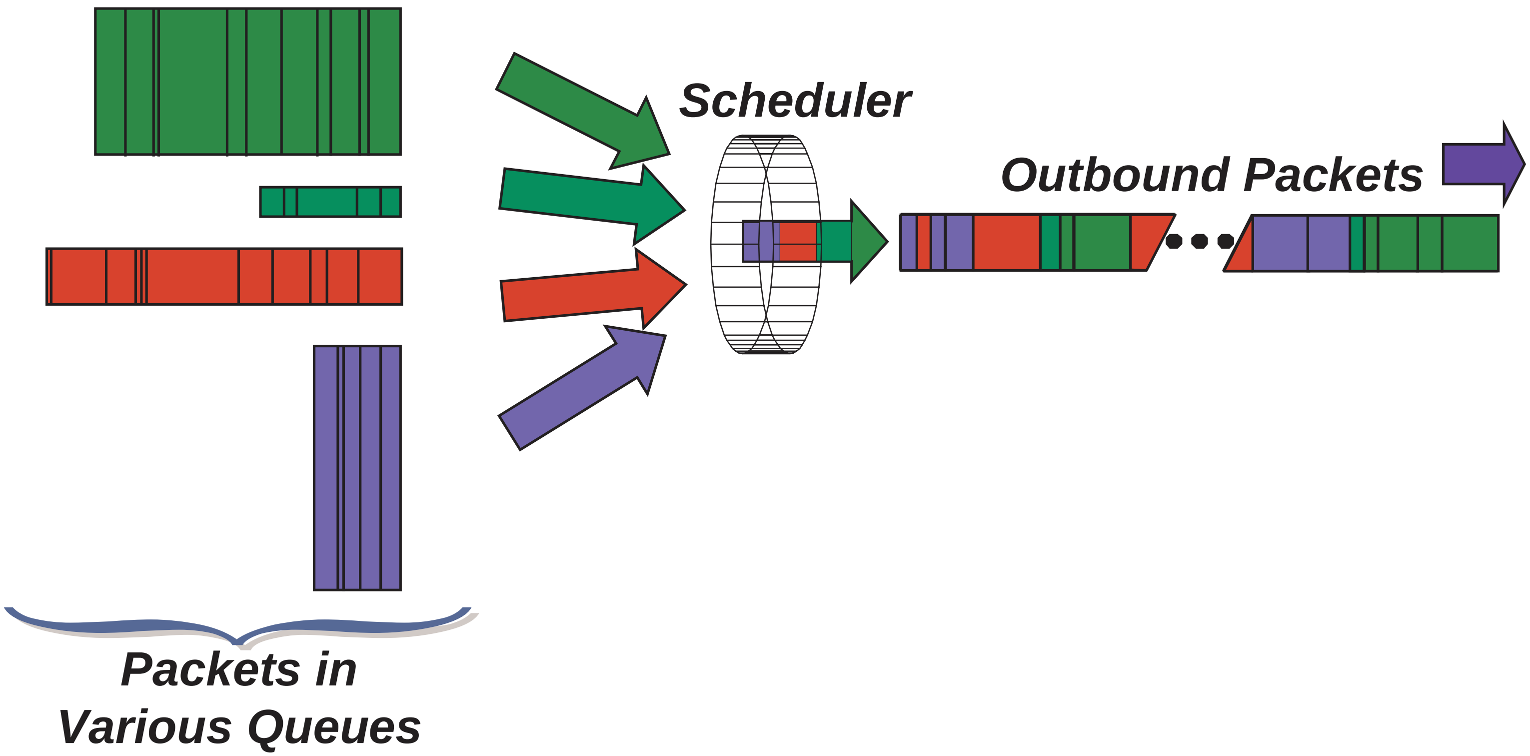
On Shaping….

- Shaping is commonly used where speed-mismatches exist (E.g.: Going from a HQ site with a T1/E1 connection to a Frame-Relay Network, down to a Remote Site with a 128Kbps Connection)
- Shaping involves buffering, and various queuing/scheduling techniques may be used when the shaped rate is reached!



How DiffServ Works
Steps 5 & 6: PHB by Queuing and/ Dropping

- **Queuing refers to: (Congestion Management)**
  - Buffering packets when interface is congested
  - Scheduling packets out of the buffer onto the link (Algorithms: FIFO, CBQ, WRR, etc…)



How DiffServ Works
Steps 5 & 6: PHB by Queuing and/ Dropping (Cont.)

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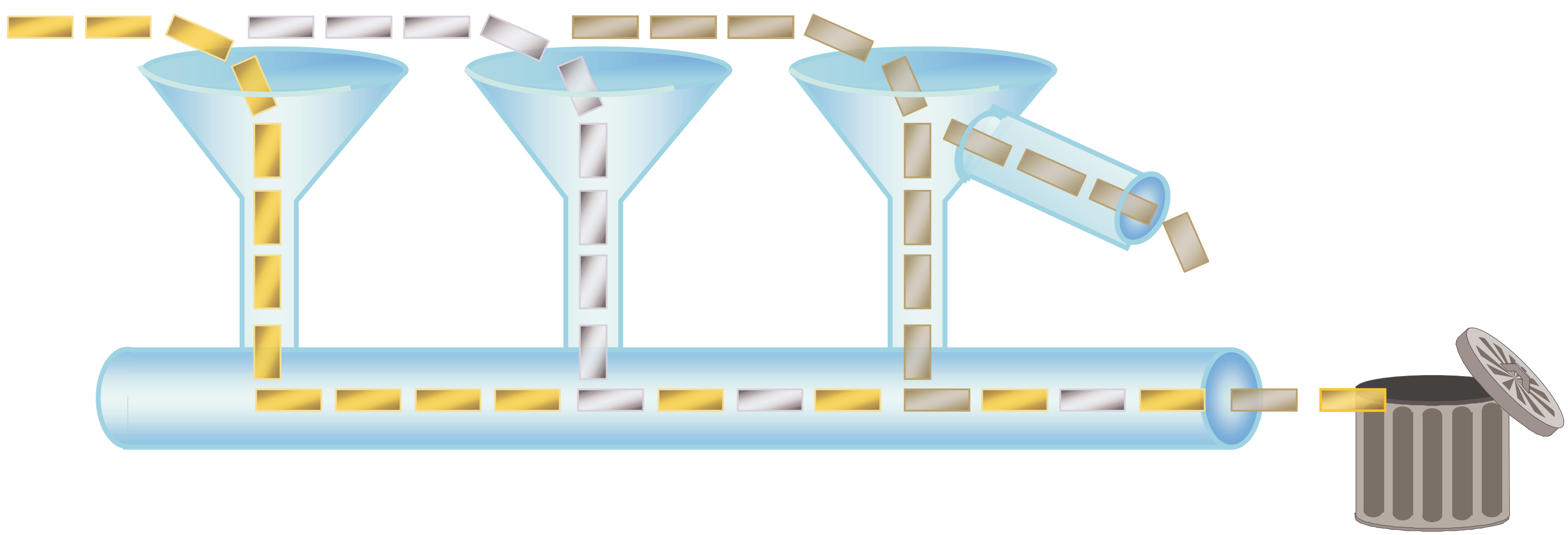
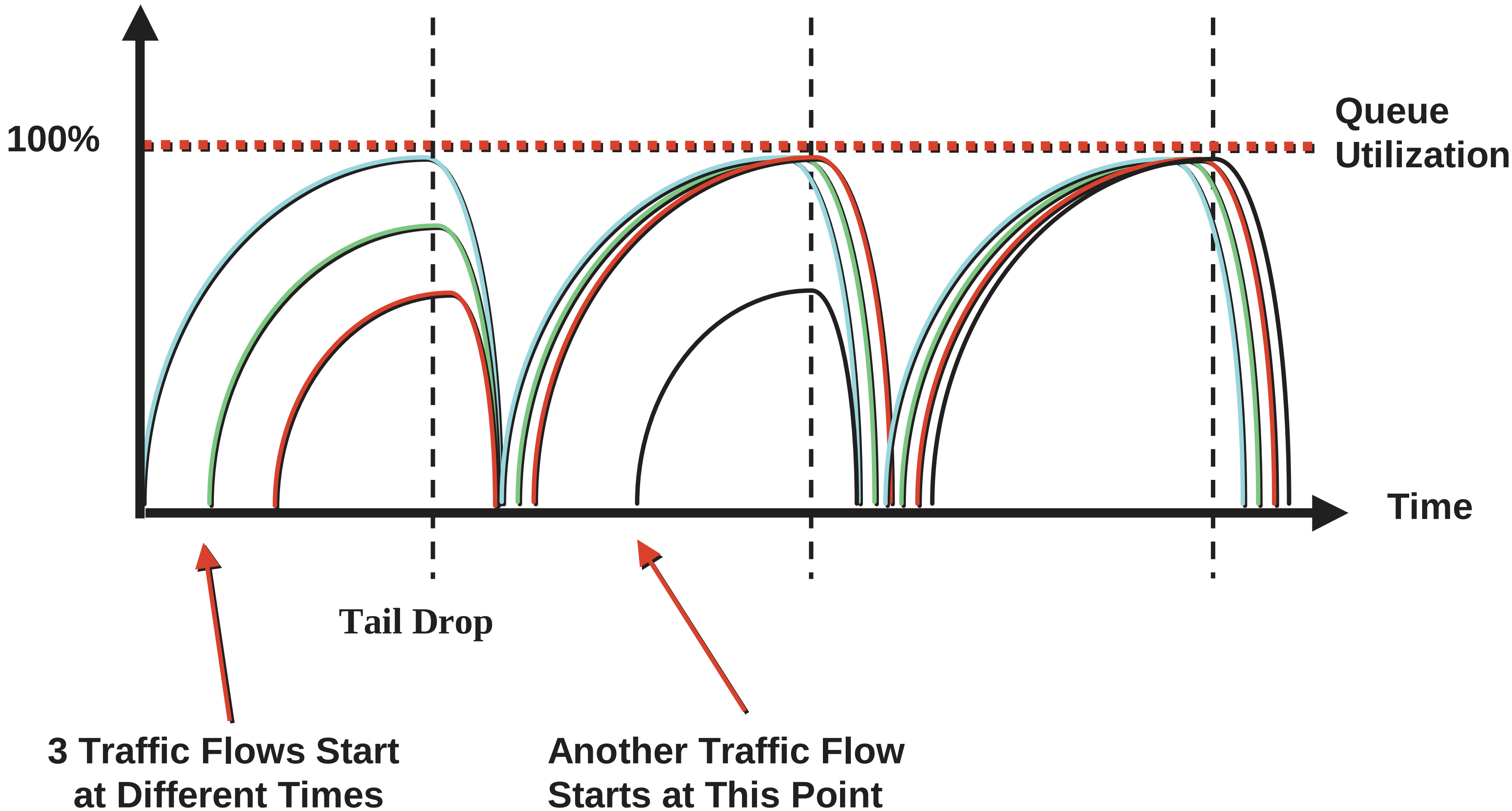
- **Dropping can happen:**
  - **At the edge when policing**
  - **In the edge/core when buffers are exhausted and signal congestion to the end-nodes for back-off (Tail Drop)**
  - **In the edge/core to do congestion avoidance and signal congestion to the end-nodes that can back-off**



A Note on Congestion Avoidance Avoiding Global Synchronization!



A Note on Congestion Avoidance Achieved through Dropping…

- **Definition of Congestion Avoidance:**

  When the physical interface is maxxed out, packet buffers start to fill up. Congestion Avoidance aims to prevent buffer exhaustion, and future congestion by dropping packets in anticipation of the sources backing off!

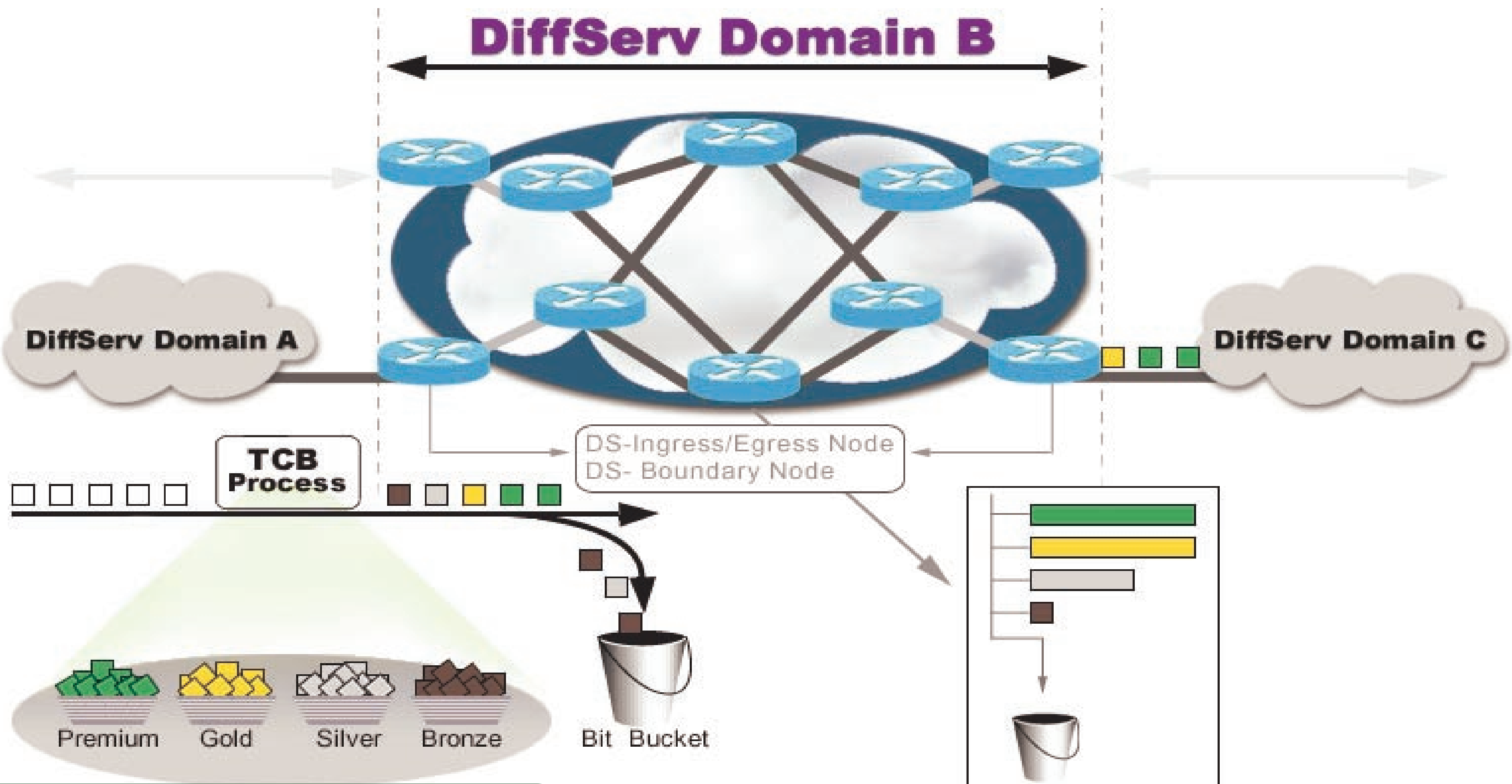
- **The Congestion Mechanisms available are RED (Random Early Detection), and WRED (Weighted RED) – Covered in Session: IPS-230**

- **TCP-Based Applications back-off when packet drop is detected. Other UDP-based Intelligent applications such as RealAudio/RealVideo can also react to congestion signals such as packet loss**

The Various PHBs (Using Queuing and Dropping)

- **Expedited Forwarding (EF): RFC2598**
  - Very low delay, low jitter, assured bandwidth
  - Compare to Express Mail, with Overnight Delivery
- **Assured Forwarding (AF): RFC2597**
  - Assured amount of bandwidth
  - IETF has defined Four AF Classes
  - Compare to Registered Mail – Very safe, and assured
- **Class Selector: Backwards Compatible with IP Precedence for Forwarding Probability (FP)**
  - FP(Precedence (x+1)) ≥ FP(Precedence (x))
  - Compare to FP(Express Mail) ≥ FP(Priority Mail)
- **Default: Best Effort ~ Normal Mail**

The DiffServ Architecture Again…(RFC-2475)



TCB in Cisco IOS

Class-Based Policing and Shaping

MQC-Based Classification and Marking

Packet "color" in **DSCP**

PHB in Cisco IOS

LLQ and WRED

Cisco IOS DiffServ

- Cisco IOS 12.1(5)T,12.2(1)M and later versions are fully compliant with all the Core DiffServ RFCs (RFCs: 2474,2475,2597,2598)
- Compliant Platforms*:

    C26xx, C36xx, C72xx, C75xx

    Other Platforms have most of the pieces

    Full compliancy in the near future…

→ ARM Your Network with DiffServ!

Real-World DiffServ!

EQUANT ANNOUNCES PRIORITY SERVICE FOR URGENT VOICE and DATA TRAFFIC
Equant will support:

Real Time Class -- optimized for toll quality Voice over IP and time-sensitive applications. { The EF PHB }

Interactive Class -- designed to give quick response for business critical applications. { The AF PHB }

Standard Business Class -- suitable for day-to-day business applications, client server traffic and corporate web traffic. { The AF PHB }

General Class -- ideal for email, Internet http traffic and Notes replication. { The AF / Default PHB }

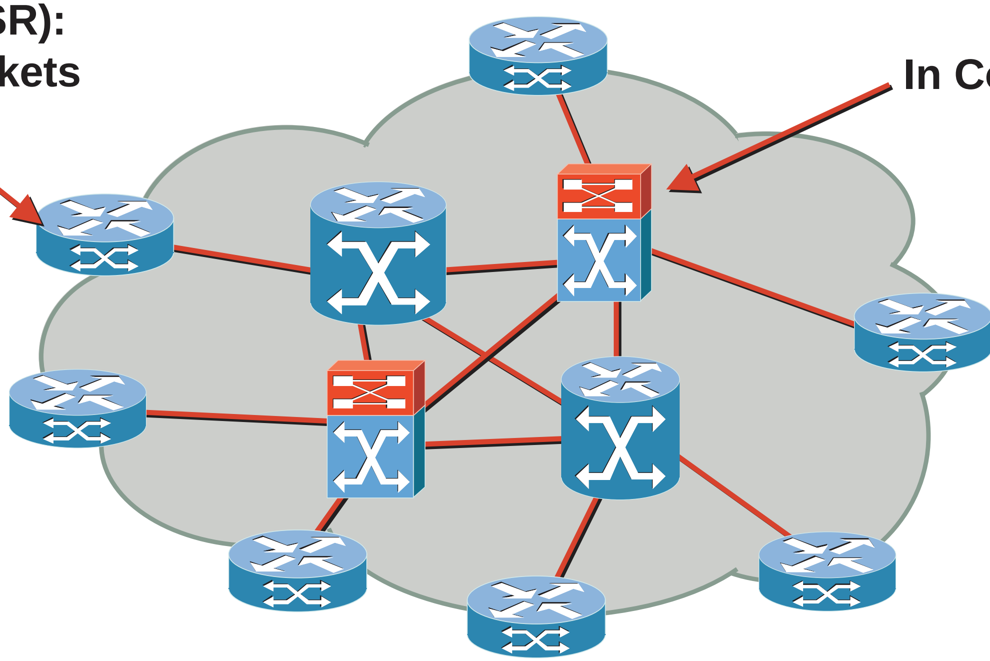
For further information..http://www.equant.com

DiffServ over MPLS

QoS for MPLS Networks

The MPLS Concept
(Employs Label Switch Routers (LSRs))

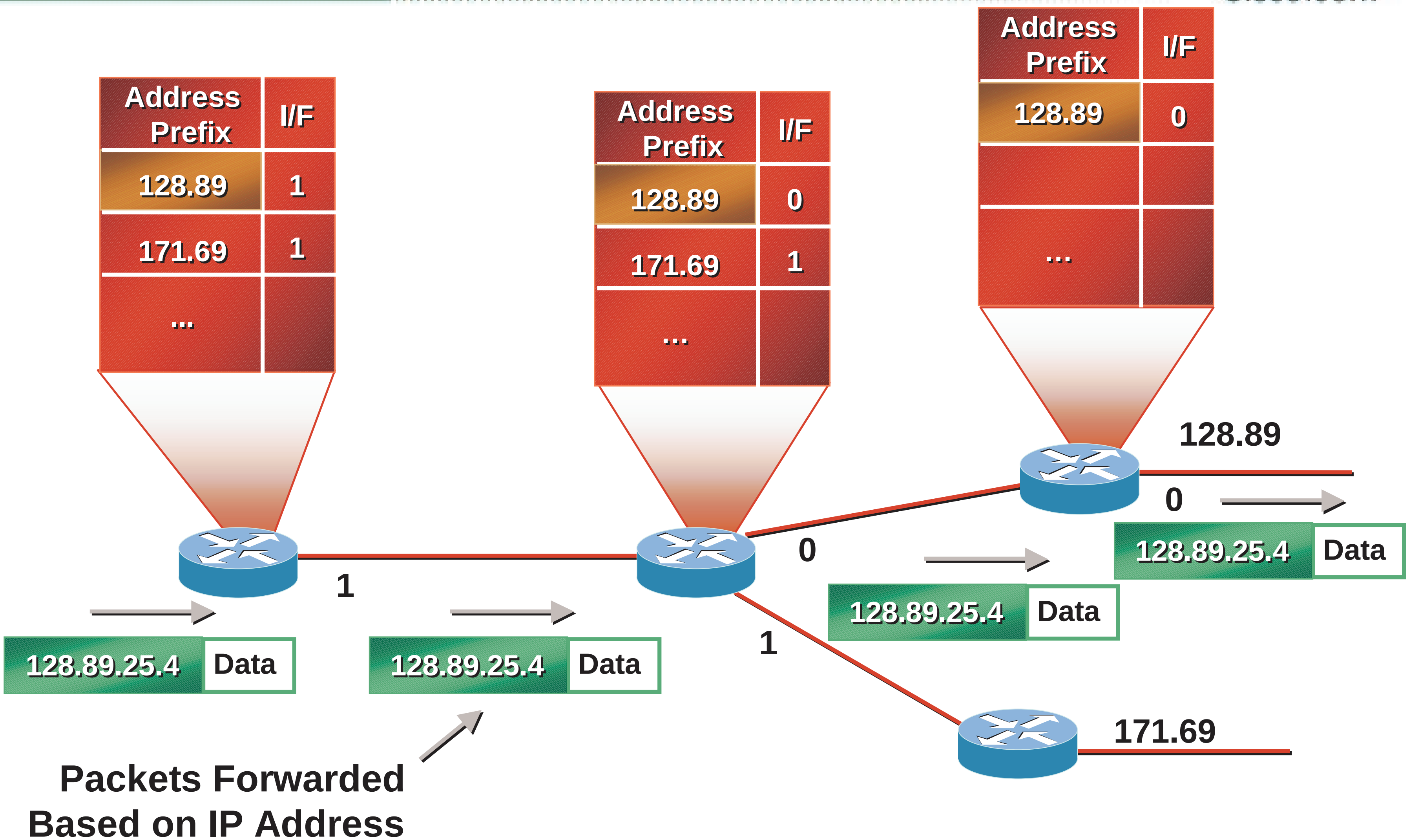
At Edge (Edge LSR):
Classify Packets
Label Them



In Core (LSR):
Forward Using Labels
As Opposed to IP Addr

- **Forwarding Using Labels!**
- **MPLS-VPNs and MPLS Traffic Engineering are the KEY Applications**

Regular IP Forwarding…



MPLS Forwarding…

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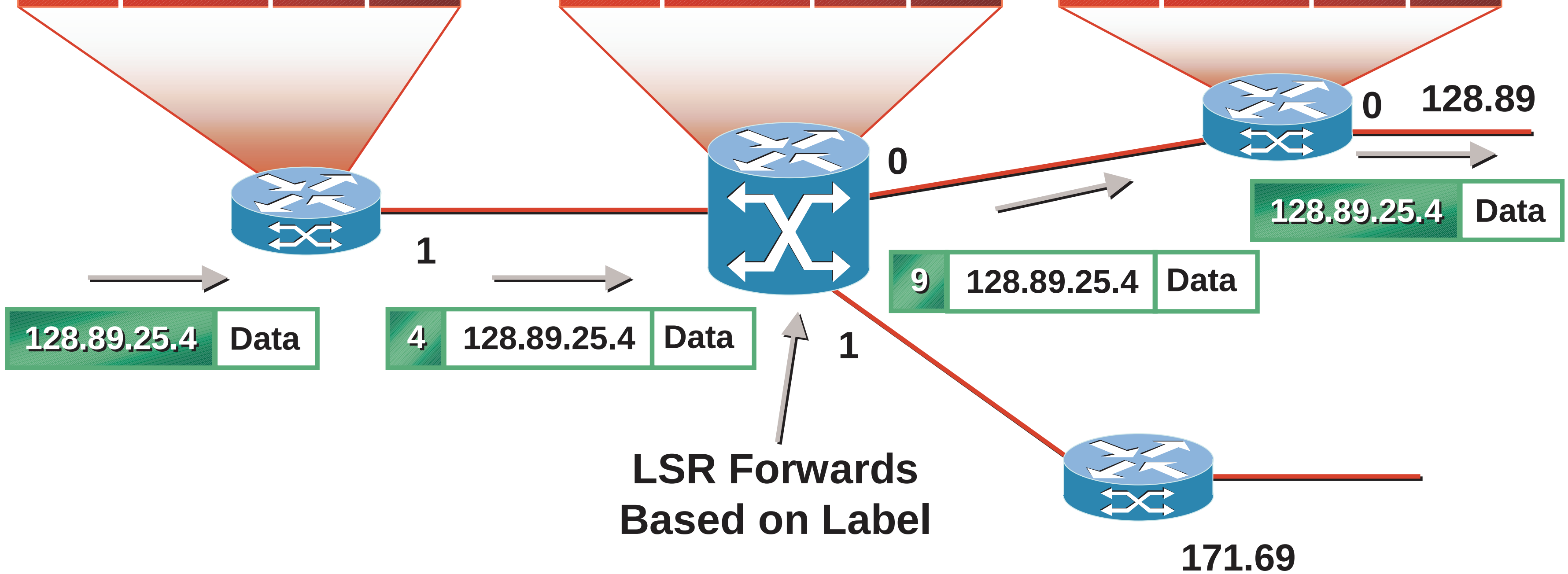
In Label	Address Prefix	Out I'face	Out Label
-	128.89	1	4
-	171.69	1	5
...	...	...	...

In Label	Address Prefix	Out I'face	Out Label
4	128.89	0	9
5	171.69	1	7
...	...	...	...

In Label	Address Prefix	Out I'face	Out Label
9	128.89	0	-
...	...	...	...



DiffServ Scalability via Aggregation

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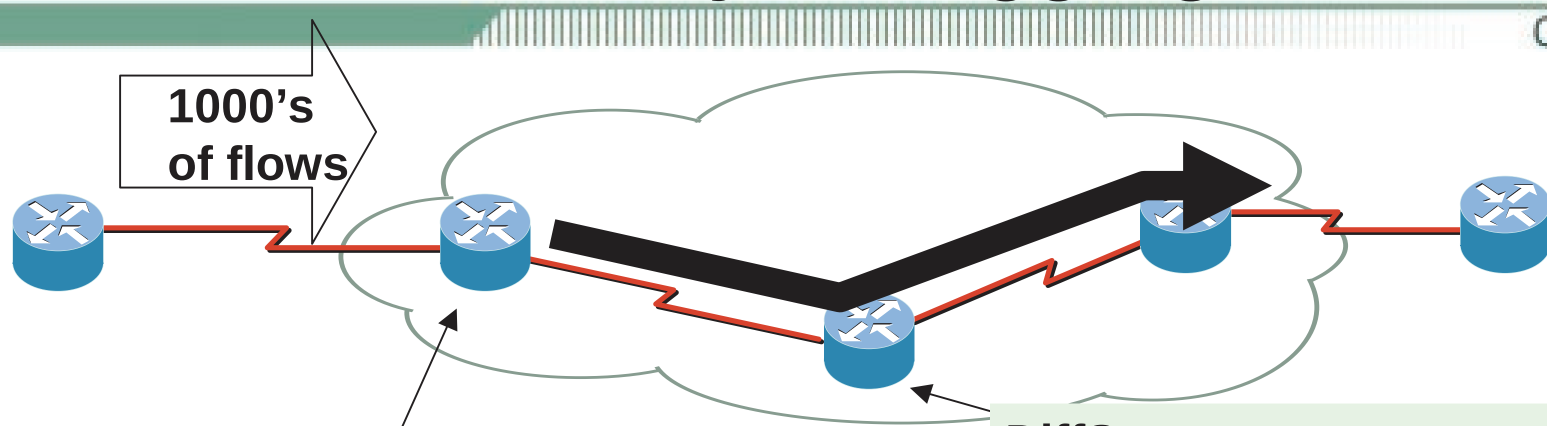


DiffServ:

Aggregation on Edge

Many flows associated with a Class (marked with DSCP)

DiffServ:

Aggregated Processing in Core

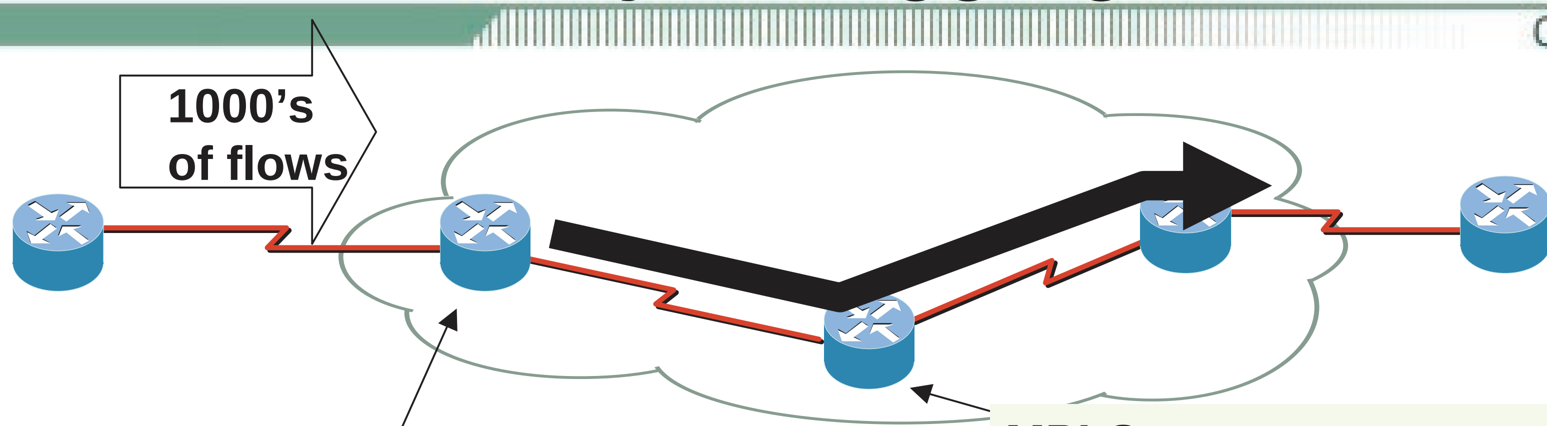
Scheduling/Dropping (PHB) based on DSCP

- **DiffServ scalability comes from:**

  Aggregation of traffic on Edge

  Processing of Aggregate only in Core

MPLS Scalability via Aggregation



MPLS:

Aggregation on Edge

Many flows associated with a Forwarding Equivalent Class (marked with label)

MPLS:

Aggregated Processing in Core

Forwarding based on label

- **MPLS scalability comes from:**

  Aggregation of traffic on Edge

  Processing of Aggregate only in Core

MPLS and DiffServ— The Perfect Match!

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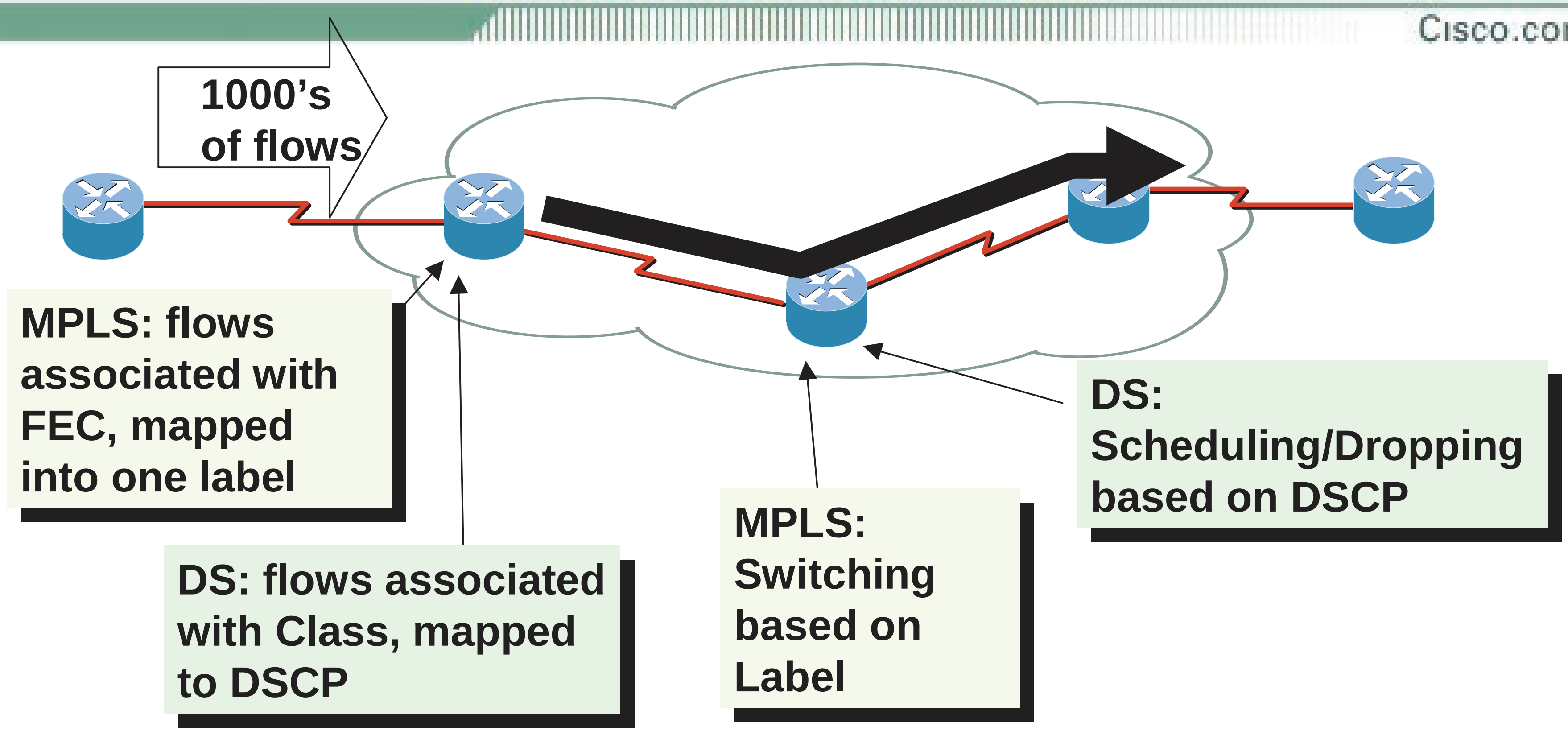

- **Because of same scalability goals, both models do:**
  - Aggregation of traffic on Edge
  - Processing of Aggregate only in Core

MPLS—So What's New? The Shim Header!!

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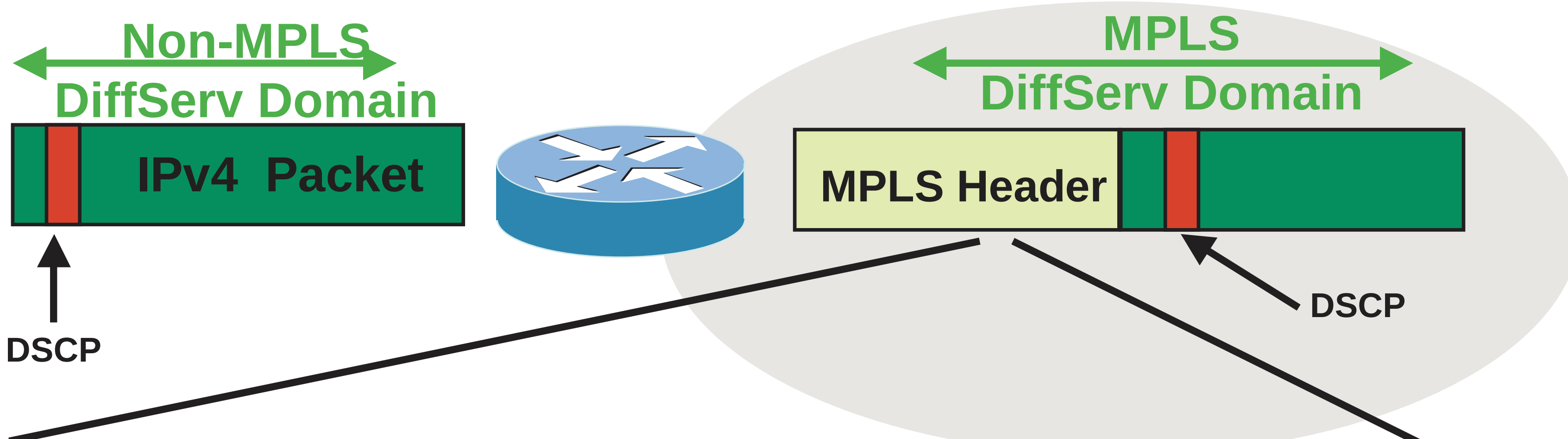


```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Label                  | EXP |S|      TTL      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- The DSCP field is not directly visible to MPLS Label Switch Routers (they forward based on MPLS Header)
- Information on DiffServ must be made visible to LSR in the MPLS Header (using EXP field/Label)

DiffServ over MPLS: On Classification for QoS

- This describes how "DiffServ" information is conveyed to LSRs in MPLS Header
- Two methods:

  E-LSP {{ Cisco IOS 12.1(5)T, 12.0(11)ST }}

  "Queue" inferred from Label and EXP field

  "Drop priority" inferred from label and EXP field

  L-LSP {{ Planned, once an RFC }}

  "Queue" inferred exclusively from Label

  "Drop priority" inferred from EXP field

→ *For More Information on MPLS-QoS, please attend*

Sessions: PS-542 and RST-231

Integrated Services (IntServ with RSVP)

The Control Plane for QoS

The Fundamentals of IntServ (RFC-2210, 2211,2212,2215)

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- Preserve the End-to-End Semantics of IP for QoS
- Key end-points are The Senders and The Receivers
- Applications request desired Service from the Network for a Set of Microflows
- Definition of a Microflow (MF – The 5-Tuple):

  Source Address

  Destination Address

  Transport Protocol

  Source Port#

  Destination Port#
- E.g.: A VoIP Call (Two MFs: From Me to You and From You to Me)

  → Imagine a Custom Postal-Service for You!!

The Three IntServ Components

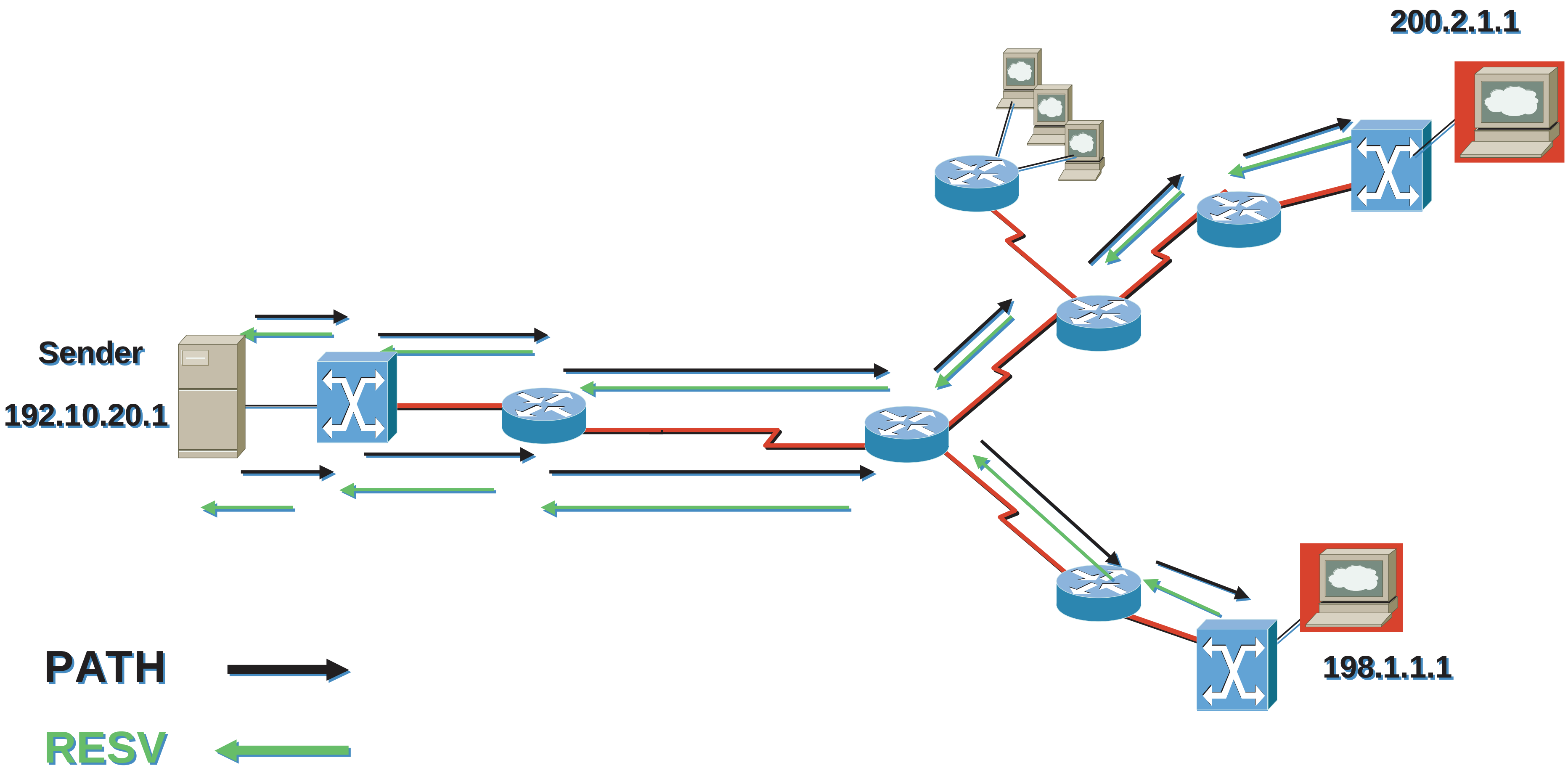
- Specification of WHAT The Sender is Sending: (Rate,MTU,etc.)—The TSpec
- Specification of WHAT the Receiver Needs: (Bandwidth,Path MTU, etc.)—The RSpec
- Specification of HOW the Signaling is Done to the Network by the Sender and the Receiver:

  RSVP is the Signaling Protocol for IntServ (Resource ReSerVation Protocol)

The Motivation for IntServ/RSVP
VoIP and Video

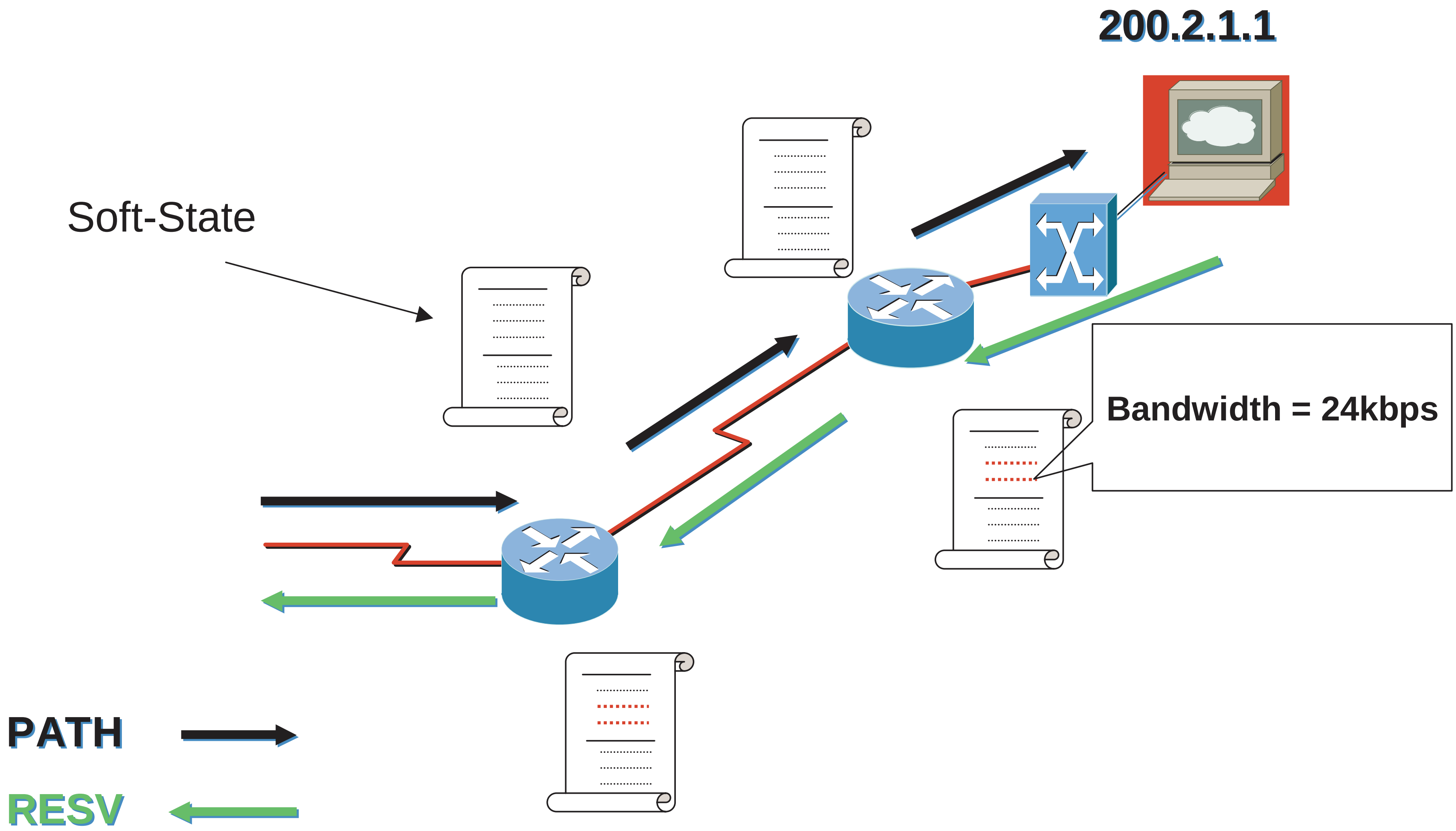
- VoIP and Video work great with the DiffServ EF PHB
- But…
  - DiffServ has no concept of a Call
  - Admission Control may be necessary
- RSVP for:
  - Signaling resources for a Call
  - Maintaining and Tearing down resources

RSVP Operation at a Glance



Note that there are 2 Separate Reservations!

RSVP: What Happens within the Routers



The Pros and Cons of IntServ/RSVP

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- **Pros:**
  - Fairly Automatic QoS! Only thing to provision is RSVP bandwidth on Interfaces
  - Integrates well with a Policy Infrastructure (COPS - Common Open Policy Service)
  - Microflow granularity for QoS
- **Cons:**
  - State and Signaling overhead for large networks
  - Constant Refresh Messages
  - Per-flow Classification,Policing,Queuing, and Scheduling is a significant overhead with very large # of flows

IntServ/RSVP Support in Cisco IOS

- Recommended IOS 12.1(5)T/12.2(1)M
- Supported Platforms:

  C8xx, C17xx, C26xx, C36xx, C72xx, C75xx

- Deployed mainly in Enterprises
- Upcoming IntServ/RSVP-DiffServ Integration very important for highly-scalable and Ubiquitous Deployments!

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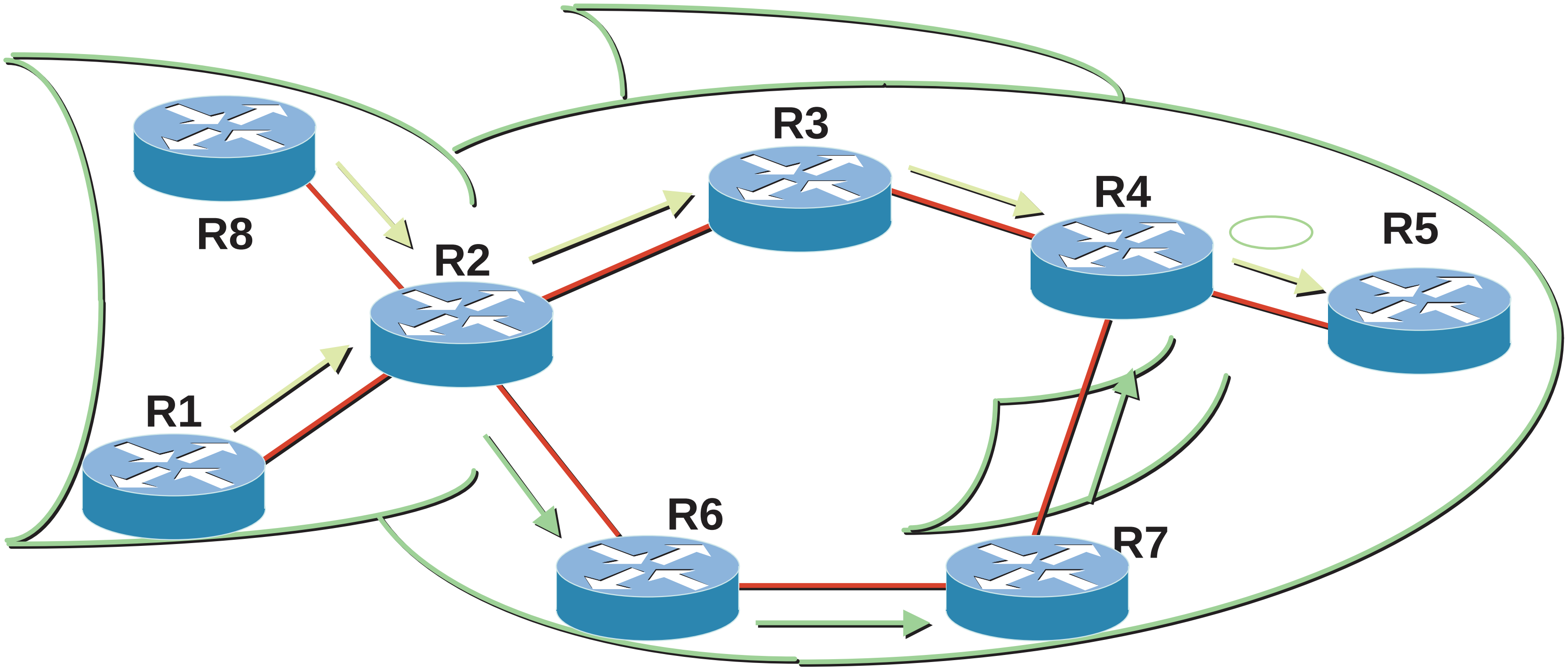
DiffServ-Aware Traffic Engineering

A Brief Overview

The “Fish” Problem



- IP Uses Shortest Path Destination-Based Routing
- Shortest Path May Not Be the only path
- Alternate Paths May Be under-Utilized while the Shortest Path Is over-Utilized

Basic Traffic Engineering—MPLS TE
(Find and Set up A Path of Bandwidth 'X')

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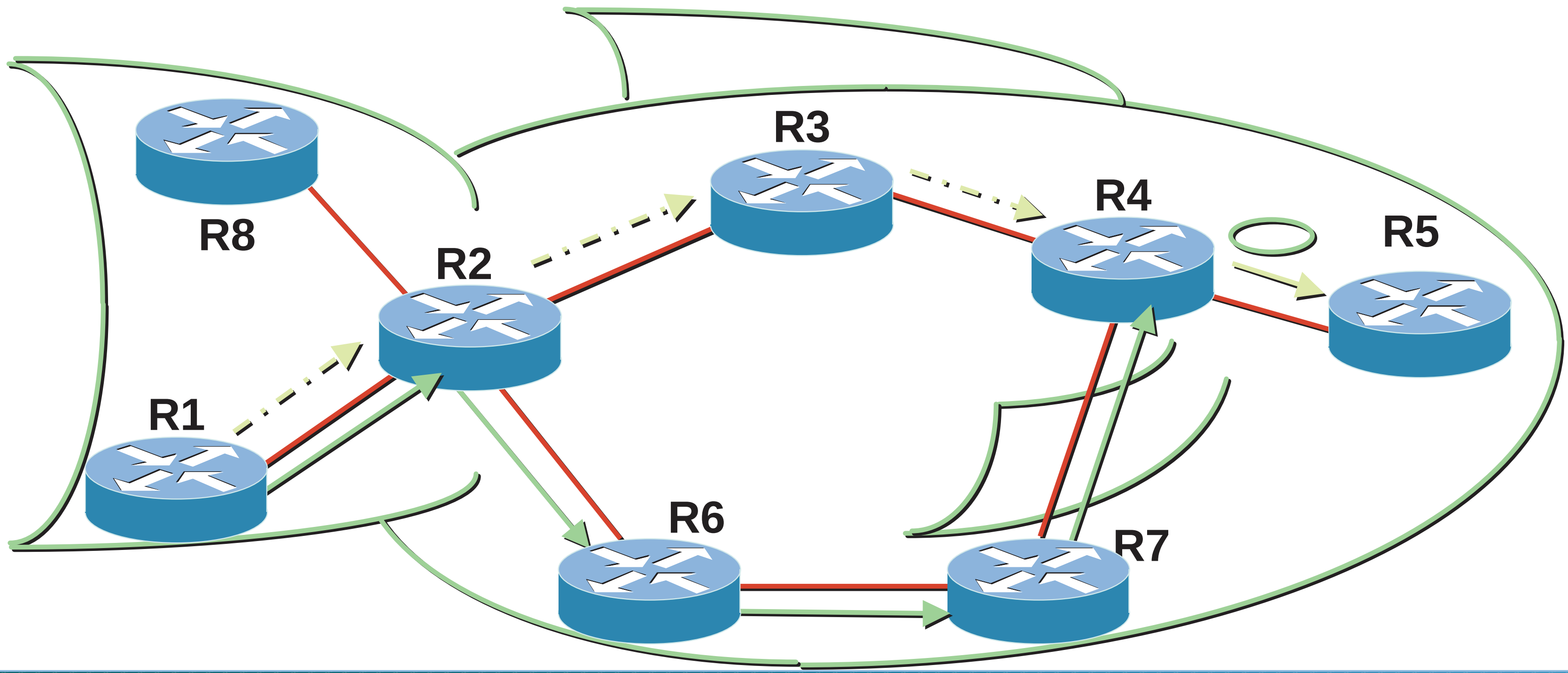
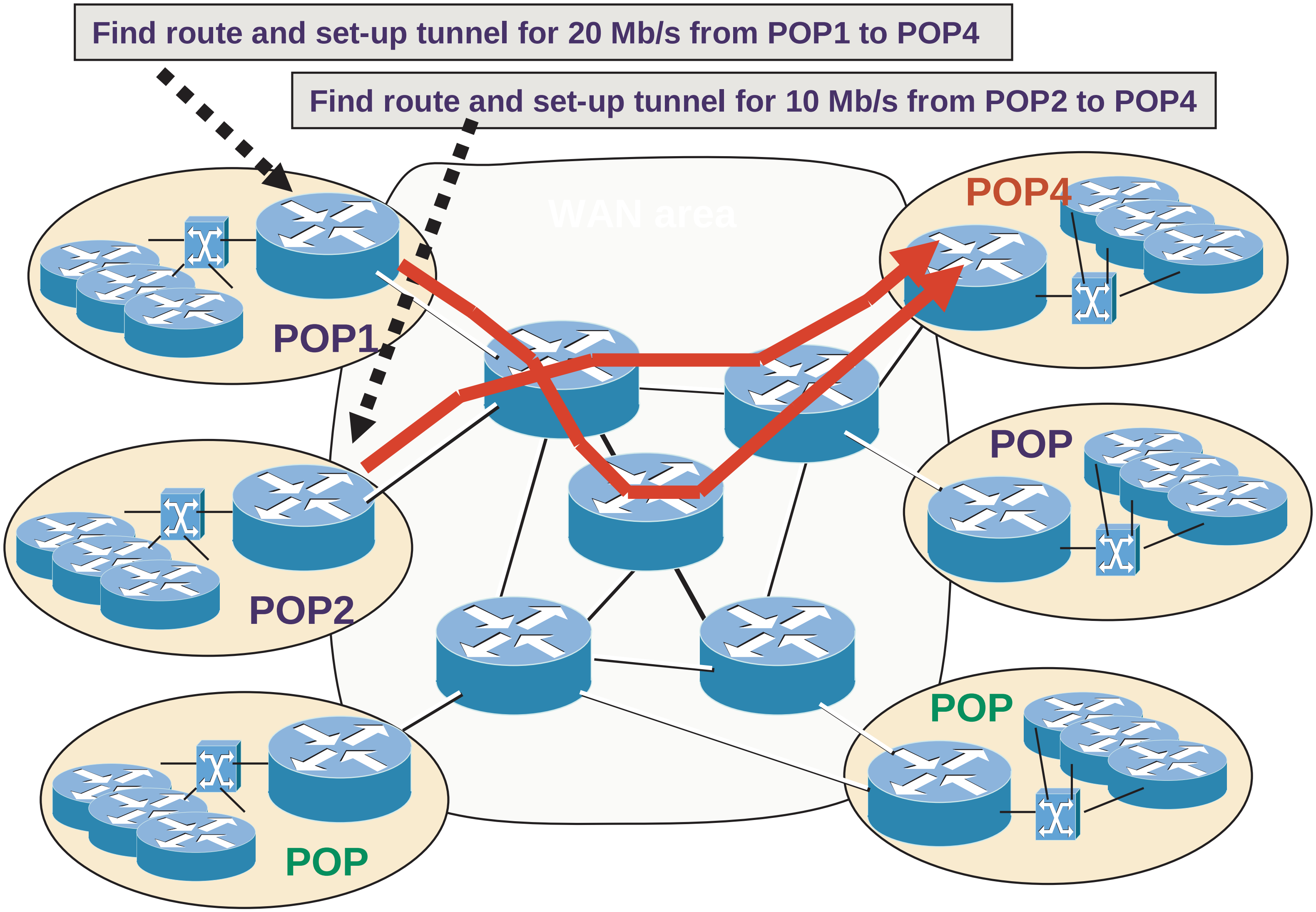


Labels, Like VCIs (ATM) Can Be Used to Establish Virtual Circuits

Normal Route R1->R2->R3->R4->R5

Tunnel: R1->R2->R6->R7->R4

Real-World MPLS TE Use!



The Motivation for DiffServ-Aware TE
(Delay/Load Trade-Off: Difficult To Do!)

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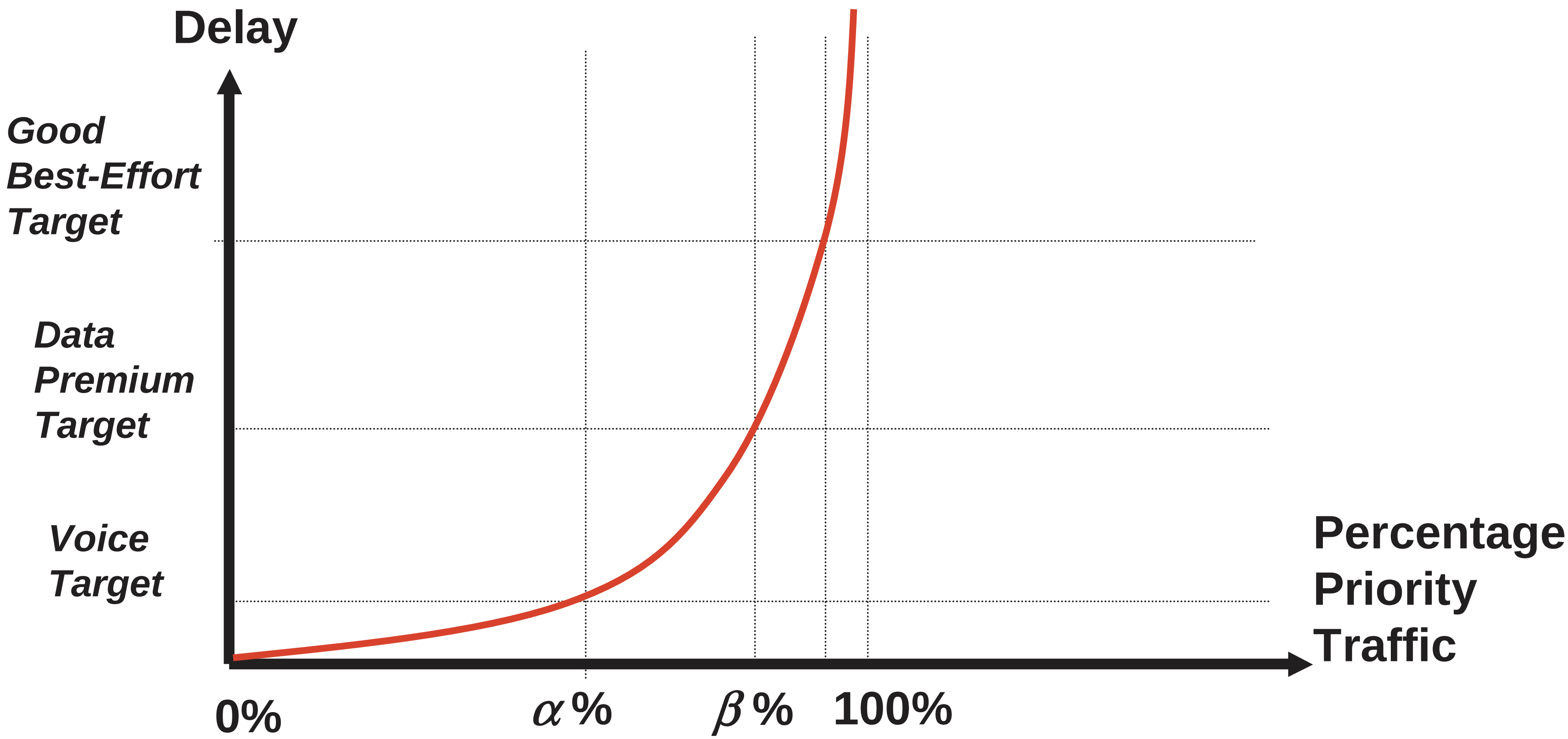

If I can keep EF traffic < α% , I will keep EF delay under *M1* ms
If I can keep AF1 traffic < β% , I will keep AF1 delay under *M2* ms

DiffServ-Aware Traffic Engineering (DS-TE)

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- The Recipe…Above and Beyond Basic TE:

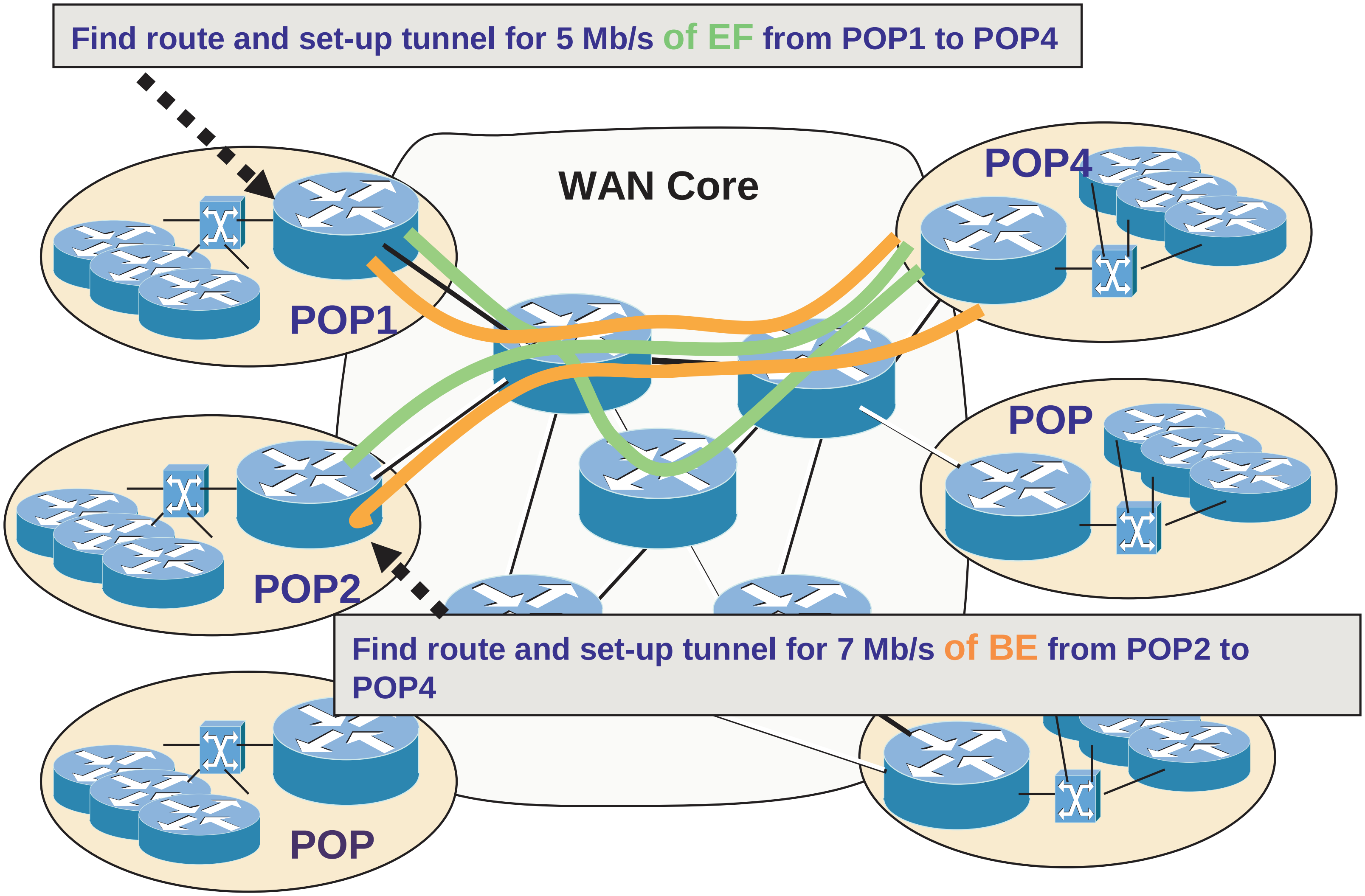
  Configure Available Bandwidth for Multiple Traffic Classes On ALL relevant Interfaces (Keeping in Mind the Required Ratios)

  Advertise Available Bandwidth for Multiple Traffic Classes (Premium, Gold, Silver, etc..)

  Separate Tunnels for each Class

- Detailed Discussion in Session#: RST-231

Real-World DS-TE Use!



Guaranteed Bandwidth Services
(DiffServ o MPLS + DS-TE = GB Services)

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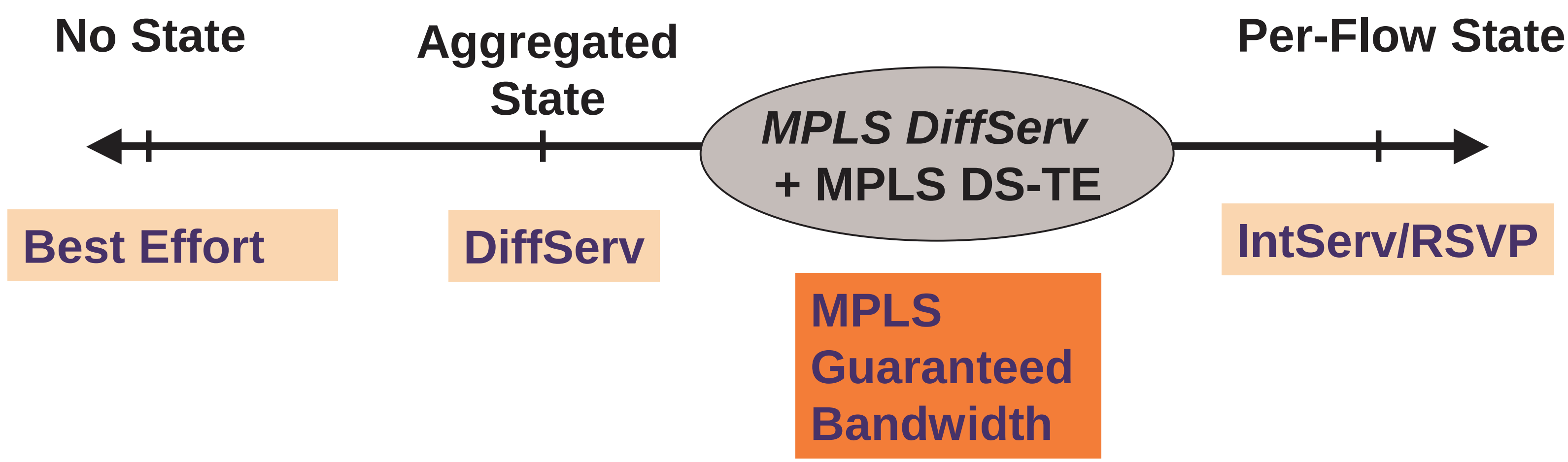
- **Combining DiffServ over MPLS and DS-TE to achieve strict Point-to-Point QoS guarantees**
- **A new "sweet-spot" on the QoS Spectrum**

Aggregated State (DiffServ)
Aggregate Admission Control (DS-TE)
Aggregate Constraint Based Routing (DS-TE)



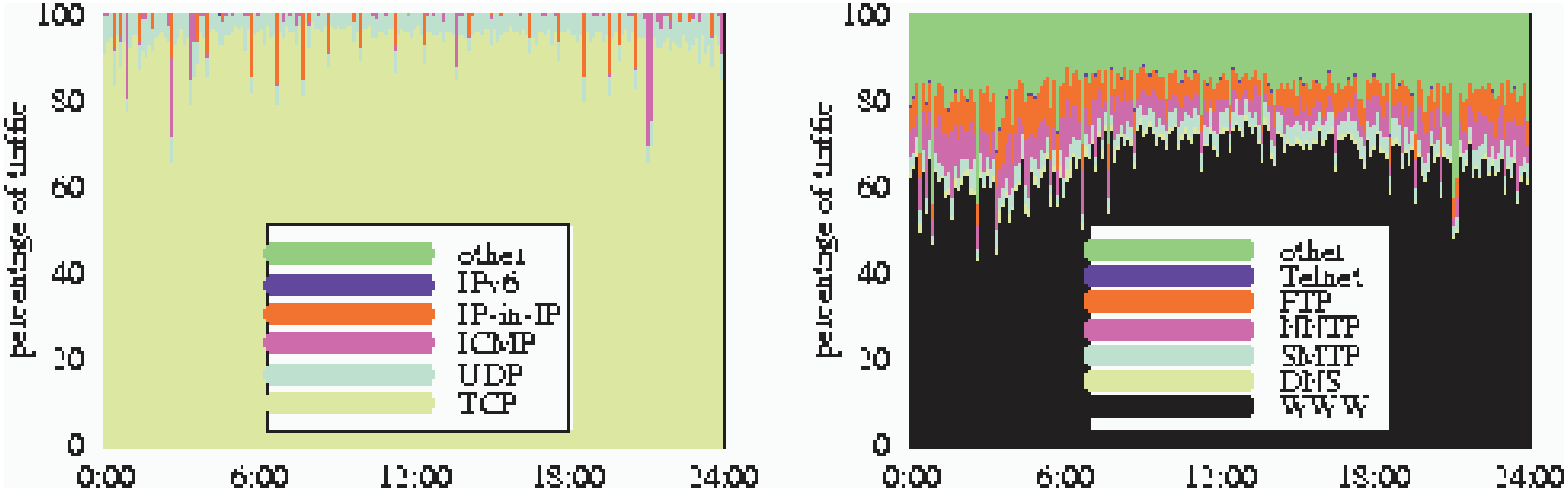
Agenda

- What Is QoS?
- Why QoS—Isn’t Bandwidth Enough?
- The QoS Architectures
- The Applications and Their Needs
- Q&A

Typical Backbone Traffic Mix

Traffic Distribution

TCP Traffic Breakdown

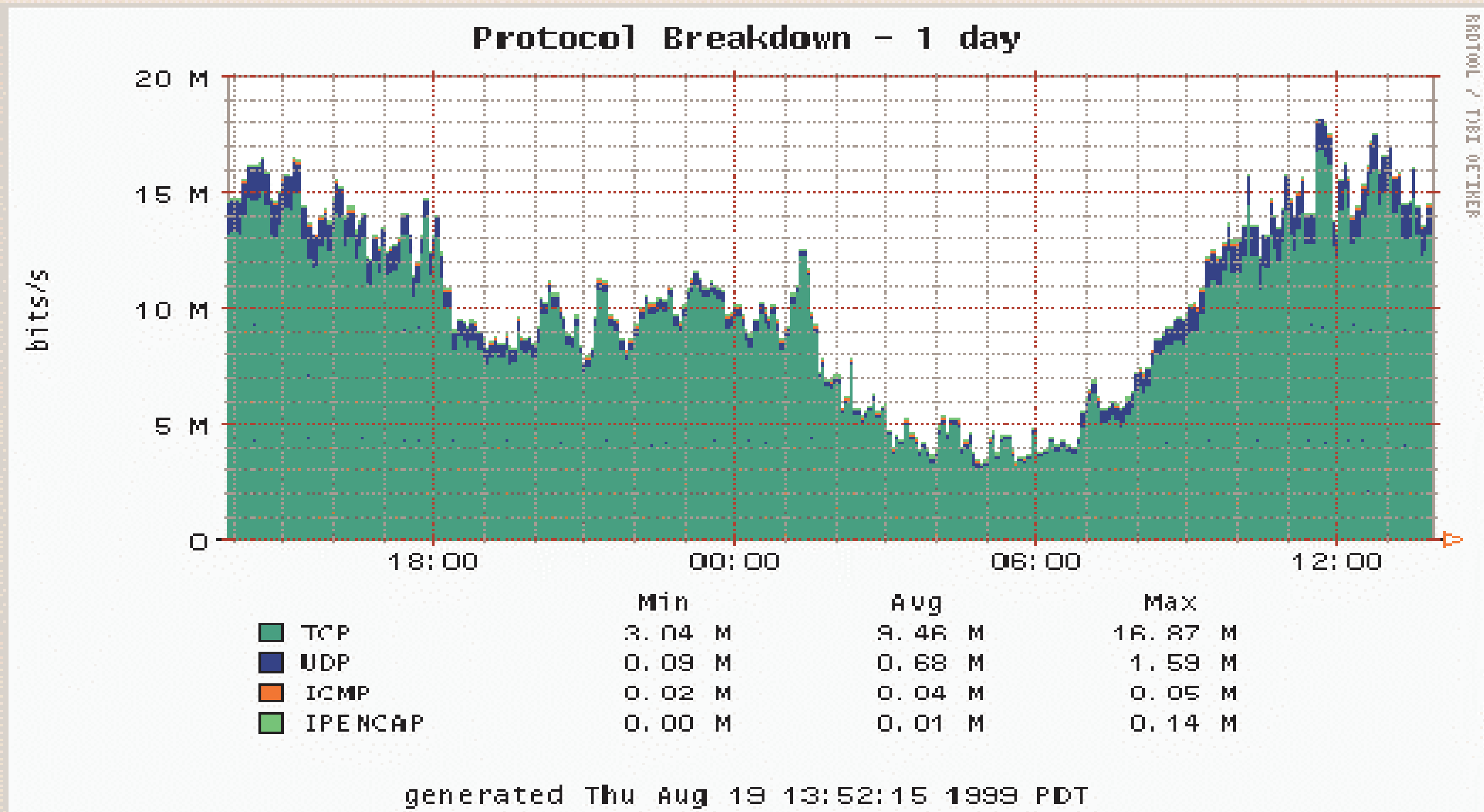


Source: MCI/NSF OC-3MON via http://www.nlanr.net, 1998

More Evidence…
TCP #1 Traffic On Network

traffic workload by protocol

19 aug 99, ucsd-cerfnet



Source: http://www.caida.org

On Source Predictability…

- TCP will keep at most a certain amount of traffic in flight
  - We say it is “elastic”—rate is proportional to latency
- Voice will send only and exactly as fast as the coding algorithm permits (Also Video to an extent)
  - We say it is “inelastic”

TCP Flow Statistics

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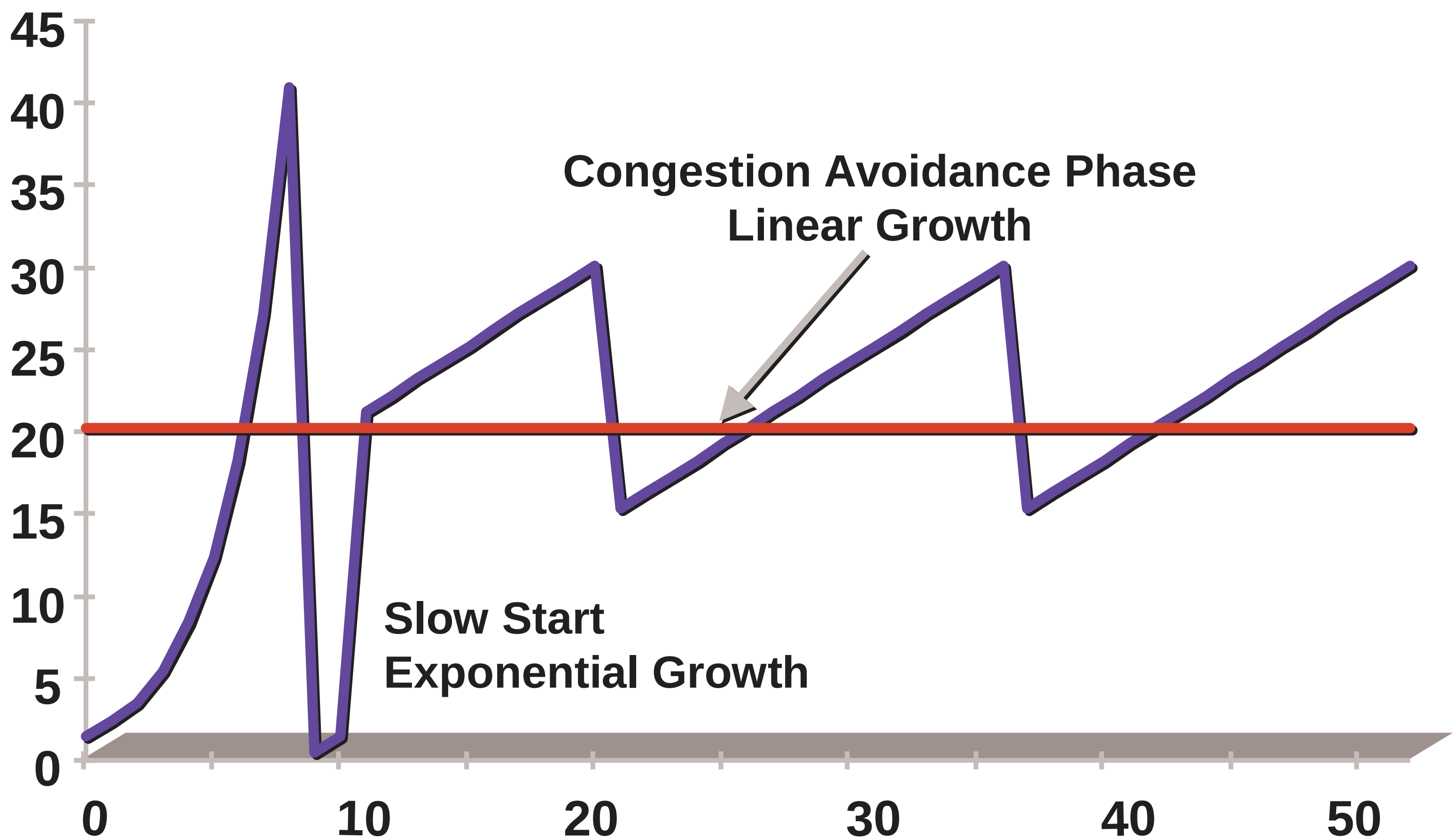
- >90% of sessions have ten packets each way or less

  Transaction mode (mail, small web page)

- >80% of all TCP traffic results from <10% of the sessions, in high rate bursts

  → It is these that we worry about managing

Behavior of a High-Throughput/ Bulk-Transfer TCP Session



H.323 Voice/Video

- **Voice**

  Constant bit rate when sending

  Relatively small messages (44–170 bytes)

- **Video**

  Generally high variable bit rate

  Controlled by codec efficiency on picture

  Message size can be close to the MTU (100-1500 bytes variation)

VoIP Delay Budget

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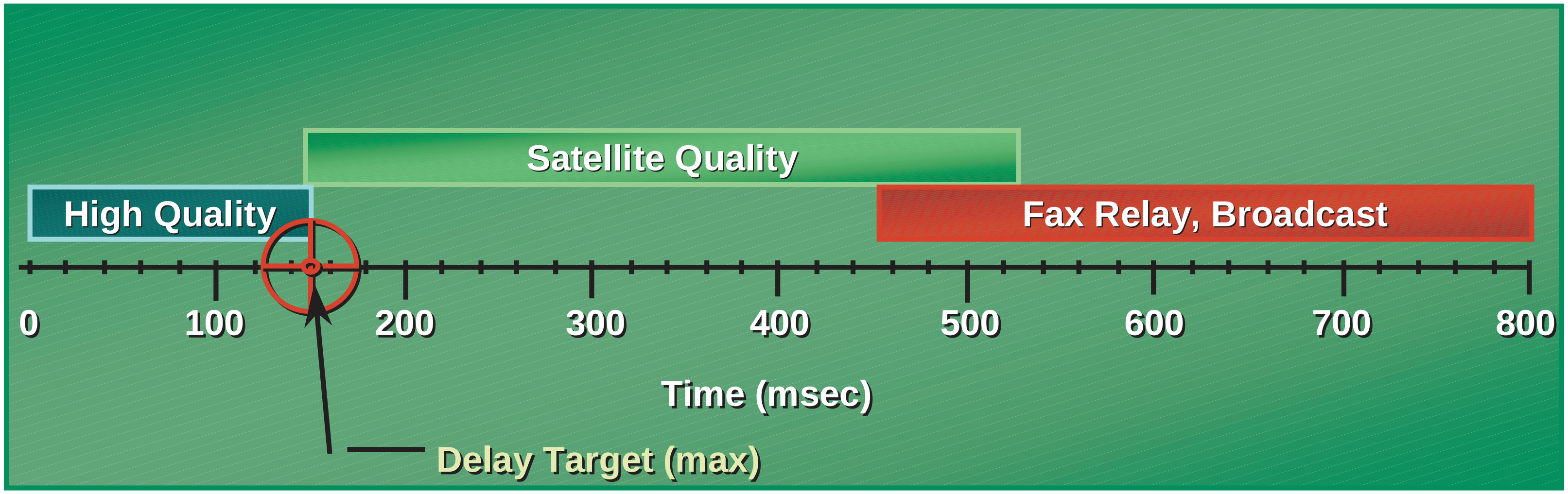
Cumulative Transmission Path Delay

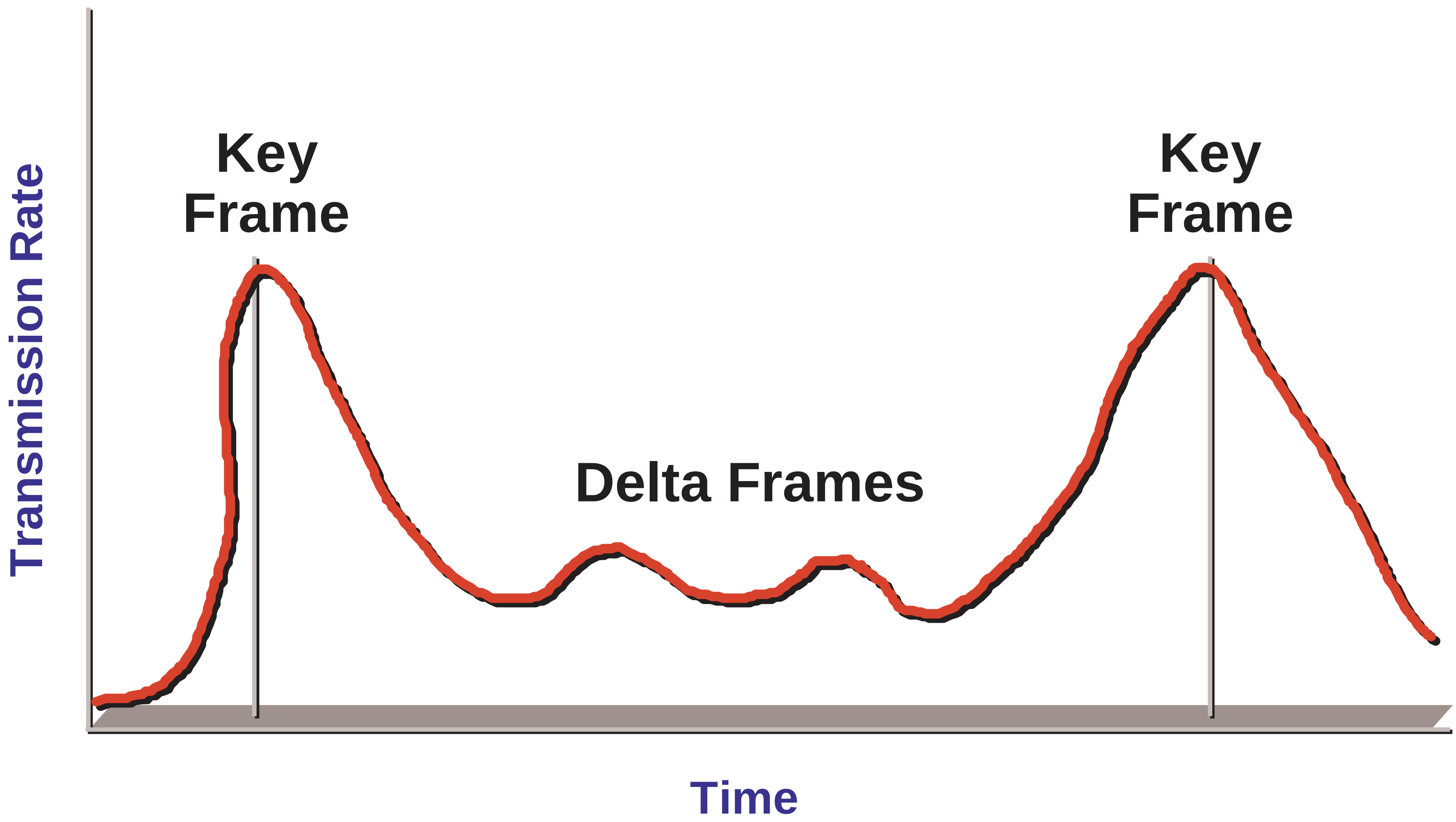


ITU's G.114 Recommendation = 0–150 msec 1-Way Delay

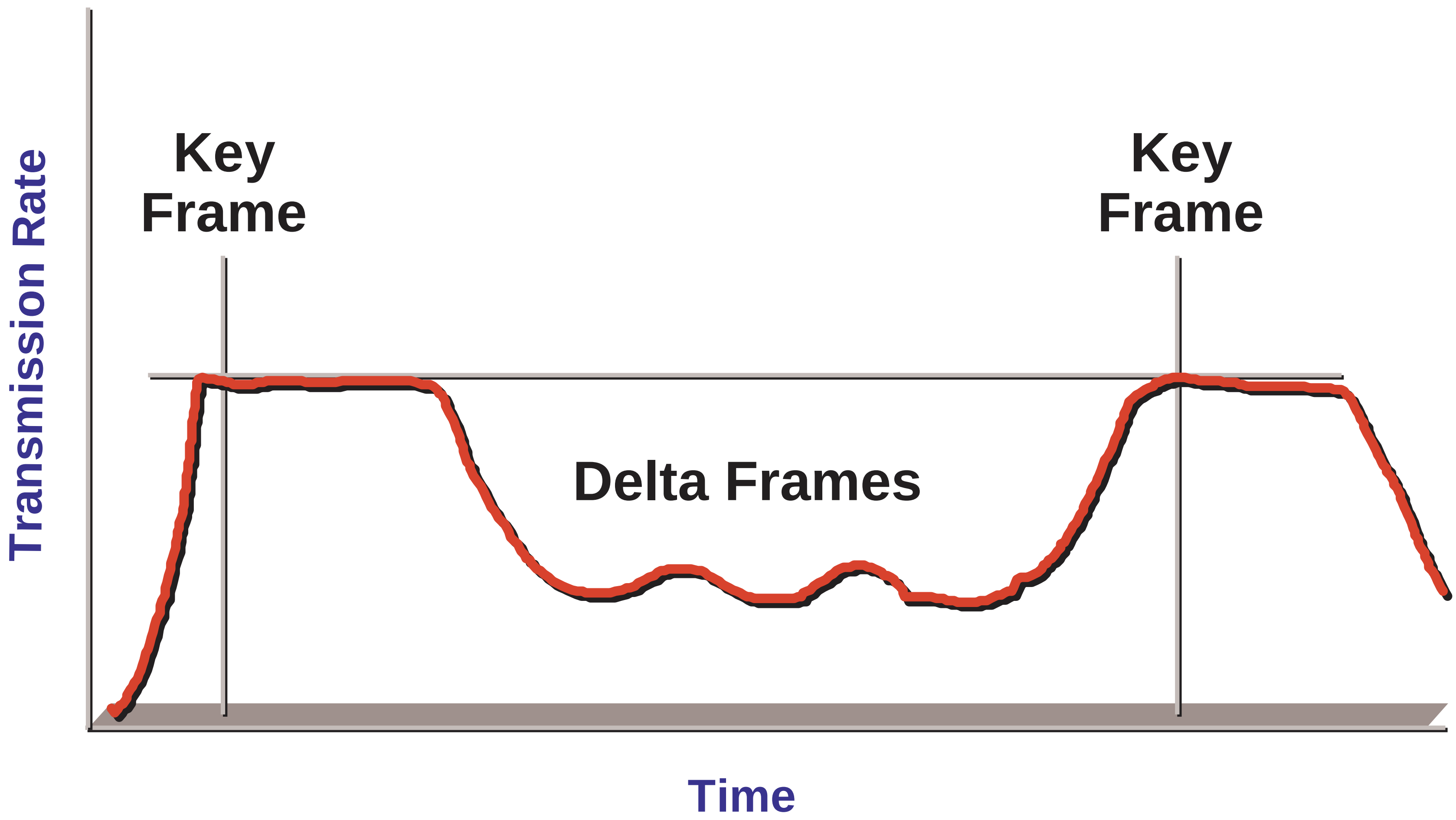
→ **For more information on VoIP Deployment Issues,**

Please see Session#: VVT-101 and VVT-213

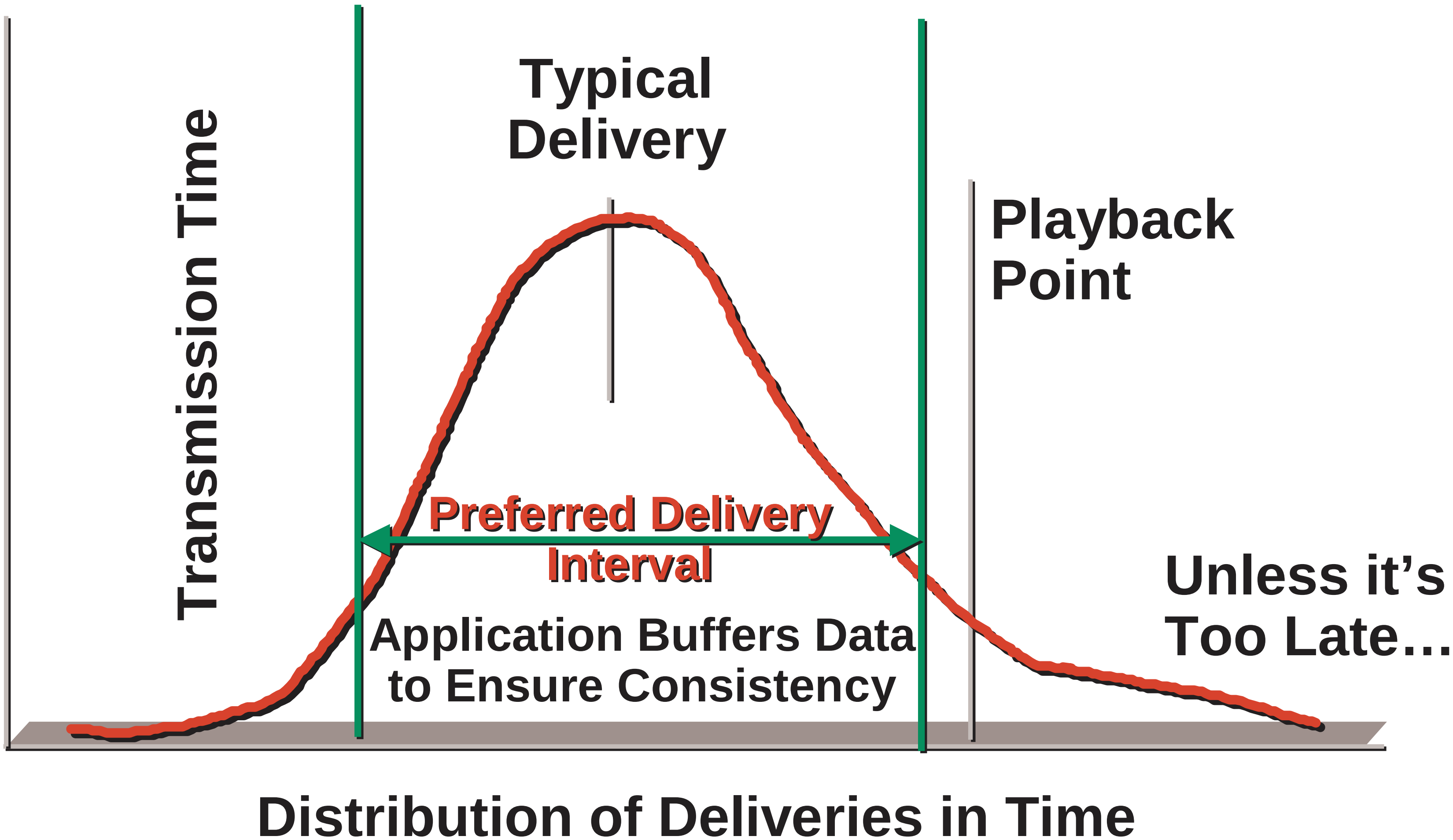
Video: Typical Traffic Pattern



Video: Effect of Delay



Video: Playback Point



Typical Application QoS Requirements

	Voice	FTP	ERP and Mission-Critical
Bandwidth	Low to Moderate	Moderate to High	Low
Random Drop Sensitive	Low	High	Moderate To High
Delay Sensitive	High	Low	Low to Moderate
Jitter Sensitive	High	Low	Moderate

In Summary…
ARM Your Network with QoS!

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Understand Application Needs

Construct a QoS Policy (Queuing, Dropping, Signaling,etc)

Test the QoS Policy (Lab, Portion of Network)

Adjust and Implement a QoS Policy

Monitor Key Network Hotspots!

Questions??

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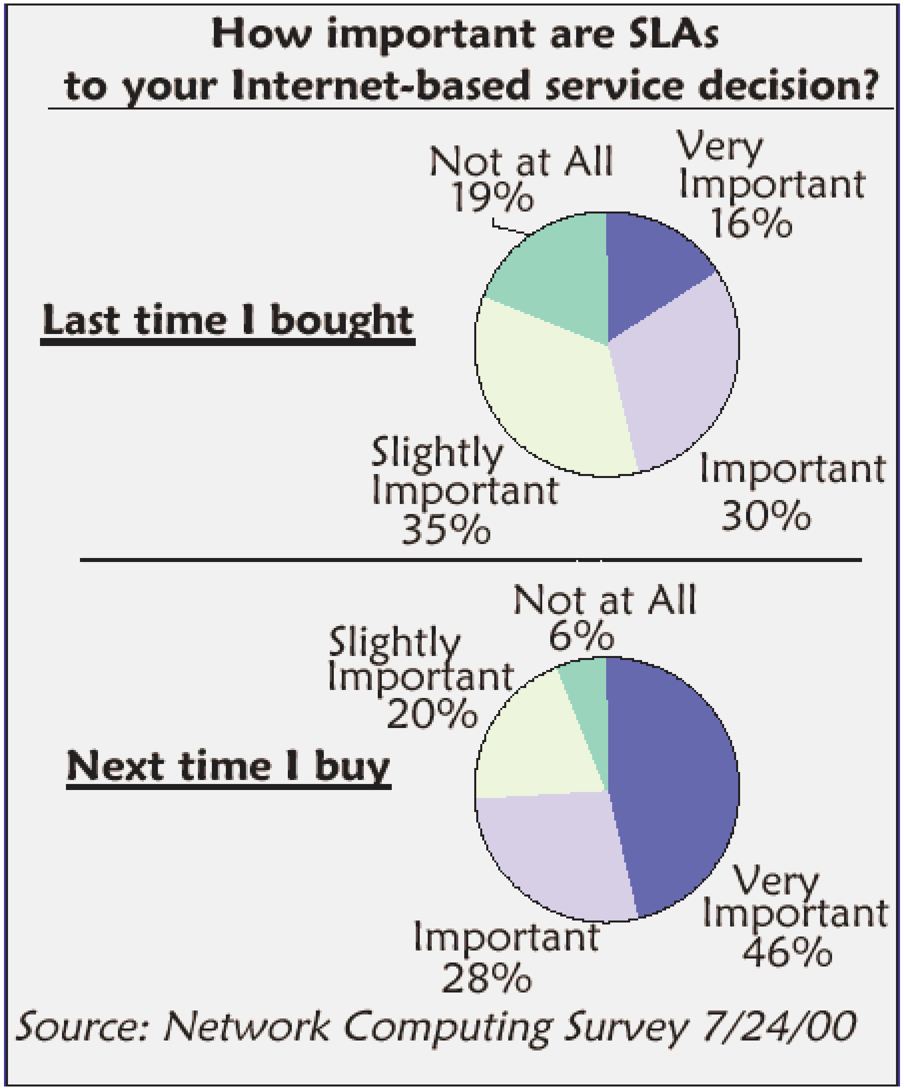
Appendix

Misc. Information

Are SLAs Important? Absolutely!



The DiffServ AF PHB
(4 Classes, 3 Drop Preferences)

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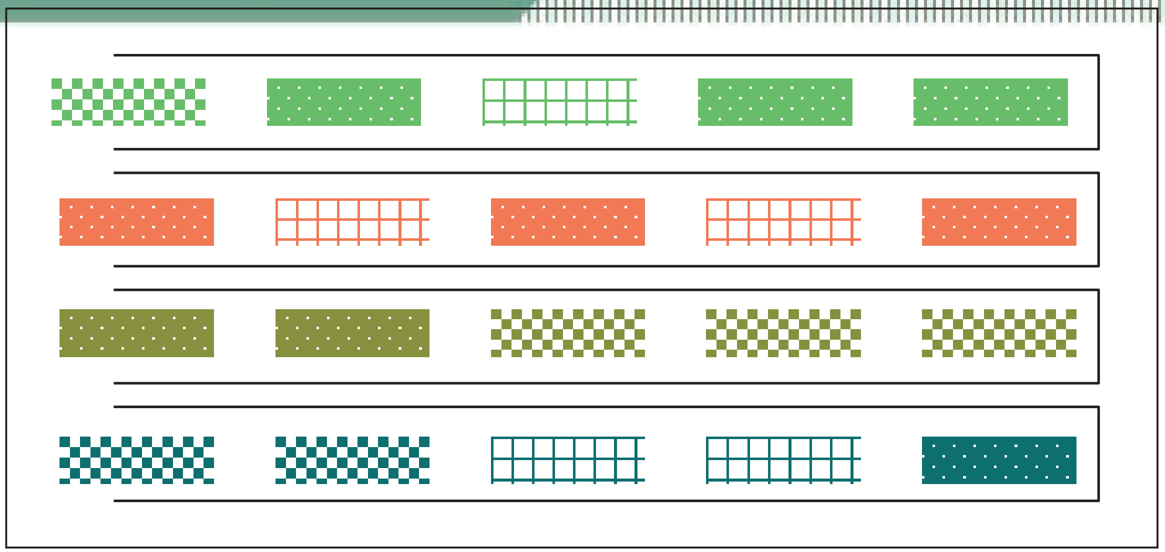


AF Class 1: 001” 0

AF Class ⁚’010 ” 0

AF Class ⁚’011 ” 0

AF Class ⁚’100 ” 0

dd ndrop preerece

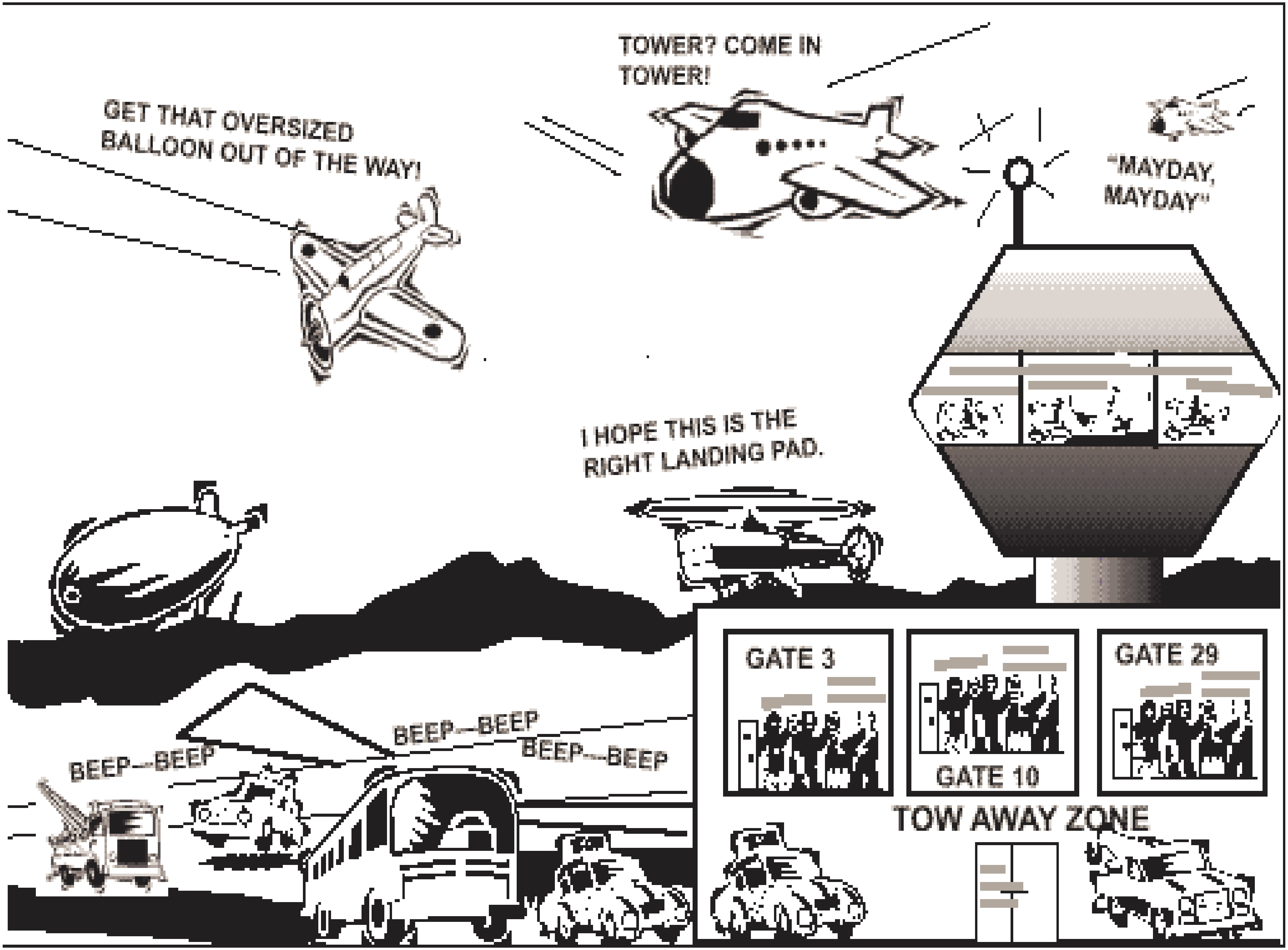
”AF1” ”Class 1””s
001100”

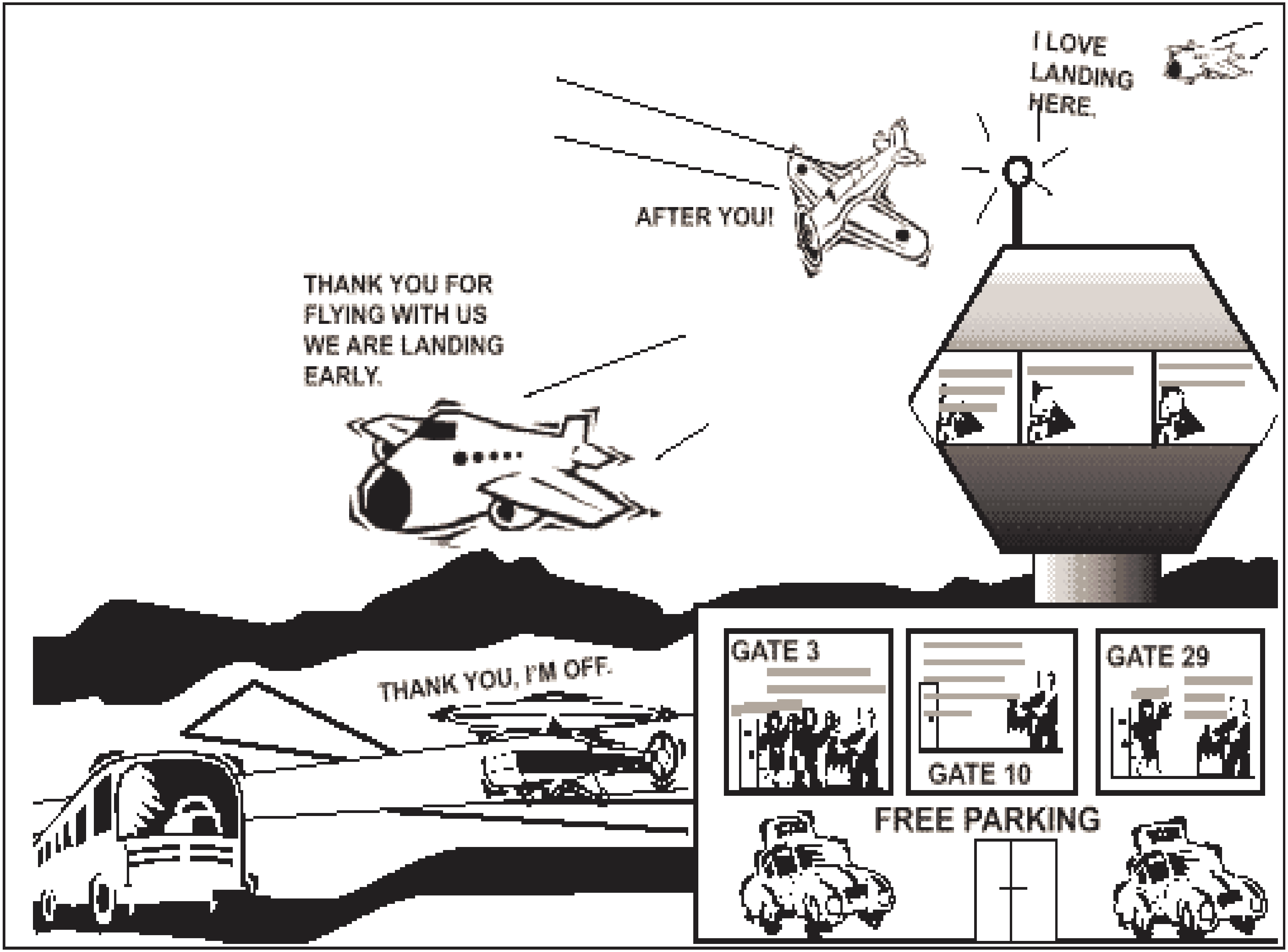
- Four Independently Forwarded/Queued Classes
- Within each AF class, 3 levels of drop preference

  Used to increase the probability of dropping, especially when traffic exceeds configured rate/CIR

References

- http://www.ietf.org/html.charters/diffserv-charter.html
- http://www.ietf.org/rfc
- http://www.ietf.org/
- http://www.cisco.com/go/qos
- http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/qos_c/index.htm
- Other Talks in PS-560 and Sessions: IPS-230,231,330,430 (QoS), RST-231 (MPLS Traffic Engineering), and MPLS Power-Session: PS-542 http://www.cisco.com/go/qos


TOWER? COME IN TOWER!
GET THAT OVERSIZED BALLOON OUT OF THE WAY!
"MAYDAY, MAYDAY"
I HOPE THIS IS THE RIGHT LANDING PAD.
GATE 3
GATE 10
GATE 29
BEEP—BEEP
BEEP—BEEP
BEEP—BEEP
TOW AWAY ZONE


I LOVE LANDING HERE.
AFTER YOU!
THANK YOU FOR FLYING WITH US WE ARE LANDING EARLY.
THANK YOU, I'M OFF.
GATE 3
GATE 10
GATE 29
FREE PARKING

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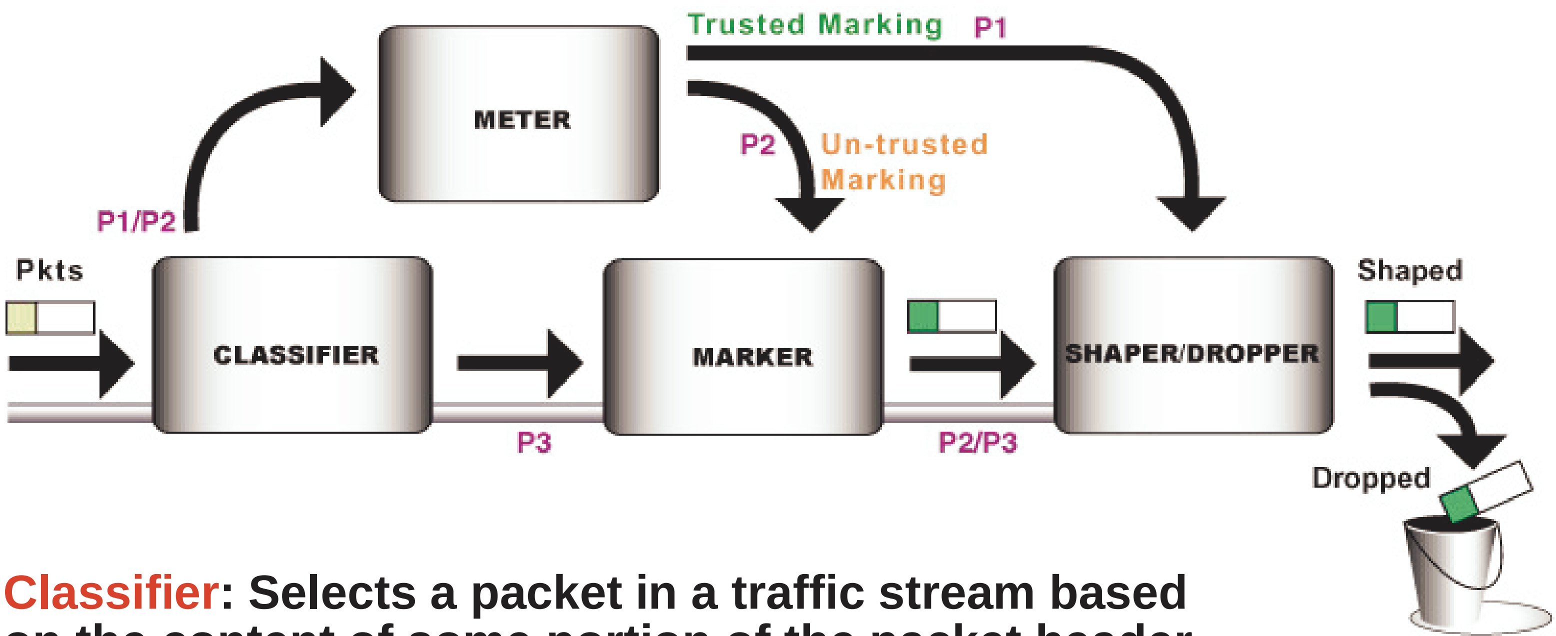
QoS Features in Cisco IOS®

Section 2

Agenda

- DiffServ QoS Feature Set
- Link Efficiency Mechanisms
- RSVP Feature Set
- QoS L2-L3 Interworkings

DiffServ Traffic Conditioner



- **Classifier**: Selects a packet in a traffic stream based on the content of some portion of the packet header
- **Meter**: Checks compliance with traffic parameters (e.g., Token Bucket) and passes result to marker and shaper/dropper to trigger particular action for in/out-of-profile packets
- **Marker**: Writes/rewrites the DSCP value
- **Shaper**: Delay some packets for them to be compliant with the profile

QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Modular QoS CLI

- Template-based command syntax for QoS
- Uniform CLI across all main Cisco IOS- based platforms
- Uniform CLI structure for all QoS features
- Separates classification engine from the policy
- Up to 64 classes per policy if queuing, otherwise up to 256 classes per policy

MQC Components

- **Class-maps**

  Classification to create aggregate behavior groups

- **Policy-maps**

  Utilize combination of QoS features to define PHB

- **Service-policy**

  Apply a policy on a participating interface to enable PHB

Modular QoS CLI Syntax


```
Router(config)# class-map <match all | match any> class-map-name
Router(config-cmap)# match <access-group | destination-address |
  source-address | input-interface | protocol | qos-group | …..>

Router(config)# policy-map policy-map-name
Router(config-pmap)# class class-name
Router(config-pmap-c)# <bandwidth | police | random-detect | …..>

Router(config)# interface interface-name
Router(config-if)# service-policy <input | output> policy-map-name
```


QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Packet Classification

- Incoming/outgoing interface
- All/any IP traffic
- Predefined class-maps
- Standard or Extended source/destination access list
- IP rtp ports
- DSCP or IP precedence value
- 0-99 qos-group Ids
- NBAR
- CoS value
- MPLS experimental bits
- Frame Relay DE bit

L2-L3 Interoperability

Packet Classification

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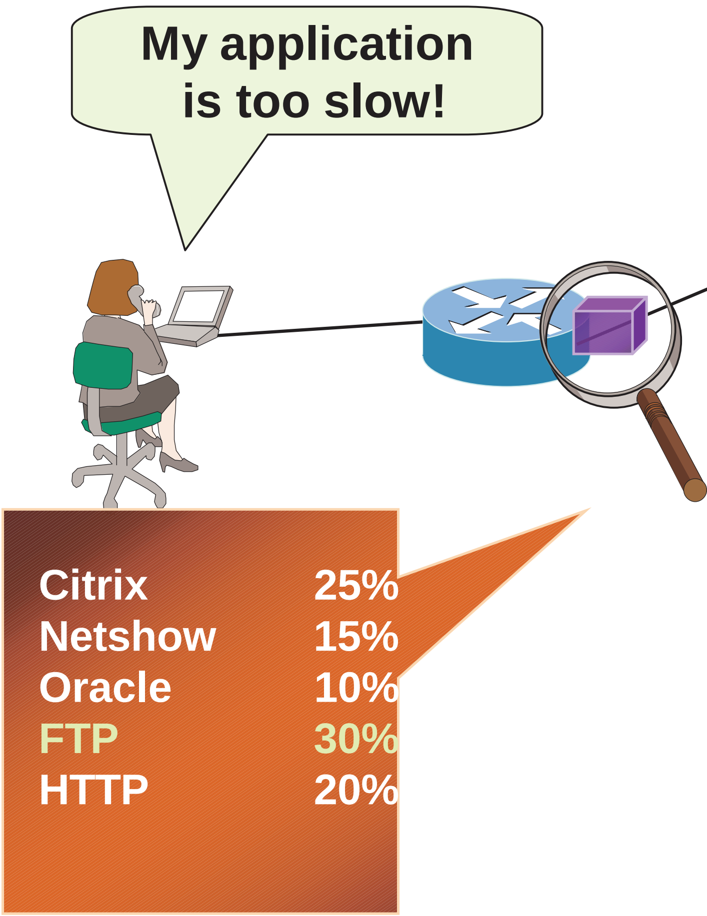
```
Router#conf t
Router(config)#class-map match-all video
Router(config-cmap)#match ?
  access-group          Access group
  any                   Any packets
  class-map             Class map
  cos                   IEEE 802.1Q/ISL class of
                         service/user priority values
  destination-address   Destination address
  input-interface       Select an input interface to match
  ip                    IP specific values
  mpls                  Multi Protocol Label Switching
                        specific values
  not                   Negate this match result
  protocol              Protocol
  qos-group             Qos-group
  source-address        Source address
```

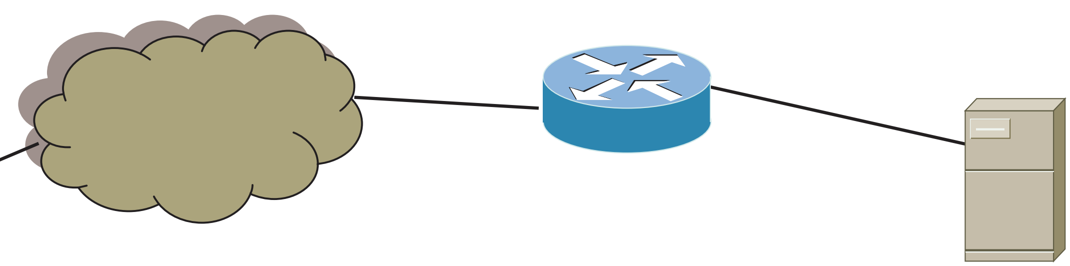

Packet Classification Config


```
Router(config)# class-map match-all voip
Router(config-cmap)# match ip rtp 16383 16383
Router(config)# class-map match-any data
Router(config-cmap)# match access-group 101
Router(config-cmap)# match class-map business
Router(config)# class-map match-any video
Router(config-cmap)# match qos-group 10
Router(config)# class-map match-any class-default
```


Network-Based Application Recognition (NBAR)

- Protocol Discovery





- Classification of known traffic types

Protocol Discovery Stats

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```
7200-source#sh ip nbar protocol-discovery stats byte-rate

 FastEthernet1/0
                          Input                    Output
   Protocol            30second bit rate   30second bit rate
                          (bps)                    (bps)
 --------------       -------------------   -------------------
   telnet                  368000                      0
   ftp                     163000                      0
   http                    163000                      0
   |                          |                        |
   unknown                 614000                      0
   Total                   1308000                     0
```


NBAR Capabilities

- Classification and protocol discovery of known traffic types is done using PDLM (Packet Description Language Module)
- Packet classifier is capable of classifying…
    - L4-L7 protocols which dynamically assign TCP/UDP ports
    - HTTP traffic by URL or MIME type using regular expressions (*, ?, [ ])
    - “Sub-port” criteria such as transaction types
- NBAR classification is used by QoS features…
    - Queuing, dropping, marking, policing, shaping
- Supported on 2600, 3600, 7100, 7200 and 7500 routers

Packet Description Language Module (PDLM)

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- PDLMs define applications that are recognizable by NBAR
- New applications easily supported by adding new PDLMs
- No Cisco IOS software upgrade or reboot required when adding new PDLMs

Protocol Discovery Configuration

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```
Router(config)# interface ethernet 0/0
Router(config-if)# ip nbar protocol-discovery

Router# show ip nbar protocol-discovery [interface
interface-spec] [stats {byte-count | bit-rate |
packet-count}][{protocol
protocol-name | top-n number}]
```


Classification config. using NBAR

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```
Router(config)# class-map match-all routing
 Router(config-cmap)# match protocol bgp
 Router(config)# class-map match-any erp
 Router(config-cmap)# match protocol sqlnet
 Router(config-cmap)# match protocol ftp
 Router(config-cmap)# match protocol telnet
       (! MIME  or URL Types)
 Router(config)# class-map match-any audio_video
 Router(config-cmap)# match protocol http mime ”*/audio/*"
 Router(config-cmap)# match protocol http mime ”*/video/*"

 Router(config)# class-map match-any web_images
 Router(config-cmap)# match protocol http url "*.gif"
 Router(config-cmap)# match protocol http url
"*.jpg|*.jpeg“
```


QoS Classification for VPNs: GRE, IPsec, L2TP

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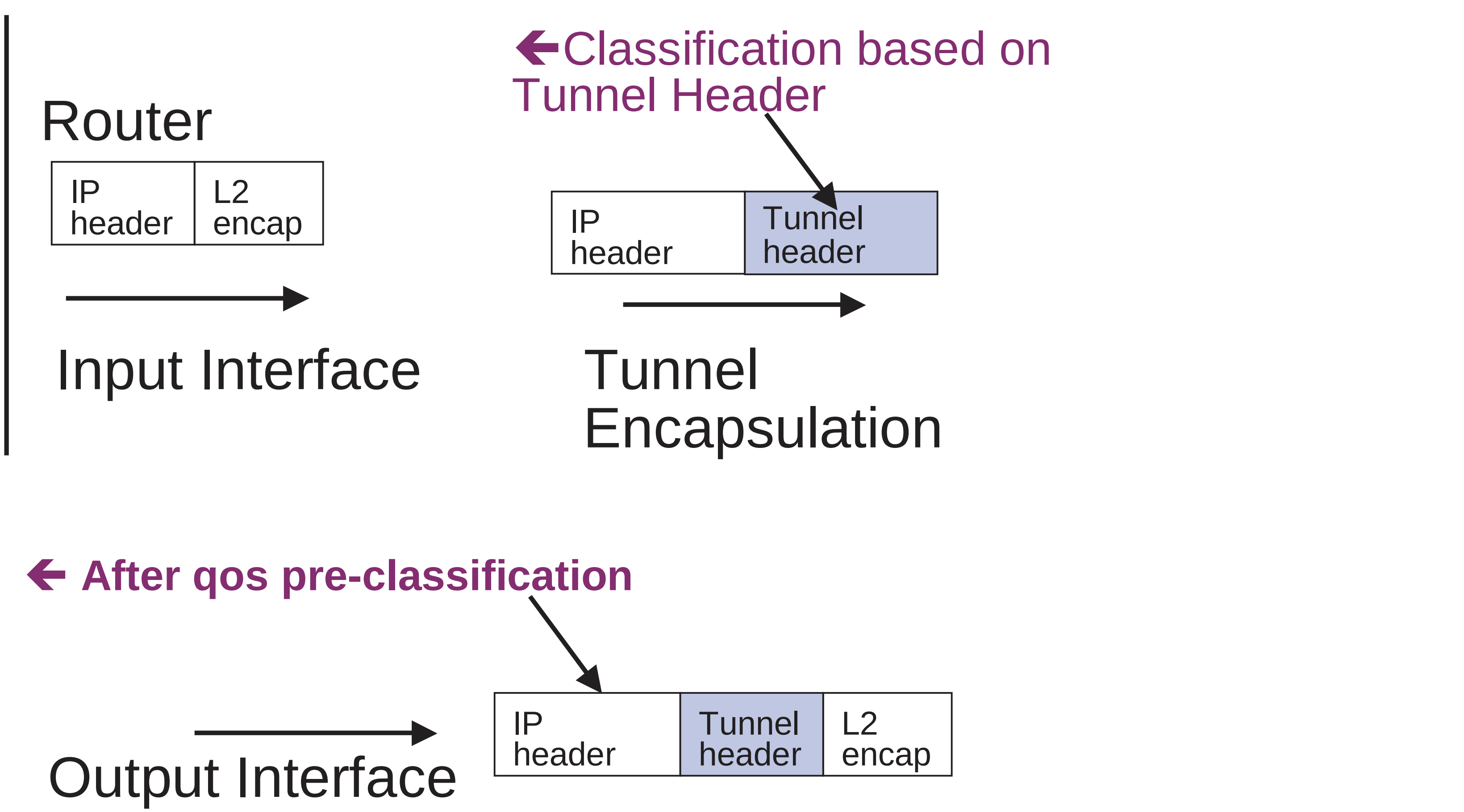
Challenge

Tunnel headers have same IP src/dst addr



Configuring QoS for VPNs

- **GRE and IPIP Tunnels**

```
secure(config# interface tunnel0
secure(config-if# qos pre-classify
```

- **L2F and L2TP Tunnels**

```
secure(config)# interface virtual-template1
secure(config-if)# qos pre-classify
```

- **IPsec Tunnels**

```
secure(config)# crypto map secured-partner-X
secure(config-crypto-map)# qos pre-classify
```


QoS Classification for VPNs: GRE, IPsec, L2TP

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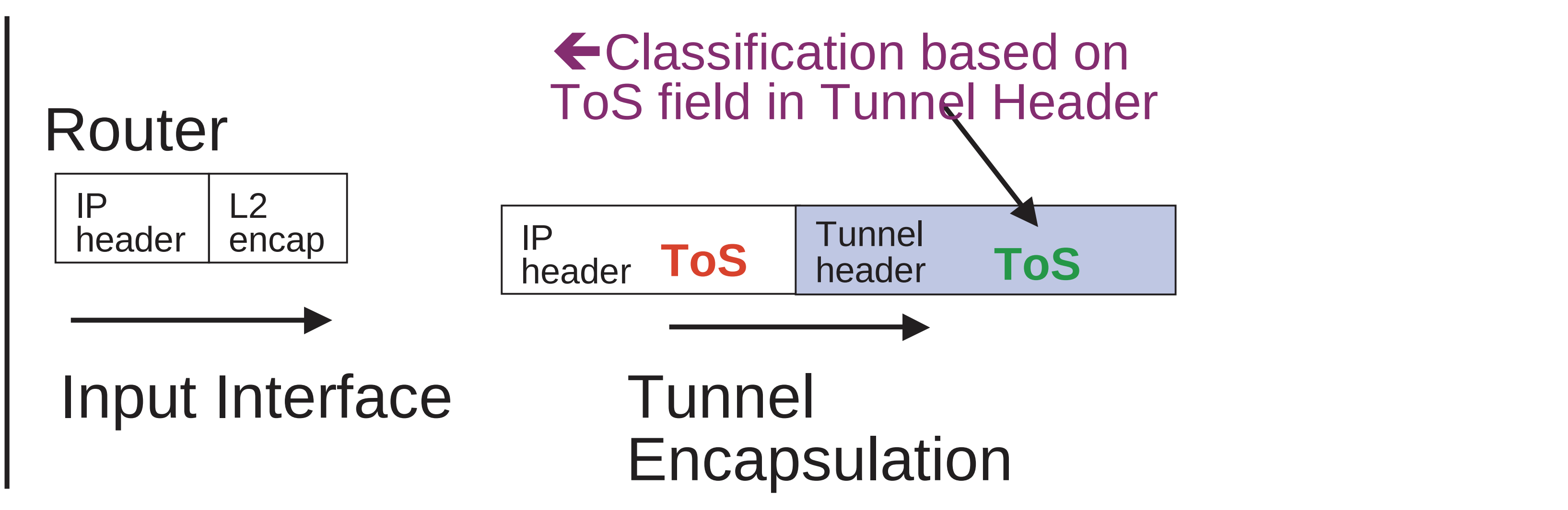
Challenge Original ToS field is encapsulated



Copy ToS from original to the tunnel header:

←Done by default for GRE and IPsec

←Use   l2tp tos reflect   for L2TP

QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Packet Marking

- IP DSCP value for Layer 3
- IP Precedence value for Layer 3
- QoS Group ID
- CoS value
- MPLS EXP bits
- FR DE Bit
- ATM CLP Bit

L2-L3 Interoperability

DSCP

DS field	DSCP	CU

DROP Precedence	*Class#1*	*Class #2*	*Class #3*	*Class #4*
Low Drop Precedence	AF11 (001010) 10	AF21 (010010) 18	AF31 011010) 26	AF41 (100010) 34
Medium Drop Prec	AF12 (001100) 12	AF22 (010100) 20	AF32 011100) 28	AF42 (100100) 36
High Drop Precedence	AF13 (001110) 14	AF23 (010110) 22	AF33 (011110) 30	AF43 (100110) 38

High Priority = EF = 101110 = 46   Best Effort = 000000 = 0

Packet Marking Syntax

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```
Router#conf t
Router(config)#policy-map Multiservice
Router(config-pmap)#class video
Router(config-pmap-c)#set ?
  atm-clp     Set ATM CLP bit to 1
  cos         Set 802.1Q ISLCoS service/user priority
  ip          Set IP specific values
  mpls        Set MPLS specific values
  qos-group   Set QoS Group
Router(config-pmap-c)#set ip ?
  dscp         Set IP DSCP (DiffServ CodePoint)
  precedence   Set IP precedence
```


Packet Marking Config.

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```
Router(config)# policy-map SETPRIORITY
Router (config-pmap)# class voip
Router(config-pmap-c)# set ip dscp 46  // DSCP for EF!
Router(config-cmap)# class video
Router(config-pmap-c)# set ip dscp 10  // DSCP for AF11!
Router(config-cmap)# class data
Router(config-pmap-c)# set ip dscp 18  // DSCP for AF21!
Router(config-cmap)# class class-default
Router(config-pmap-c)# set ip dscp 0   // for BestEffort
Router(config)# interface fastethernet4/0
Router(config-subif)# service-policy input SETPRIORITY
```


QoS Policy Propagation via BGP

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- Leverages BGP to distribute QoS policy to remote routers in your network
- Classifies packets by setting their IP precedence value based on BGP community lists, BGP AS paths, and access lists
- Other QoS features, such as CAR and WRED, use this classification to enforce their policies
- Allows ingress routers to prioritize incoming and outgoing traffic
- Allows you to classify packets based on IP precedence or QoS group ID

QoS Policy Propagation via BGP

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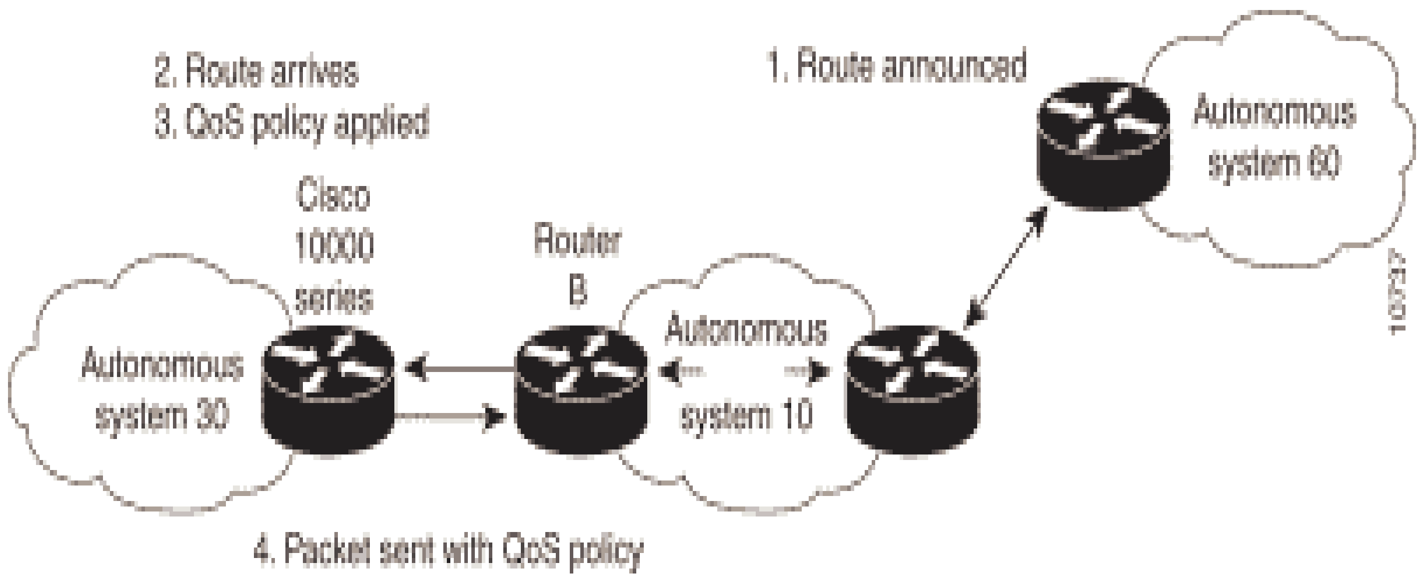


QPPB Application

- Match community 3 and set the IP precedence to flash:

```
Router(config)# route-map precedence-map permit 40
Router(config-route-ma)# match community 3
Router(config-route-ma)# set ip precedence flash
```

- Match ip address access list 69 or match AS path 1, set the IP precedence to critical, and set the QoS group to 9:

```
Router(config)# route-map precedence-map permit 50
Router(config-route-ma)# match ip address 69
Router(config-route-ma)# match as-path 1
Router(config-route-ma)# set ip precedence critical
Router(config-route-ma)# set ip qos-group 9
```

- For everything else, set the IP precedence to routine

```
Router(config)# route-map precedence-map permit 60
Router(config-route-ma)# set ip precedence routine
```


QPPB Application

- **Apply route-map**

```
Router(config)# router bgp 30
Router(config)# table-map precedence
Router(config-router)# neighbor 20.20.20.1 remote-as 10
Router(config-router)# neighbor 20.20.20.1 send-community
Router(config-router)# neighbor 20.20.20.1 route-map precedence
out
```

- **ACLs**

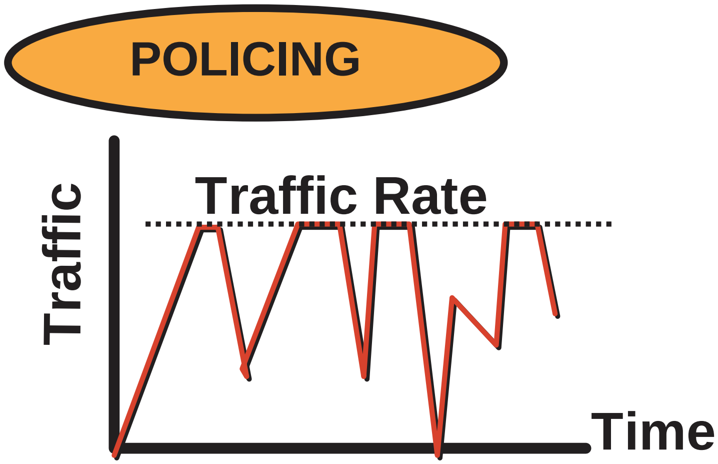
```
Router(config)# access-list 40 permit 64.0.0.0
Router(config)# access-list 50 permit 65.0.0.0
```

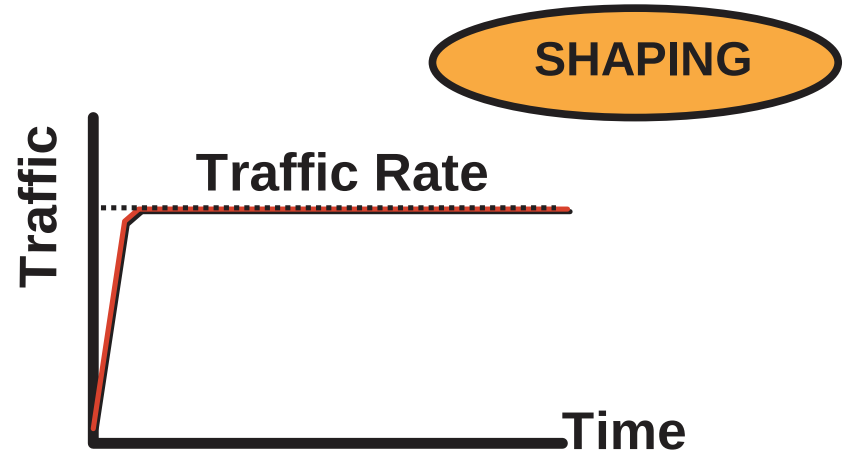
***table-map to map external entry attributes into the routing table**

QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Policer vs. Shaper





- In both incoming and outgoing directions
- Out-of-profile packets are dropped
- Causes TCP retransmits
- Supports packet marking to change priorities
- No response to BECNs FECNs

- In outgoing direction only
- Out-of-profile packets are queued until a buffer gets full
- Minimizes TCP retransmits
- Marking/remarking not supported
- Can adapt to network congestion (BECN and FECN)

Metering with Token Bucket

- **Common rate measurement mechanism used by Policer and Shaper**
- **Components:**

  Bc = Commited Burst **Be = Excess Burst**

  CIR = Committed Rate **PIR = Peak Info. Rate**

  CBS = Committed Burst Size

  PBS = Peak Burst Size

- **Basic Operation:**

  Token bucket starts out full of Tokens

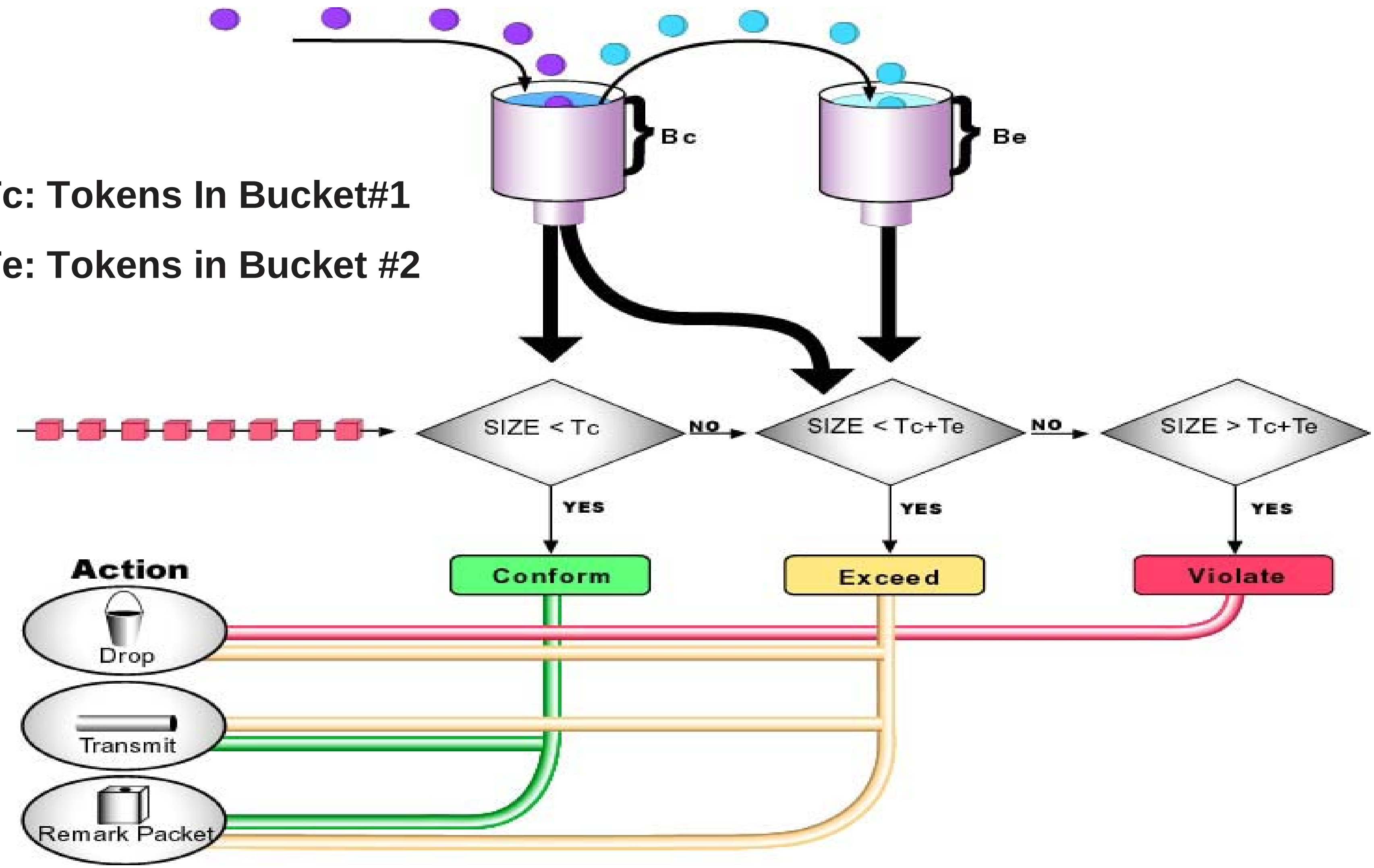
  #s of tokens based on CIR are added at delta T

  #s of tokens based on the size of the packet are removed from the token bucket upon forwarding that packet

RFC 2697: Single Rate Policer

Tc: Tokens In Bucket#1

Te: Tokens in Bucket #2



Conditions and Actions

- **Conform Condition**

  Bits-to-be-sent <= normal-burst (Bc)

- **Exceed Condition**

  normal-burst < bits-to-be-sent <= excess-burst (Be)

- **Violate Condition**

  bits-to-be-sent > excess burst (Be)

Actions: Drop/Transmit/Mark and Transmit

Action Options

Conform/Exceed/Violate Actions

drop
set-dscp-transmit
set-mpls-exp-transmit
set-prec-transmit
set-clp-transmit
set-de-transmit
set-qos-transmit
transmit

Action Options

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Conform/Exceed/Violate Actions

```
Router#conf t
Router(config)#policy-map Multiservice
Router(config-pmap)#class data
Router(config-pmap-c)#police 8000 conform-action ?
  drop                   drop packet
  set-clp-transmit       set atm clp and send it
  set-dscp-transmit      set dscp and send it
  set-prec-transmit      rewrite packet precedence and send it
  set-qos-transmit       set qos-group and send it
  set-de-transmit        set FrameRelay DE bit and send it
  set-mpls-exp-transmit set MPLS EXP bit and send it
  transmit               transmit packet
```

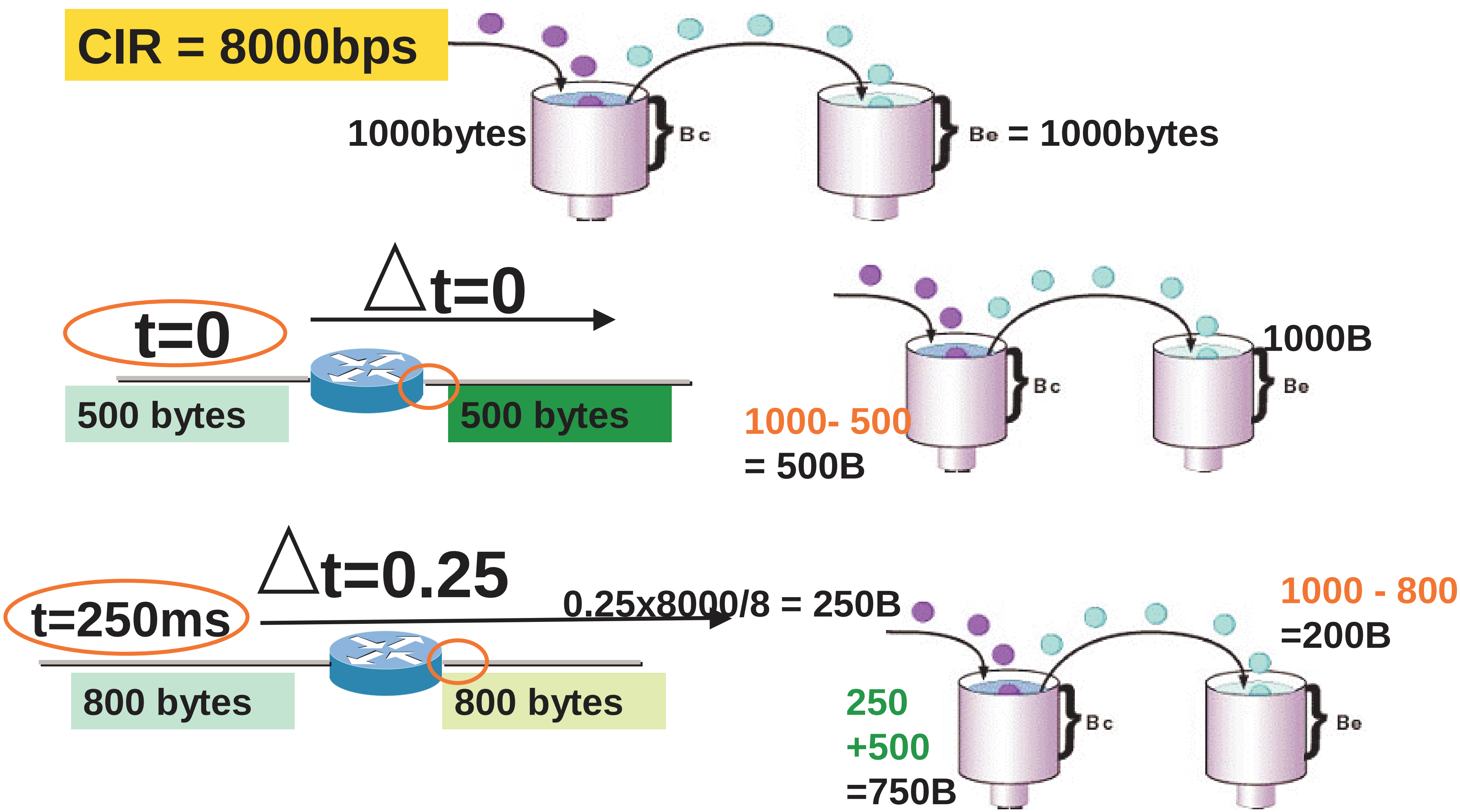

Configuring Single Rate Policer as a Marker


```
Router(config)# policy-map POLICE

Router(config-pmap)# class SingleAction
Router(config-pmap-c)# police 256000 1500 3000
conform-action set-dscp-transmit af31
exceed-action set-dscp-transmit af33
violate-action transmit
!
Router(config)# interface Serial4/1
Router(config)# service-policy output POLICE
```

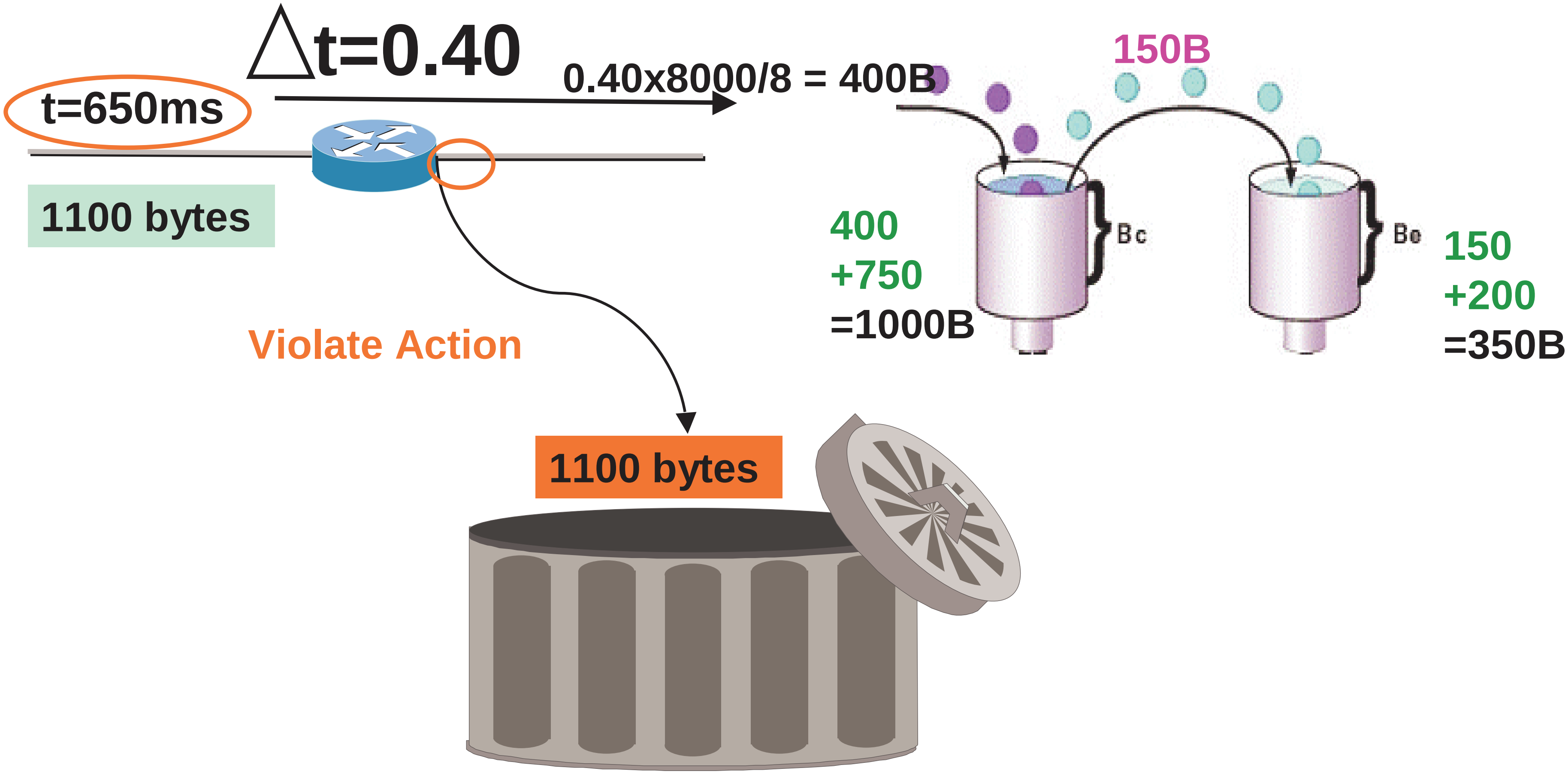

Configuring Single Rate Policer


```
Router(config)# policy-map POLICE

Router(config-pmap)# class SingleAction
Router(config-pmap-c)#police 8000 1000 1000
          conform-action transmit
          exceed-action set-qos-transmit 1
          violate-action drop
!
Router(config)# interface Serial4/1
Router(config)# service-policy output POLICE
```


RFC 2697 Token Bucket Example



RFC 2697 Token Bucket Example



Configuring Multi-Action Single Rate Policer

Cisco.com

```
Router(config)# policy-map POLICE
Router(config-pmap)# class MultiAction
(config-pmap-c)#police <cir> [bc] [be] ?
conform-action <action1>
conform-action <action2>
conform-action <action3>
conform-action <action4>

exceed-action  <action1>
exceed-action  <action2>
exceed-action  <action3>
exceed-action  <action4>

violate-action <action>
```

12.2.2T

RFC 2698: Dual Rate Policer

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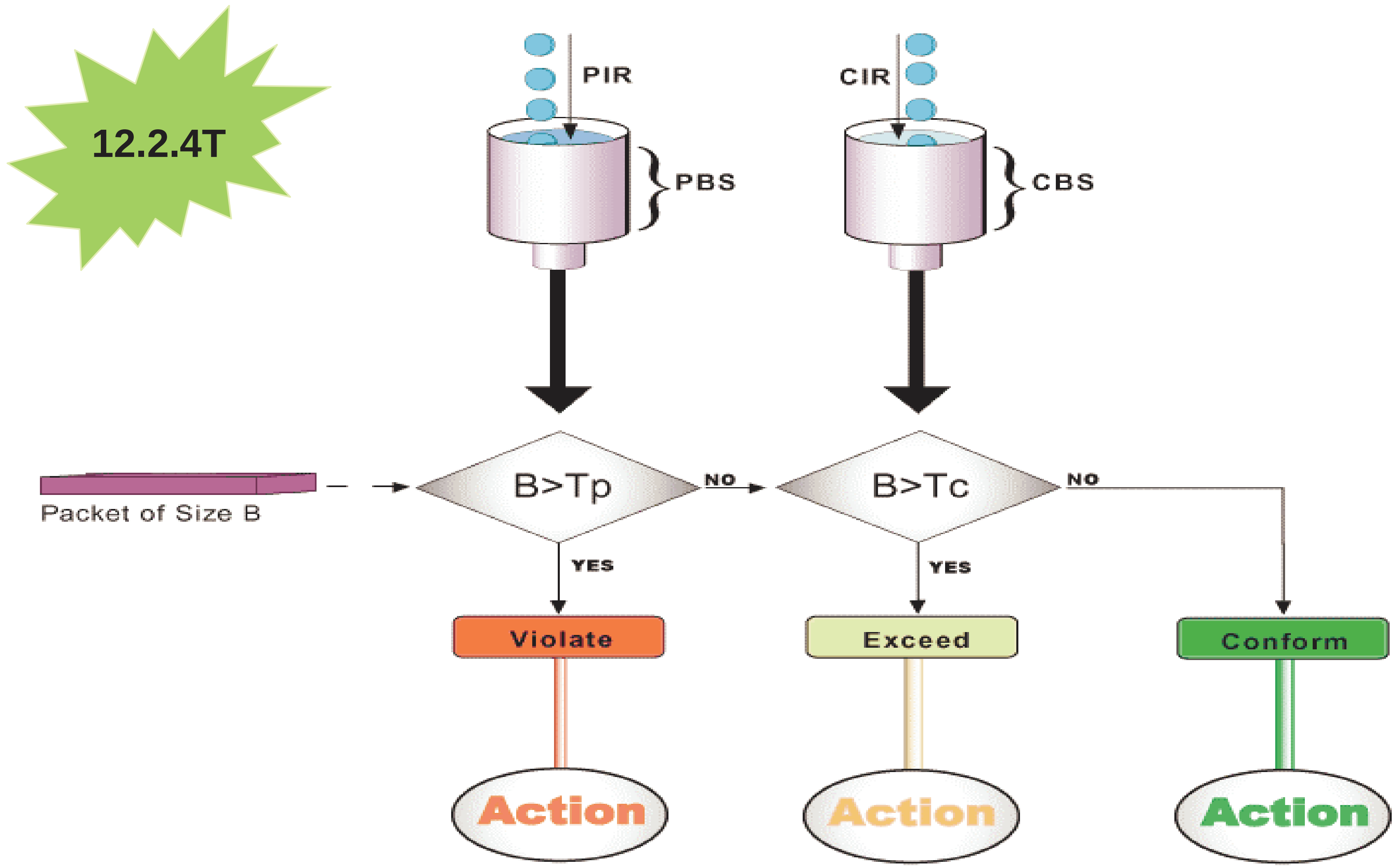


RFC-2698:
Dual Rate Policer Syntax

12.2.4T

```
qos4-72a(config-pmap-c)#police cir ?
   <8000-200000000>   Bits per second
    <cr>

qos4-72a(config-pmap-c)#police cir 80000 ?
   conform-action   action when rate is less than conform burst
   conform-burst    Conform burst
   pir              Peak Information Rate
   <cr>

qos4-72a(config-pmap-c)#police cir 80000 pir ?
   <8000-200000000>   Bits per second
     <cr>

 qos4-72a(config-pmap-c)#police cir 80000 pir 8000 ?
   conform-action   action when rate is less than conform burst
   peak-burst       Peak burst
```


RFC-2698:
Dual Rate Policer Syntax

Cisco.com

12.2.4T

```
qos4-72a(config-pmap-c)#$80000 conform-burst 2000 pir
8000 peak-burst 2500 ?
conform-action          action when rate is less than conform burst
<cr>
```

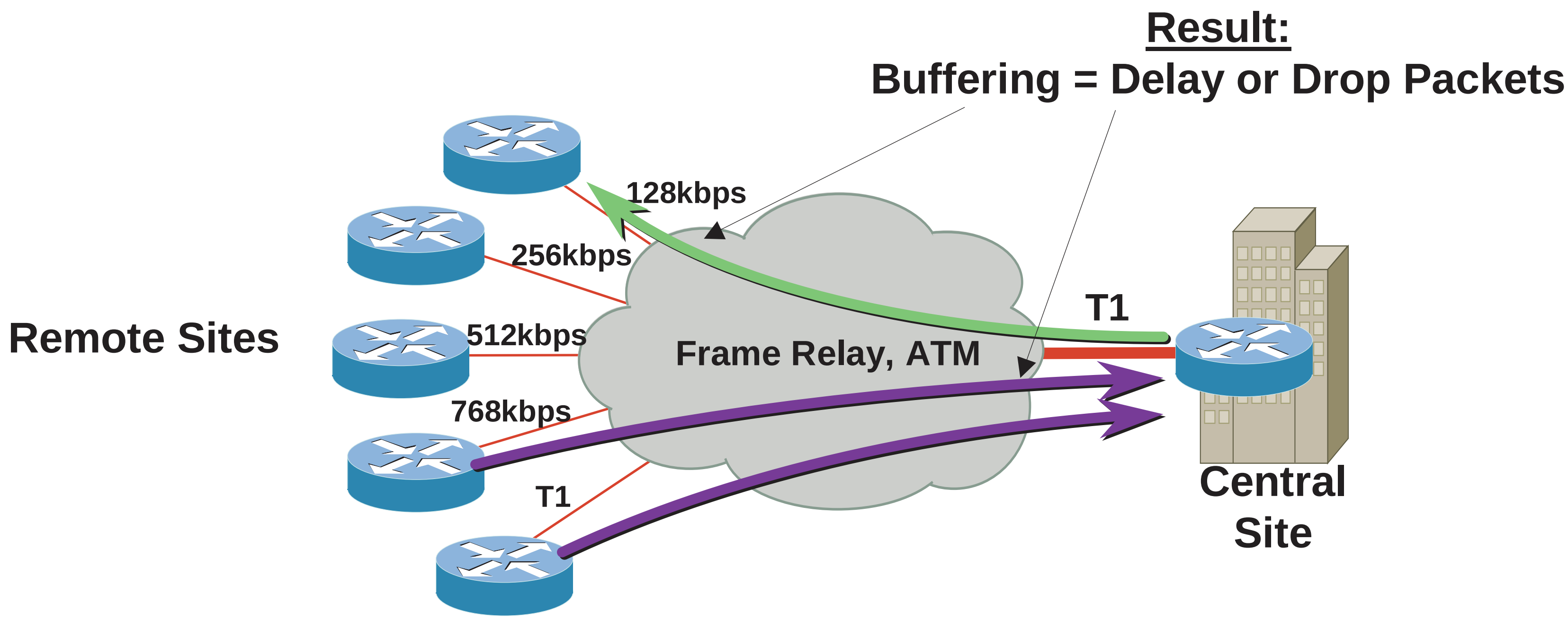

Configuring RFC-2698: Dual Rate Policer

12.2.4T

```
Policy-map 2698POLICE

   class c1
     set ip dscp 10
     police cir 80000 conform-burst 2000
      pir 80000 peak-burst 2500 conform-action transmit
                          exceed-action drop violate-action drop
   class c2
     police cir 40000 conform-burst
    pir 2000 exceed-burst 2000 conform-action transmit
                                          exceed-action drop
   class c3
     police cir 100000 conform-burst 1000
      pir 110000 peak-burst 1000  conform-action set-prec-transmit 7
                                          exceed-action set-prec-transmit 4
                                          violate-action set-prec-transmit 0
```


Shaping Applications



- Central to remote site speed mismatch
- Prohibit bursting above committed rate
- Shape a class @ CIR to satisfy SLAs

Configuring Class-Based Shaping

```
Router(config-pmap-c)# shape <average | peak>
<meanrate> [<burst size> [<excess burst
size>]]
```

```
router(config)# policy-map SHAPING
router(config-pmap)# class bronze
router(config-pmap-c)# shape average 10000000
router(config-pmap-c)# exit
router(config)# interface pos1/0/0
router(config-if)#service-policy output SHAPING
```

QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Congestion Management

- **Queuing techniques to serve traffic with guaranteed bandwidth:**

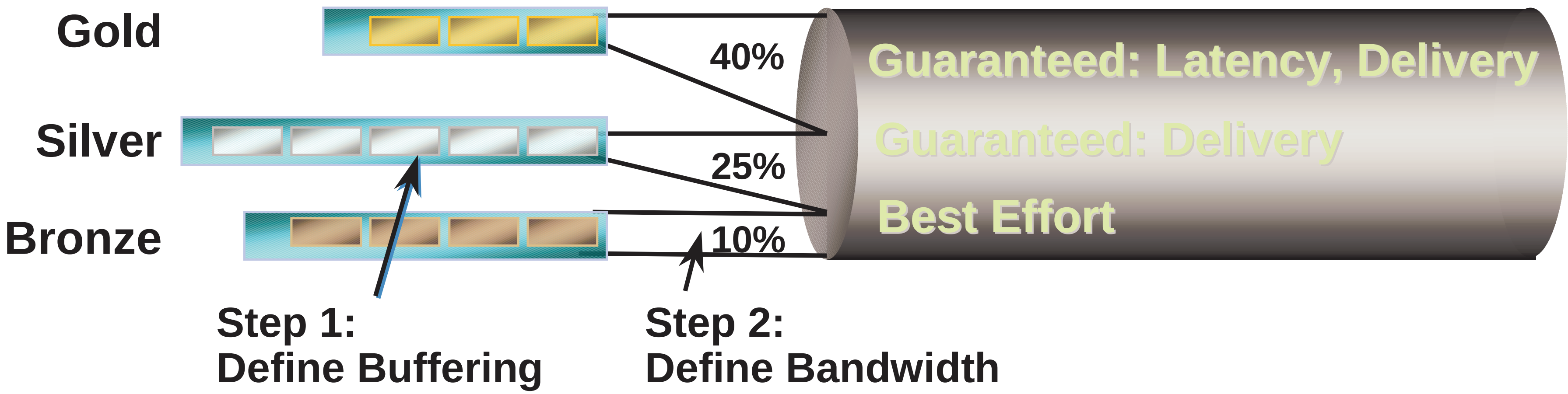
  WFQ (Weighted Fair Queue)

  CBWFQ (Class Based Weighted Fair Queue)

  LLQ (Low Latency Queue)

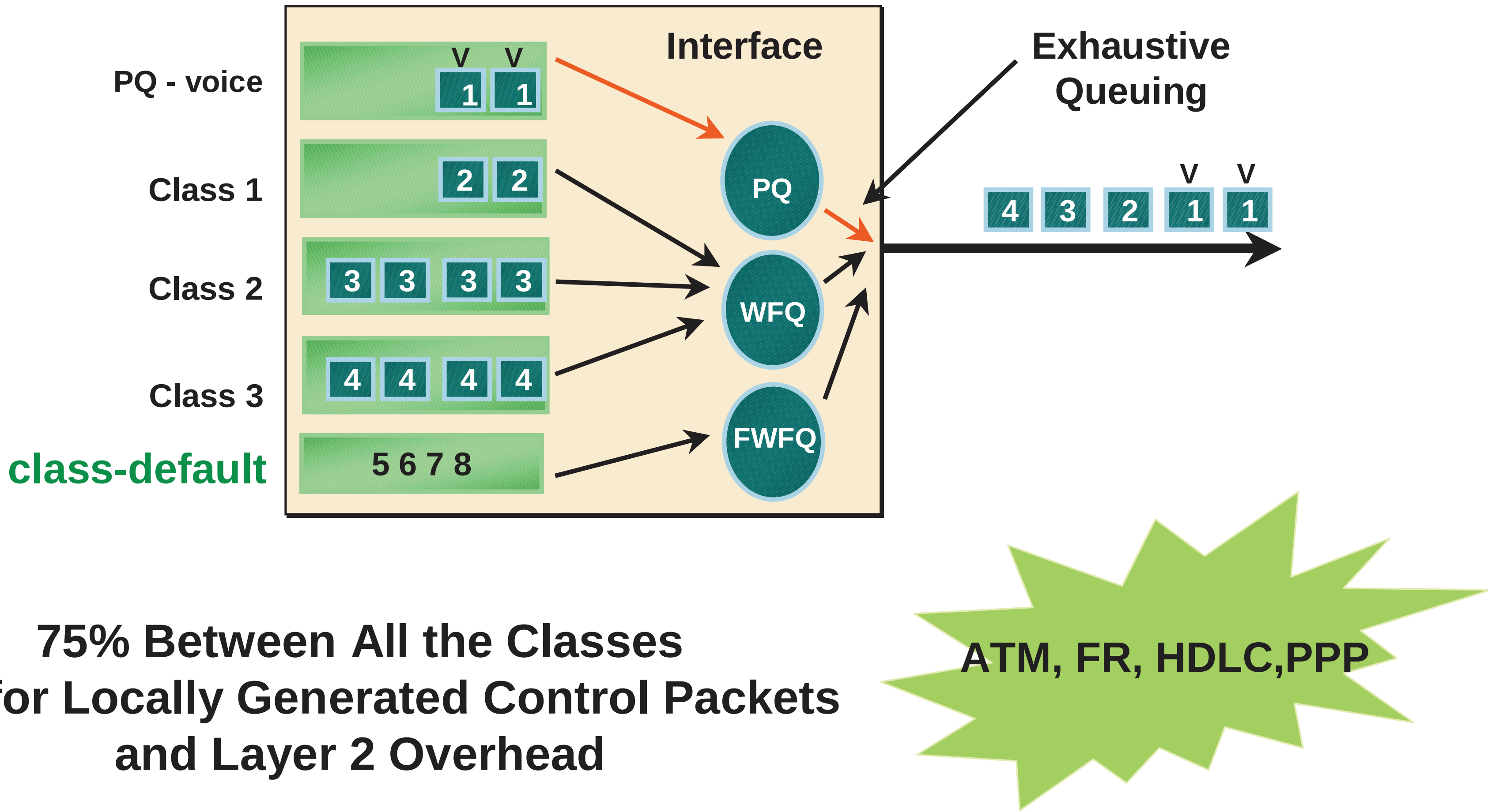
  MDRR (M Deficit Round Robin)

Class-Based WFQ: QoS Guarantees and Bandwidth Efficiency



- Weights guarantee minimum bandwidth
- Buffering controls latency
- Unused capacity is shared amongst the other classes
- Each queue can be separately configured for QoS
- Benefits:
  - Maximize transport of paying traffic
  - No loss of service class guarantees
  - No wasted bandwidth as with PVCs

Low Latency Queuing



75% Between All the Classes
25% for Locally Generated Control Packets and Layer 2 Overhead

LLQ Configuration

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>> Absolute Percent Specification

```
policy-map Multiservice
  class VoIP
    priority 240
 (OR priority percent 10)
  class business
    bandwidth percent 30
  class data
    bandwidth percent 20
```

```
policy-map Multiservice
  class VoIP
    priority 240
  OR priority percent 10
  class business
    bandwidth 512
  class data
    bandwidth 256
```

75% rule applies

>> Relative Percent Specification

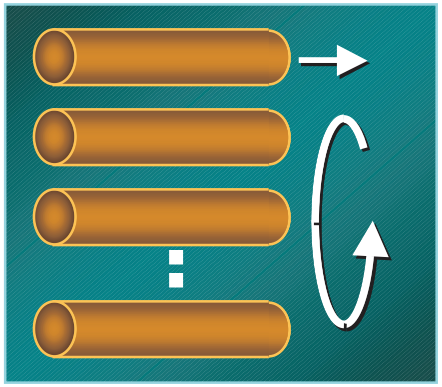
```
policy-map Multiservice
  class VoIP
    priority percent 10
  class business
    bandwidth remaining percent 30
  class class-default
    bandwidth remaining percent 20
```

75% rule doesn't apply

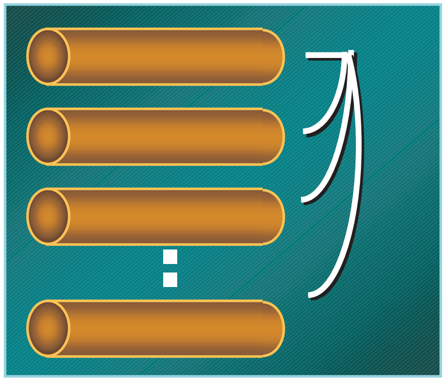
MDRR Queuing on the 12000

- 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

Strict Priority



Alternate Priority



QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Congestion Avoidance

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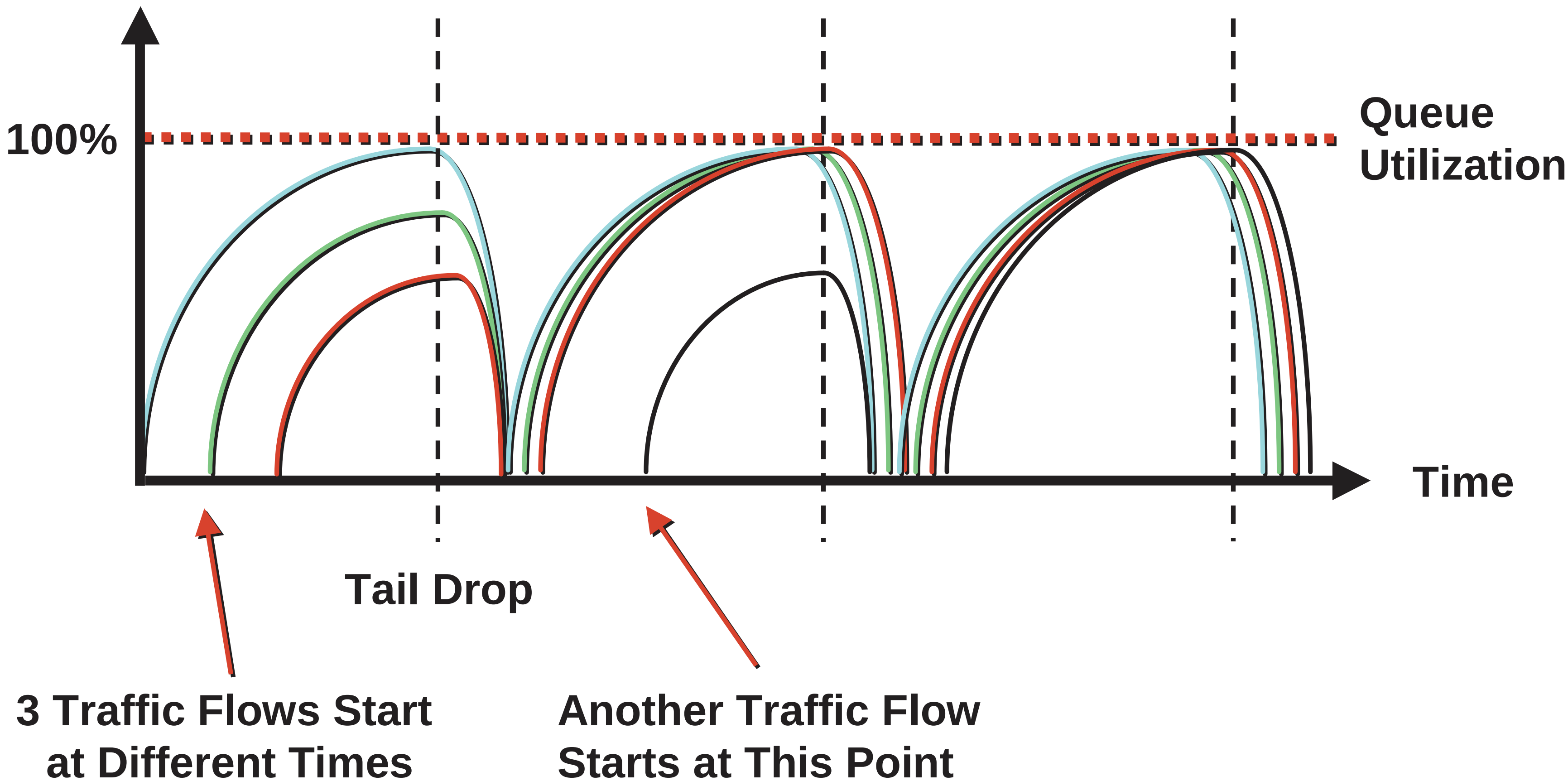
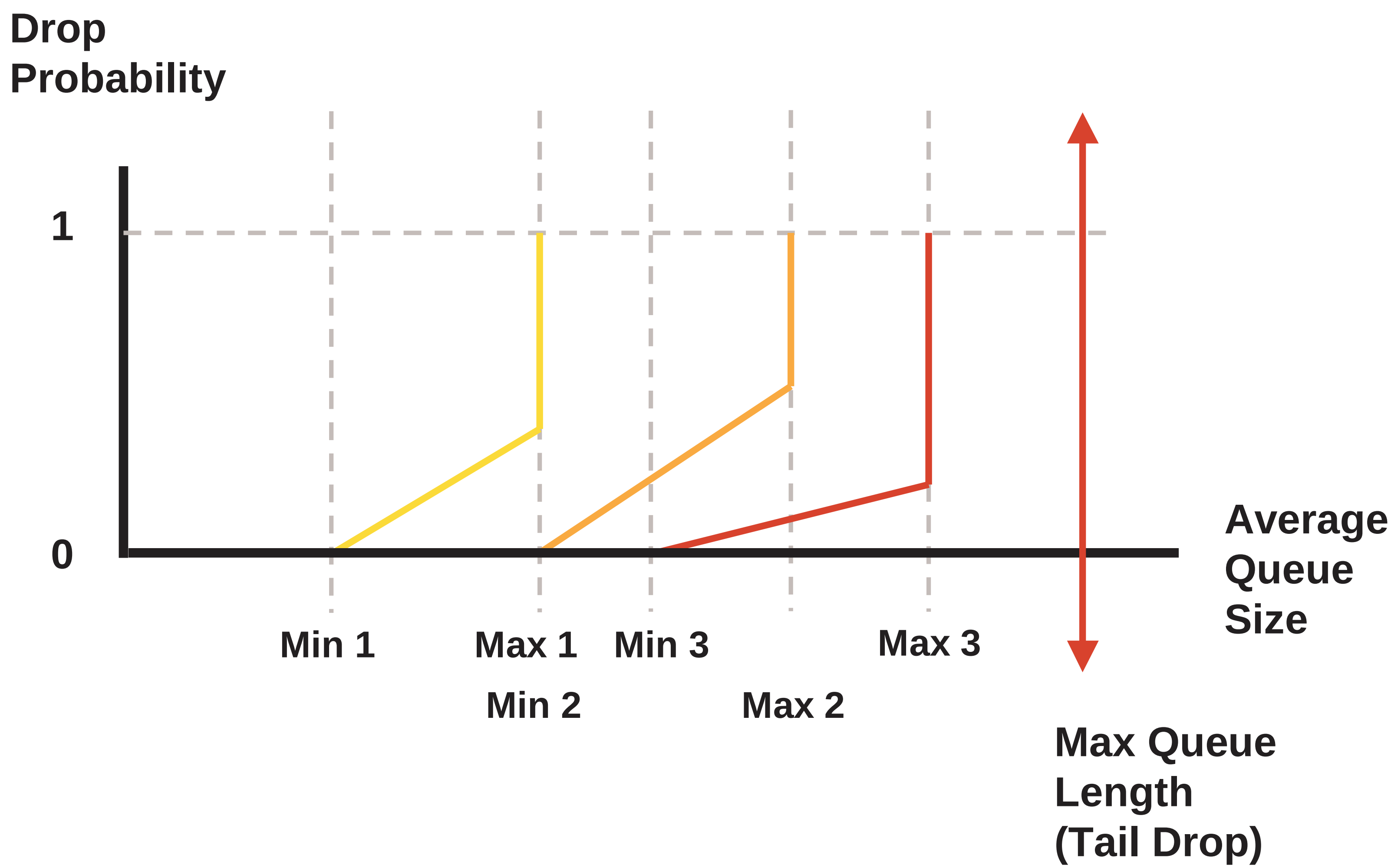


WRED Parameters



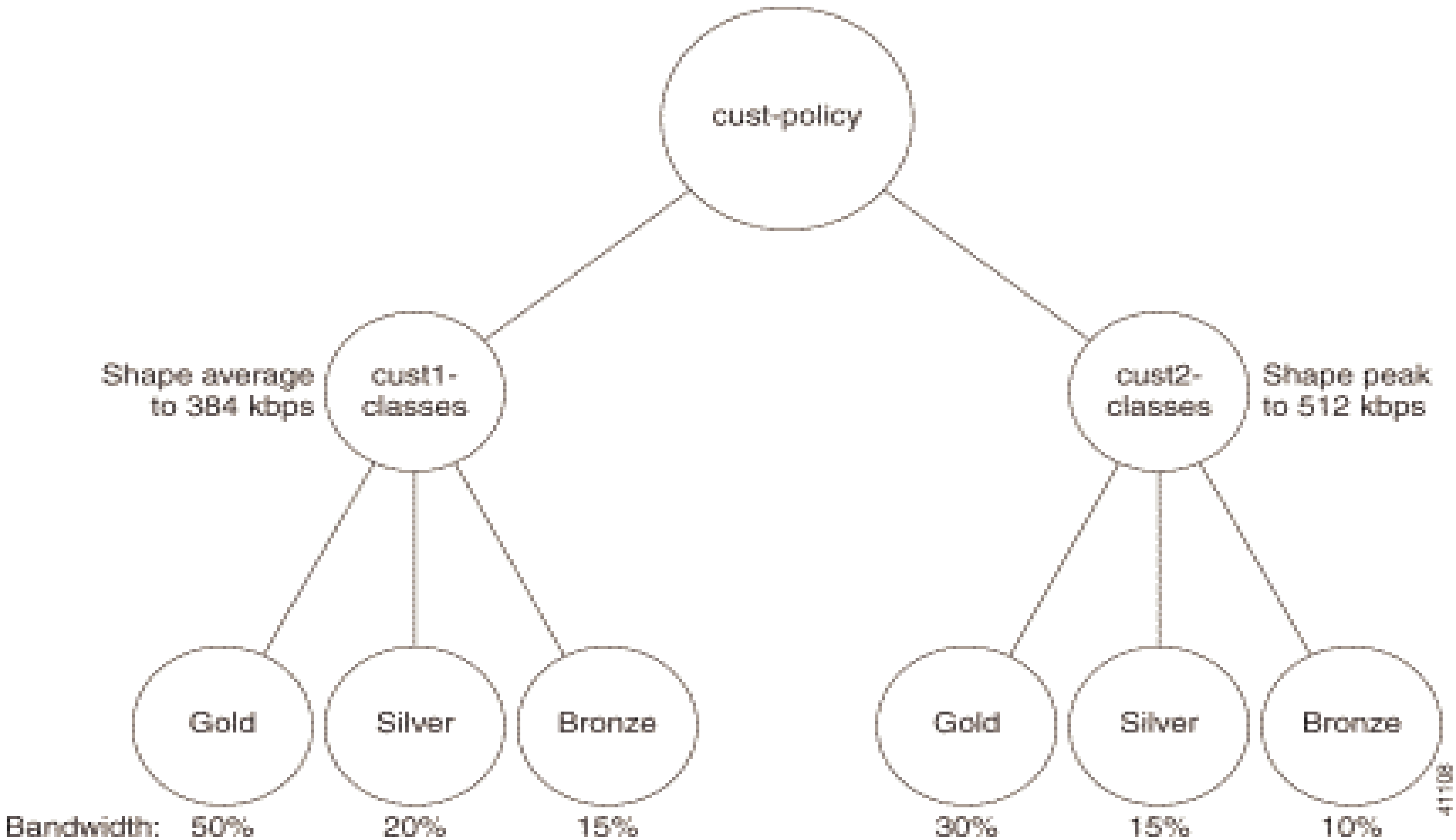
WRED Configuration


```
!
policy-map AVOID
  class gold
    bandwidth percent 50
    random-detect
  class bronze
    bandwidth percent 15
    random-detect dscp-based
    random-detect dscp af31   20    40    10
    random-detect dscp af32   20    40    20
    random-detect dscp af33   20    40    30
!
```


QoS Features

- Modular QoS CLI
- Classification
- Packet marking
- Traffic conditioners
- Congestion management
- Congestion avoidance
- Hierarchical policy rules

Hierarchical Policies



Hierarchical Policies
Child Policies


```
Router(config)# policy-map cust1-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 50
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 20
```

```
Router(config)# policy-map cust2-classes
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth percent 30
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth percent 15
```


Parent Policy Embedding Child Policies


```
Router(config)# policy-map cust-policy
Router(config-pmap)# class cust1
Router(config-pmap-c)# shape average 38400
Router(config-pmap-c)# service-policy cust1-classes
Router(config-pmap)# class cust2
Router(config-pmap-c)# shape peak 51200
Router(config-pmap-c)# service-policy cust2-classes
Router(config-pmap-c)# interface Serial 3/2
Router(config-if)# service out cust-policy
```


Hierarchical Policy Rules

- Shaping has to be at a parent level to support queuing at the child level
- Hierarchical shaping is not supported yet
- Additional supported combinations are:

Bandwidth and Shaping
Bandwidth

Shaping
Police
Priority
Bandwidth

Bandwidth
Police

Police
Police

Any to Any Combination Is Supported on 7500 Platforms!

Agenda

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- DiffServ QoS Feature Set
- Link Efficiency Mechanisms
- RSVP Feature Set
- QoS L2-L3 Interworkings

Data and Voice Opposite Needs/Behavior

Data	Voice
Bursty	Smooth
Greedy	Benign
Drop sensitive	Drop insensitive
Delay insensitive	Delay sensitive
TCP retransmits	UDP best effort

QoS for Voice

- **QoS for Voice means providing**

  No Loss | Guaranteed Bandwidth

  Low Delay | Low Jitter

- **Available Tools** | **Solution**

  Link Efficiency Mechanisms:

  Compression ← Reduce Overhead

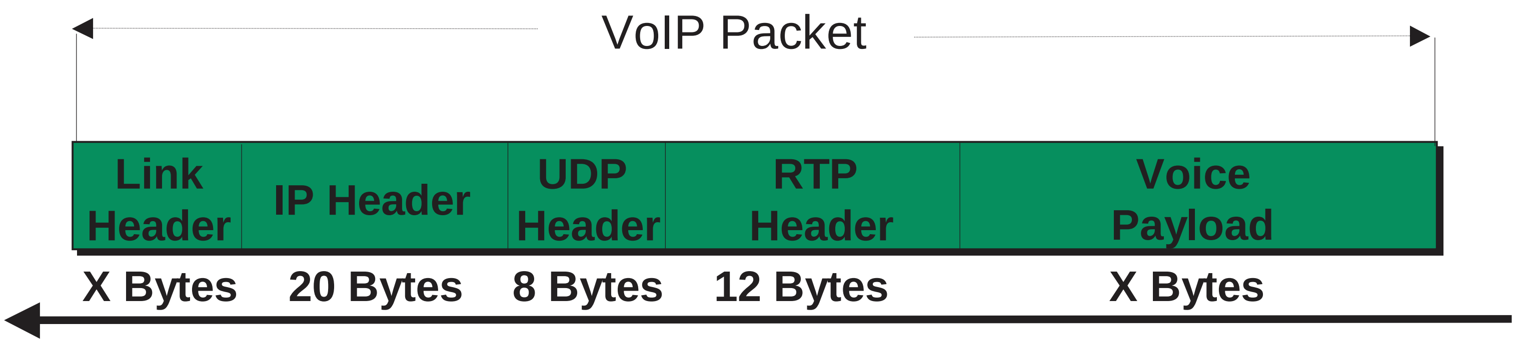
  Fragmentation/Interleaving ← Minimize Ser. Delay

  Queuing Mechanisms: ← Control Queuing Delay

  LLQ | PIPQ

  IP RTP Priority | PQ

VoIP Packet Format



- **Payload size, PPS and BPS vendor implementation specific**
- **For Example:**

<u>Not including Link Layer Header or CRTP</u>

Cisco Router at G.711	**= 160 Byte Voice Payload at 50pps (80kbps)**
Cisco Router at G.729	**= 20 Byte Payload at 50pps (24kbps)**
Cisco IP Phone at G.711	**= 240 Byte Payload at 33pps (74.6kbps)**
Cisco IP Phone at G.723.1	**= 24 Byte Payload at 33pps (17kbps)**

Note: Link Layer Sized Vary Per Media

Various Link Layer Header Sizes

"Varying Bit Rates per Media"

Example—G.729 with 60 Byte Packet (Voice and IP Header) at 50pps (No RTP Header Compression)

Media	Link Layer Header Size	Bit Rate
Ethernet	14 bytes	29.6kbps
PPP	6 bytes	26.4kbps
Frame Relay	4 Bytes	25.6kbps
ATM	5 Bytes Per Cell	42.4kbps

Note: For ATM a Single 60byte Packet Requires Two 53 Byte ATM Cells

RTP Header Compression

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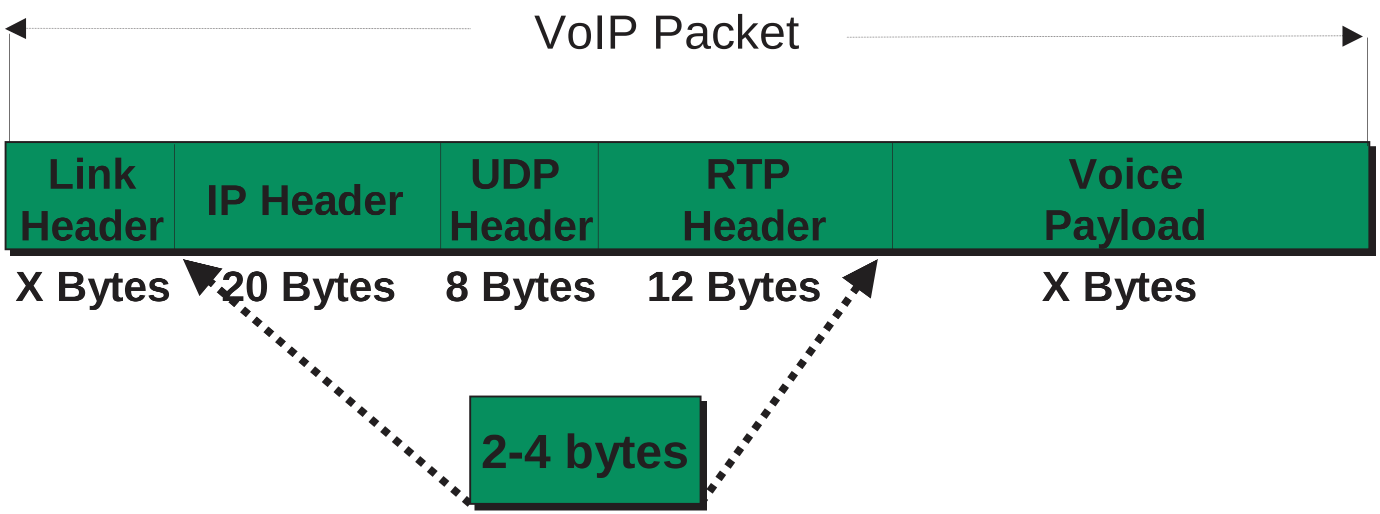

- 20ms@8kb/s yields 20 byte payload
- Overhead is 2X payload!!!!!!!!
- Header compression 40Bytes to 2-4 much of the time
- Hop-by-Hop on slow links
- CRTP—compress RTP, UDP and IP headers only

cRTP Compression Feedback

- No change in the configuration of cRTP
- Queuing, policer, and shaper look at the compressed packets
- Perform accurate admission control since class bandwidths configured based on the compressed data

```
interface Serial5/2
  description to qos1-72a
  bandwidth 2015
  ip address 10.20.20.1 255.255.255.0
  no keepalive
  service-policy output policy1
  ip rtp header compression
```


Delay Budgeting

Voice Path

Loss
+
Delay

- CODEC
- Packetization
- Output queuing

- Access (up) link transmission
- Backbone network transmission
- Access (down) link transmission

- Input queuing
- Jitter buffer
- CODEC

Fragmentation Recommendations

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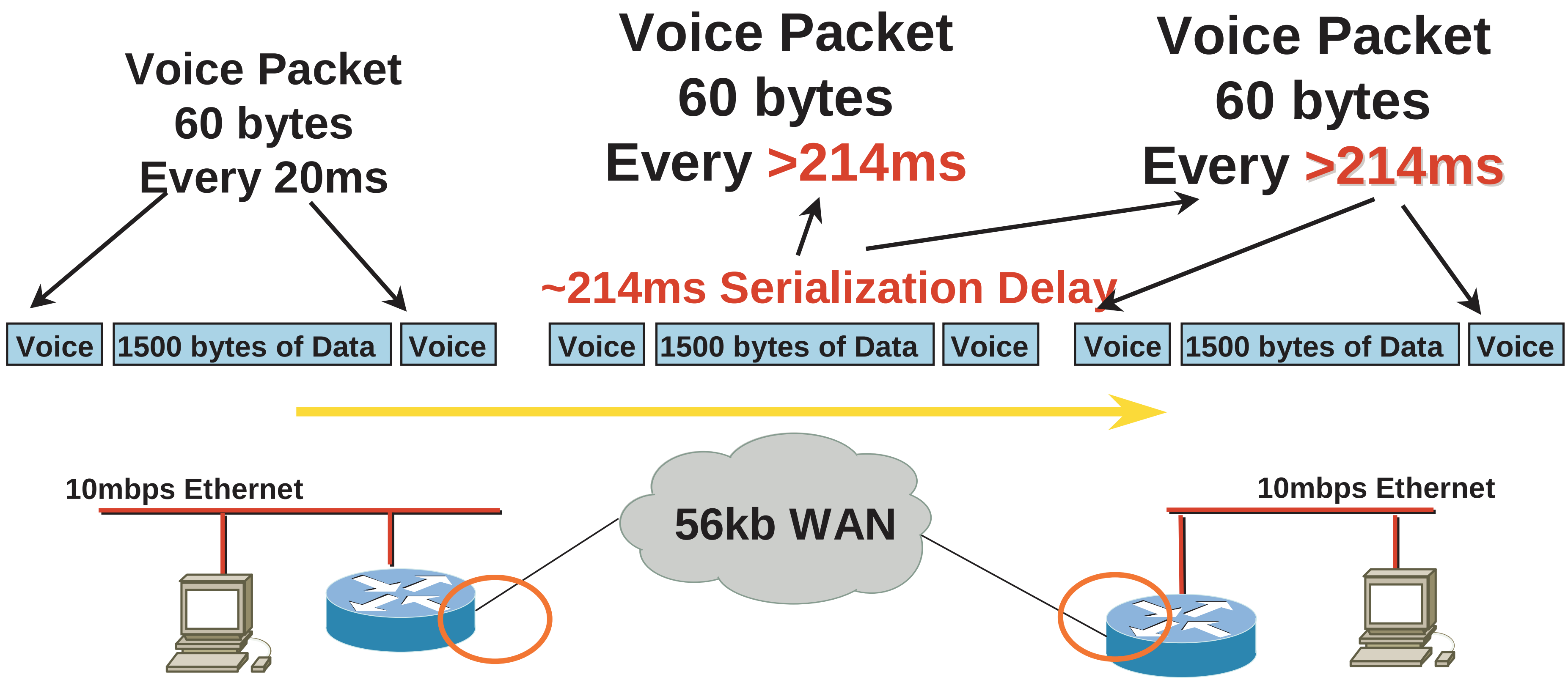
Packet Serialization Delay

Link BW	10ms	20ms	30ms	40ms	50ms	100ms	200ms
56kbps	70 Bytes	140 Bytes	210 Bytes	280 Bytes	350 Bytes	700 Bytes	1400 Bytes
64kbps	80 Bytes	160 Bytes	240 Bytes	320 Bytes	400 Bytes	800 Bytes	1600 Bytes
128kbps	160 Bytes	320 Bytes	480 Bytes	640 Bytes	800 Bytes	1600 Bytes	3200 Bytes
256kbps	320 Bytes	640 Bytes	960 Bytes	1280 Bytes	1600 Bytes	3200 Bytes	6400 Bytes
512kbps	640 Bytes	1280 Bytes	1920 Bytes	2560 Bytes	3200 Bytes	6400 Bytes	12800 Bytes
768kbps	1000 Bytes	2000 Bytes	3000 Bytes	4000 Bytes	5000 Bytes	10000 Bytes	20000 Bytes
1536kbs	2000 Bytes	4000 Bytes	6000 Bytes	8000 Bytes	10000 Bytes	20000 Bytes	40000 Bytes

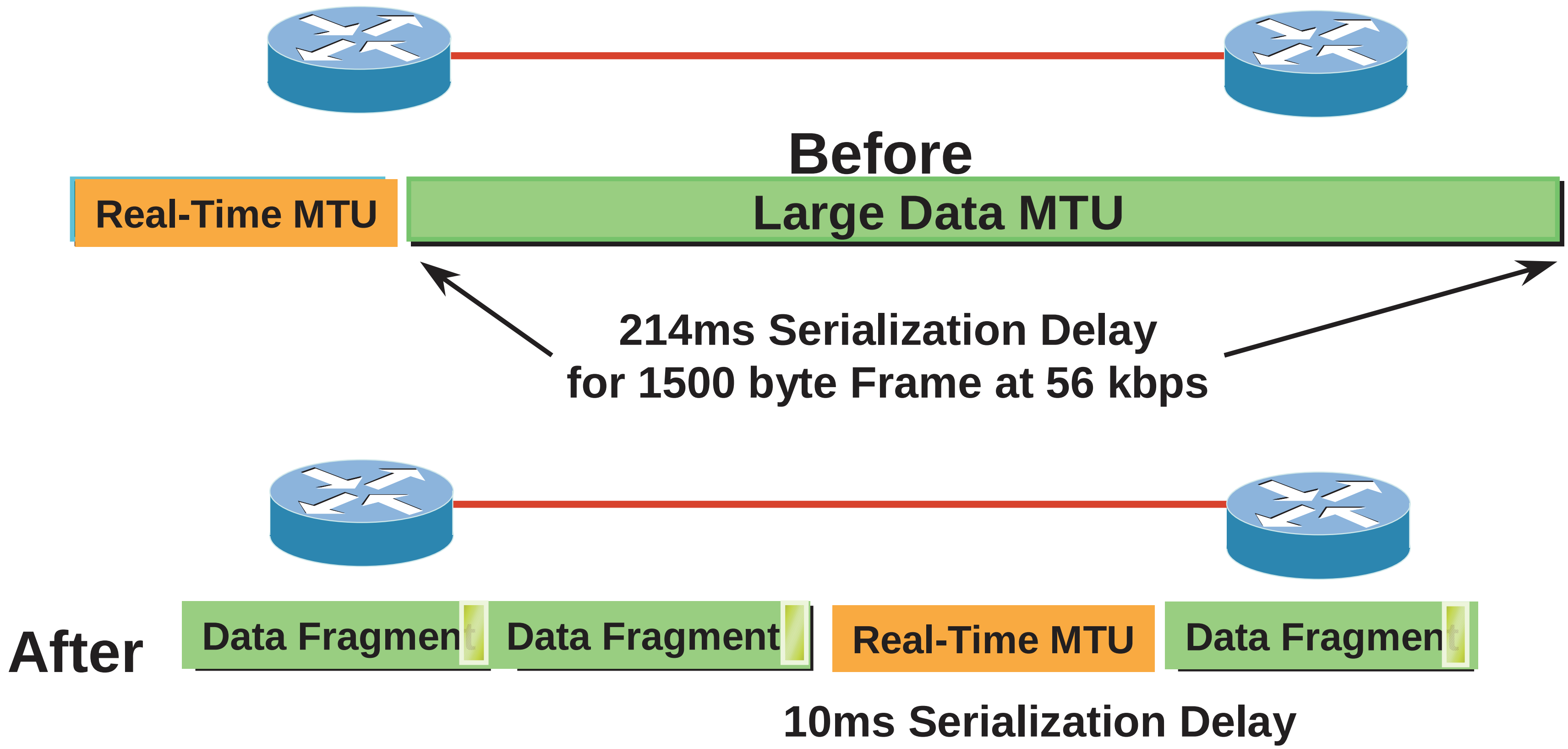
For 1500-byte packets, fragmentation is not necessary above T1 (1.5M)

Jitter



Large Packets "Freeze Out" Voice

Fragmentation and Interleave



Fragment Size Recommendations

This Assumes 10 ms Blocking Delay Per Fragment

Link Speed	Frag Size
56 kbps	70 Bytes
64 kbps	80 Bytes
128 kbps	160 Bytes
256 kbps	320 Bytes
512 kbps	640 Bytes
768 kbps	1000 Bytes
1536 kbs	~~2000 Bytes~~

Note:
For Frame Relay PVC's the Fragment Size Should Be Set According to the Speed of the PVC

i.e.; A 128 kbps PVC on a T1 Would Have the Fragment Size on that PVC Set to 160 bytes

Fragmentation Techniques

- FRF.12 for Frame Relay links
- MLPPP/LFI for PPP links
- ATM fragmentation via MLPPP
- MTU size reduction

FRF.12 Configuration

Hub

```
interface Serial0/0
 no ip address
 encapsulation frame-relay
 bandwidth 1300000
 frame-relay traffic-shaping
!
interface Serial0/0.1 point-to-
point
 ip address 10.1.1.1 255.255.255.0
 no ip directed-broadcast
 bandwidth 1300000
 frame-relay class gene

map-class frame-relay gene
 frame-relay fragment      70
 no frame-relay adaptive-shaping
 frame-relay bc 1000
 frame-relay mincir 56000
 frame-relay fair-queue
```

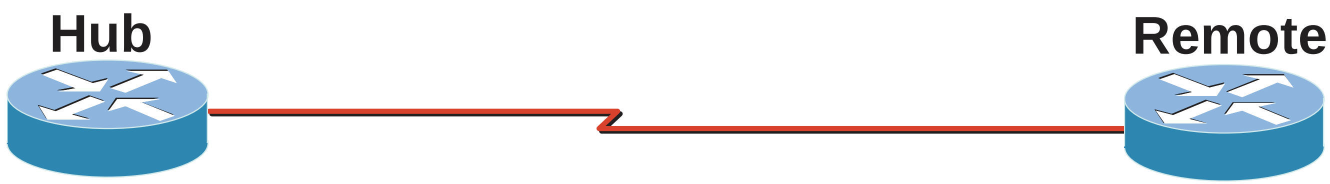
Remote

```
interface Serial0/0
 no ip address
 encapsulation frame-relay
 bandwidth 56000
 frame-relay traffic-shaping
!
interface Serial0/0.1 point-
to-point
 ip address 10.1.1.2
255.255.255.0
 no ip directed-broadcast
 bandwidth 56000
 frame-relay class gene

map-class frame-relay gene
 frame-relay fragment      70
 no frame-relay adaptive-
shaping
 frame-relay bc 1000
 frame-relay mincir 56000
 frame-relay fair-queue
```

Note: Bc set lower than the default of 1/8th the CIR
Lower interval better on high speed links with low CIR (can result in quicker credit exhaustion)

Configuring Multilink PPP Fragmentation and Interleave



Hub

```
interface Virtual-Template1

 fair-queue 64 256 1000

 ppp multilink fragment-delay 10
 ppp multilink interleave
!
```

Remote

```
interface Virtual-Template1

 fair-queue 64 256 1000

 ppp multilink fragment-delay 10
 ppp multilink interleave
!
```

Desired Max Blocking Delay in ms

Fragmentation size a result of this and “bandwidth” statement

Agenda

- DiffServ QoS Feature Set
- Link Efficiency Mechanisms
- RSVP
- QoS L2-L3 Interworkings

Integrated Services—RSVP Agenda

- RSVP Basics
- RSVP for CAC
- Deployment
- RSVP Enhancements

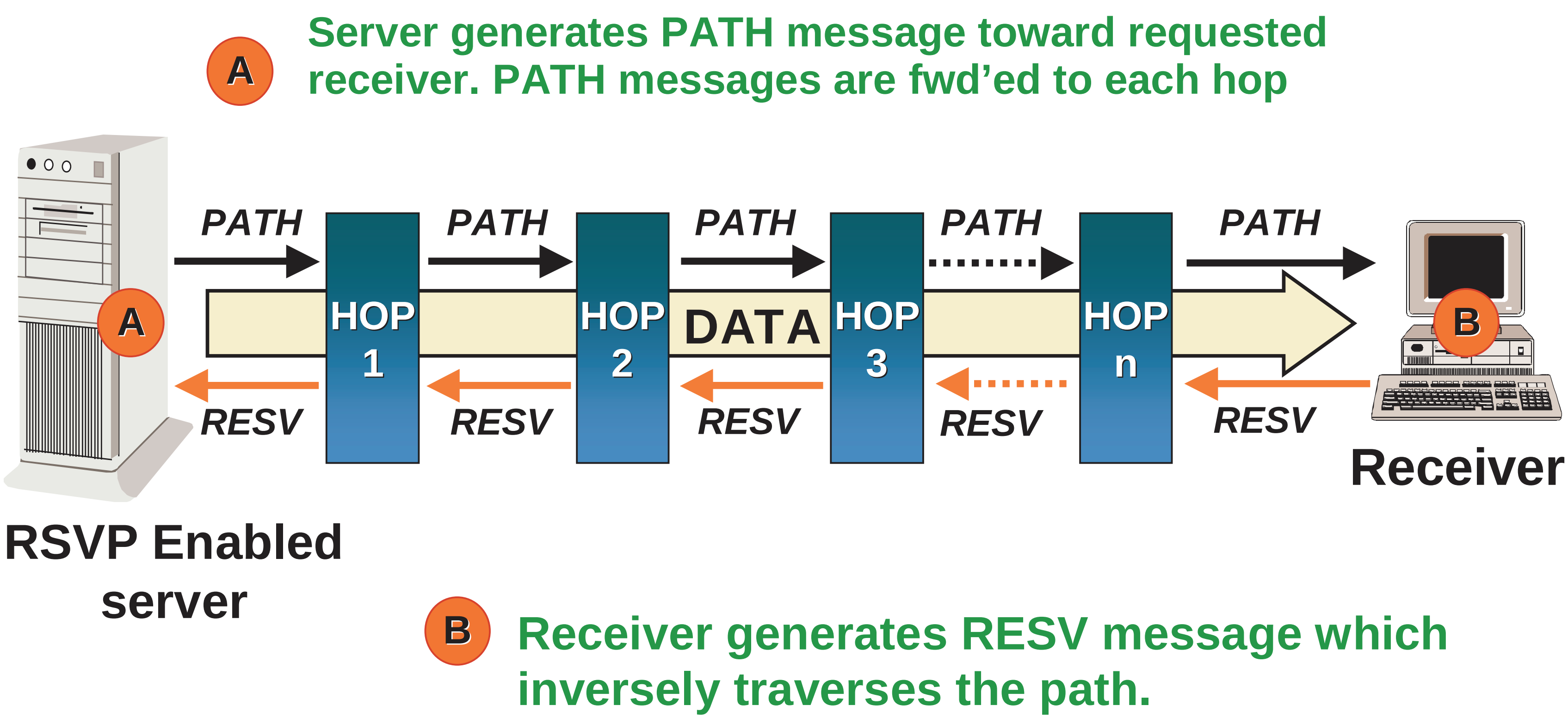
RSVP Messages

RSVP supports four basic message types

- Reservation request messages
- Path messages
- Error and confirmation messages
- Teardown messages

RESV and Path Messages

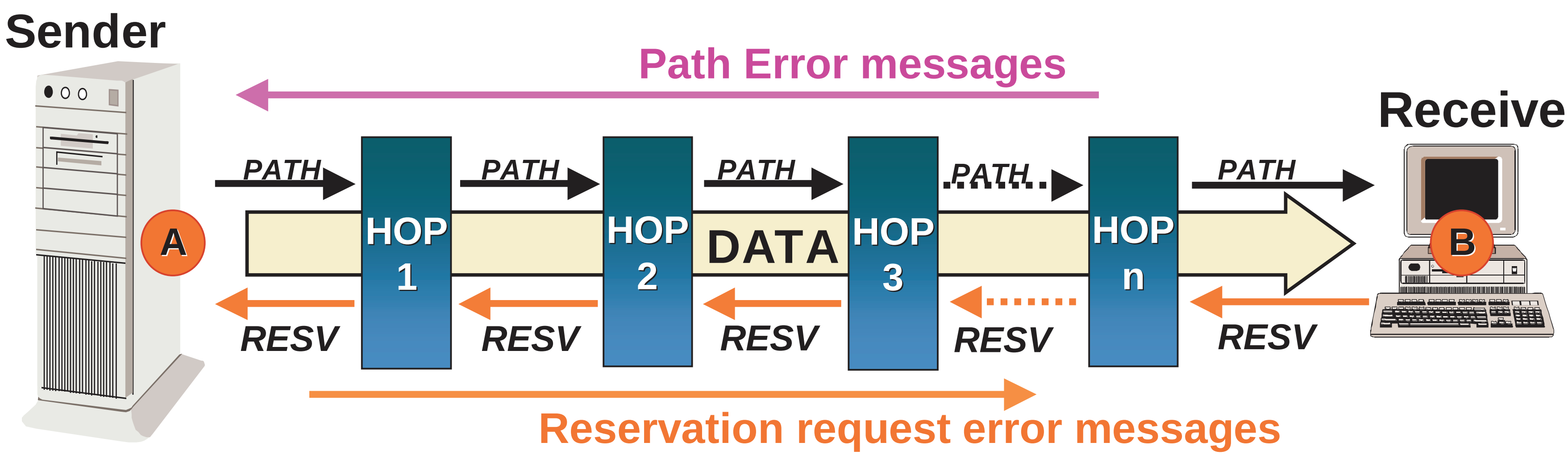
- **Path messages**



- **Reservation request messages**

Error and Confirmation Messages

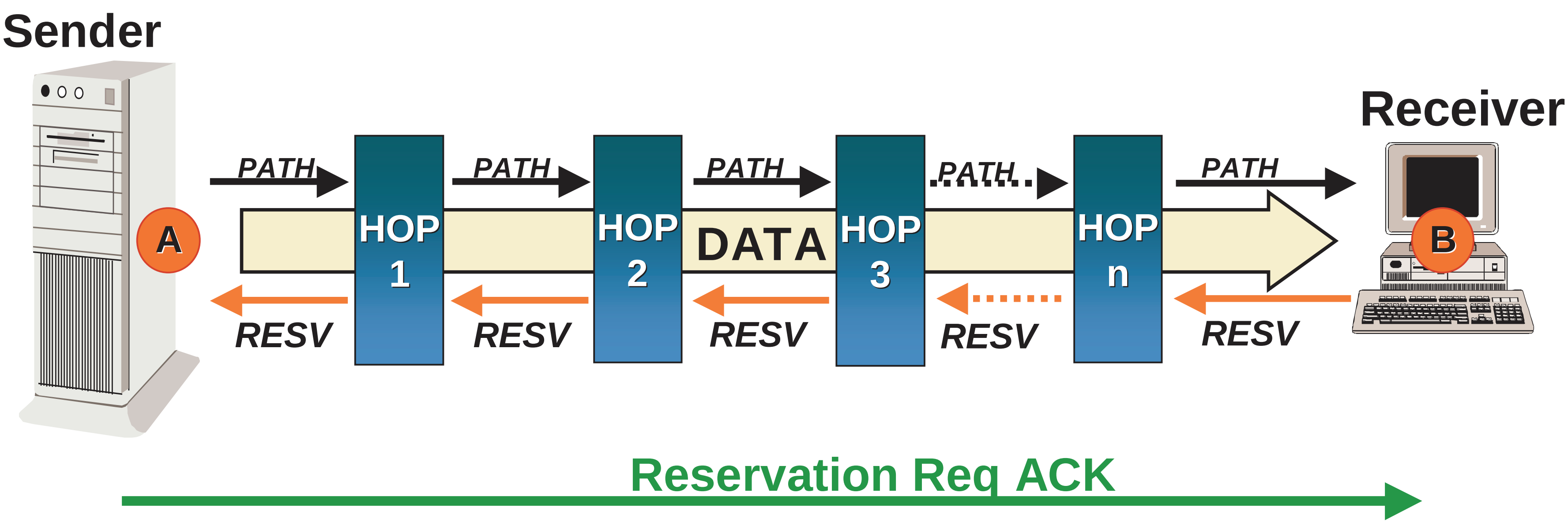
- Path Error messages result from path messages and travel toward senders



- Reservation request error messages →
  - Admission failure
  - Bandwidth unavailable
  - Service not supported
  - Bad flow specification
  - Ambiguous path

Error and Confirmation Messages

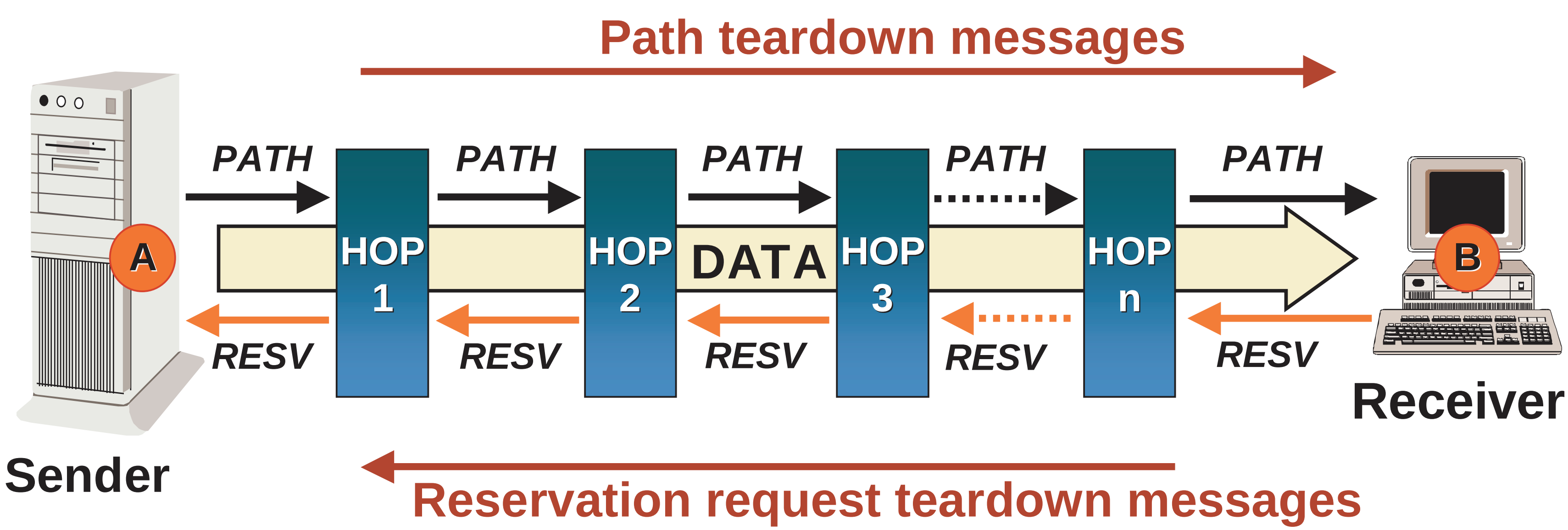
- Reservation request acknowledgment messages



- These messages travel towards the receiver.

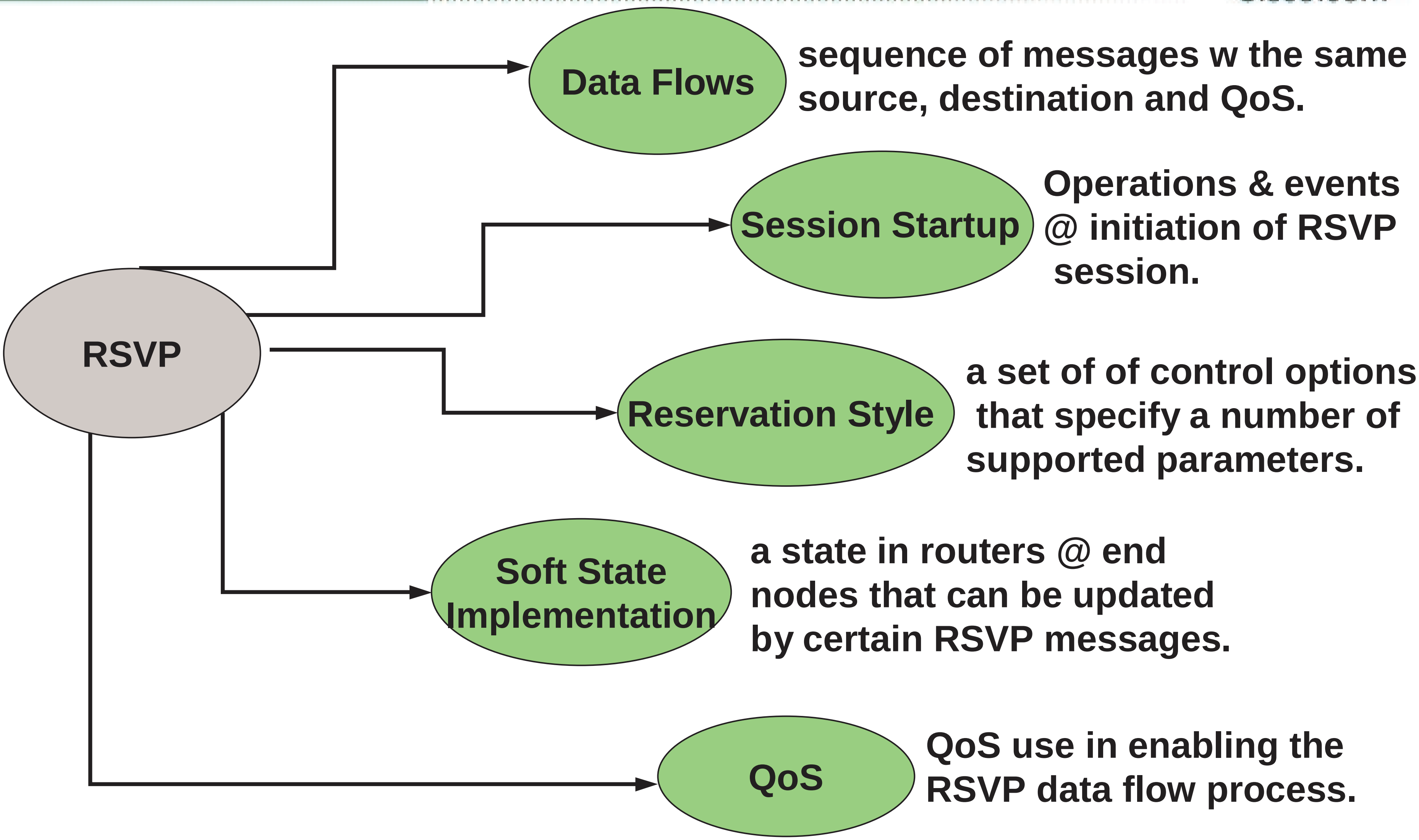
Teardown Messages

Two Types →
- Path teardown messages
- Reservation request teardown messages



Both types travel from the point of initiation

RSVP Components



Integrated Services—RSVP Agenda

- RSVP Basics
- RSVP for CAC
- Deployment
- RSVP Enhancements

RSVP for CAC
Why?

- **Can take alternative action if resources not available, w/o degrading the quality of existing calls**
- **For VoIP CAC, RSVP is synchronized with H323 V2.**
- **Ensures that the called party phone rings only after the resources for the call have been reserved.**
- **Take appropriate actions if BW reservation fails.**
- **H323V1 and H323V2 supported.**

RVSP for CAC

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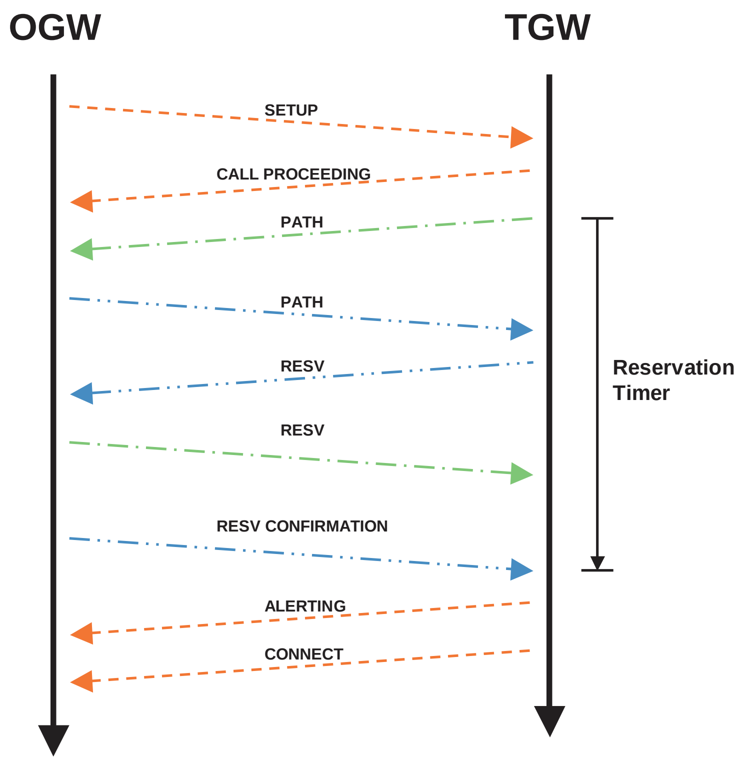
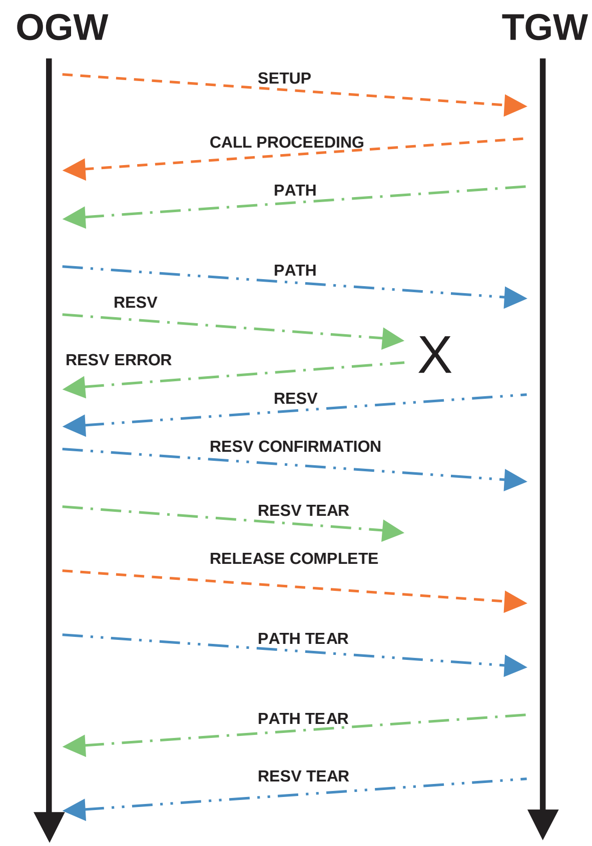


Call does not move to alerting until reservations are complete



Call is disconnected when reservation fails

Possible RSVP CAC Results

Originating Gateway		Terminating Gateway		
Requested QoS	Acceptable QoS	Requested QoS	Acceptable QoS	Results
Guaranteed delay or controlled load	Guaranteed delay or controlled load	Guaranteed delay or controlled load	Guaranteed delay or controlled load	RSVP is attempted from both directions and call proceeds only if both reservations succeed.
Guaranteed delay or controlled load	Guaranteed delay or controlled load	Guaranteed delay or controlled load	best effort	RSVP is attempted from both directions and call proceeds only if both reservations succeed.
Guaranteed delay or controlled load	Guaranteed delay or controlled load	best effort	best effort	RSVP is not attempted and the call is released
Guaranteed delay or controlled load	best effort	Guaranteed delay or controlled load	Guaranteed delay or controlled load	RSVP is attempted from both directions and call proceeds only if both reservations succeed.
Guaranteed delay or controlled load	best effort	Guaranteed delay or controlled load	best effort	RSVP is attempted from both directions and call proceeds regardless of RSVP results. Call receives best-effort service if reservation fails.
Guaranteed delay or controlled load	best effort	best effort	best effort	RSVP is not attempted and the call proceeds with best-effort service.
best effort	best effort	Guaranteed delay or controlled load	Guaranteed delay or controlled load	Terminating gateway attempts RSVP reservation. Reservation request times out and call is released.
best effort	best effort	Guaranteed delay or controlled load	best effort	Terminating gateway attempts RSVP reservation. Reservation request times out and call proceeds with best-effort service.
best effort	best effort	best effort	best effort	RSVP is not attempted in either direction and call proceeds with best-effort service.

Call Treatment if RSVP Fails

- Release call and signal the calling party
- Reroute the call through another path
- Allow the call with best-effort service

RSVP Support for LLQ

- The RSVP TSpec is compared with PQ profile
- Flows with TSpec within PQ profile use the PQ (no MQC configuration required)
- Flows with TSpec above PQ profile get a reserved queue within WFQ
- A voice-like PQ profile is enabled by default

Integrated Services—RSVP Agenda

- RSVP Basics
- RSVP for CAC
- Deployment
- RSVP Enhancements

Configuring RSVP Support for LLQ

- For resources to be reserved, WFQ must be enabled on interface or PVC
- Reservation only takes care of voice and some signaling packets
- Guaranteed delay and controlled load get the same resources reserved
- Guaranteed delay QoS is recommended

RSVP Configuration on Gateways

Cisco.com

Configuring H.323 Synchronization with RSVP

```
hostname OGW
!
call rsvp-sync
!
interface Serial0/0
 bandwidth 1536
 ip address 10.10.1.1 255.255.255.0
 fair-queue
 ip rsvp bandwidth 1152 24
!
dial-peer voice 300 voip
 destination-pattern 3......
 session target ipv4:10.77.39.129
 req-qos guaranteed-delay
 acc-qos guaranteed-delay
```

RSVP configuration on Intermediate Devices

Cisco.com

```
hostname ID1
!
interface Serial0/0
 bandwidth 1536
 ip address 10.10.1.1 255.255.255.0
  fair-queue
 ip rsvp bandwidth 1152 24
!
interface Serial2/0
 bandwidth 1536
 ip address 10.100.10.1 255.255.255.0
  fair-queue
 ip rsvp bandwidth 1152 24
!
```


Integrated Services—RSVP Agenda

- RSVP Basics
- RSVP for CAC
- Deployment
- RSVP Enhancements 12.2T

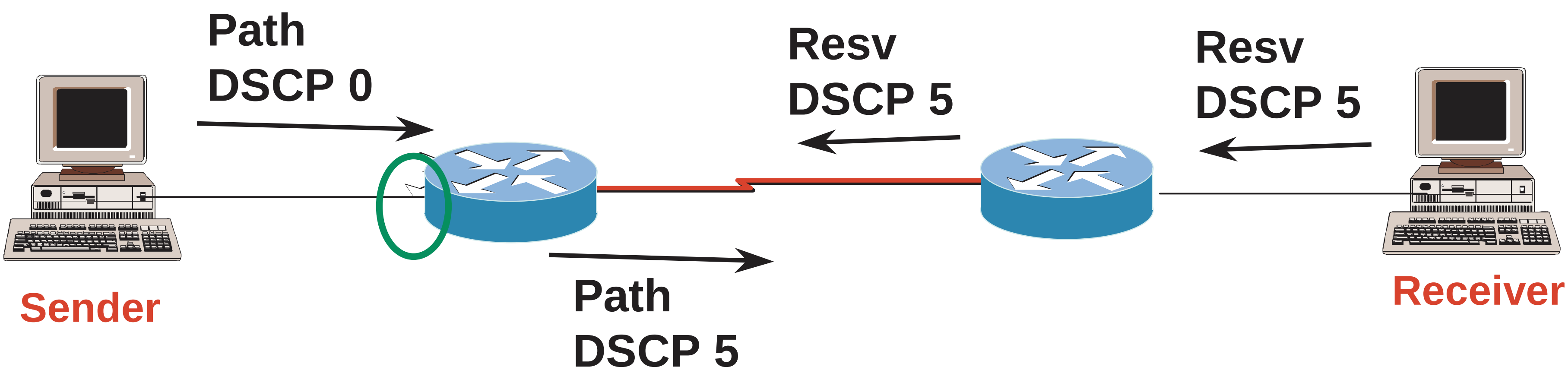
RSVP Enhancements
Control Plane DSCP support for RSVP

- Set DSCP values for path and reservation messages
- By default, RSVP messages are marked best effort

- Benefits:
    - Faster Call Setup time
    - Improved Message Delivery
    - Faster Recovery and Failure Conditions

RSVP Enhancements
Control Plane DSCP support for RSVP

Cisco.com




```
Router(config-if) ip rsvp signalling dscp <value>
Router(config-if) ip rsvp signalling dscp  5
```

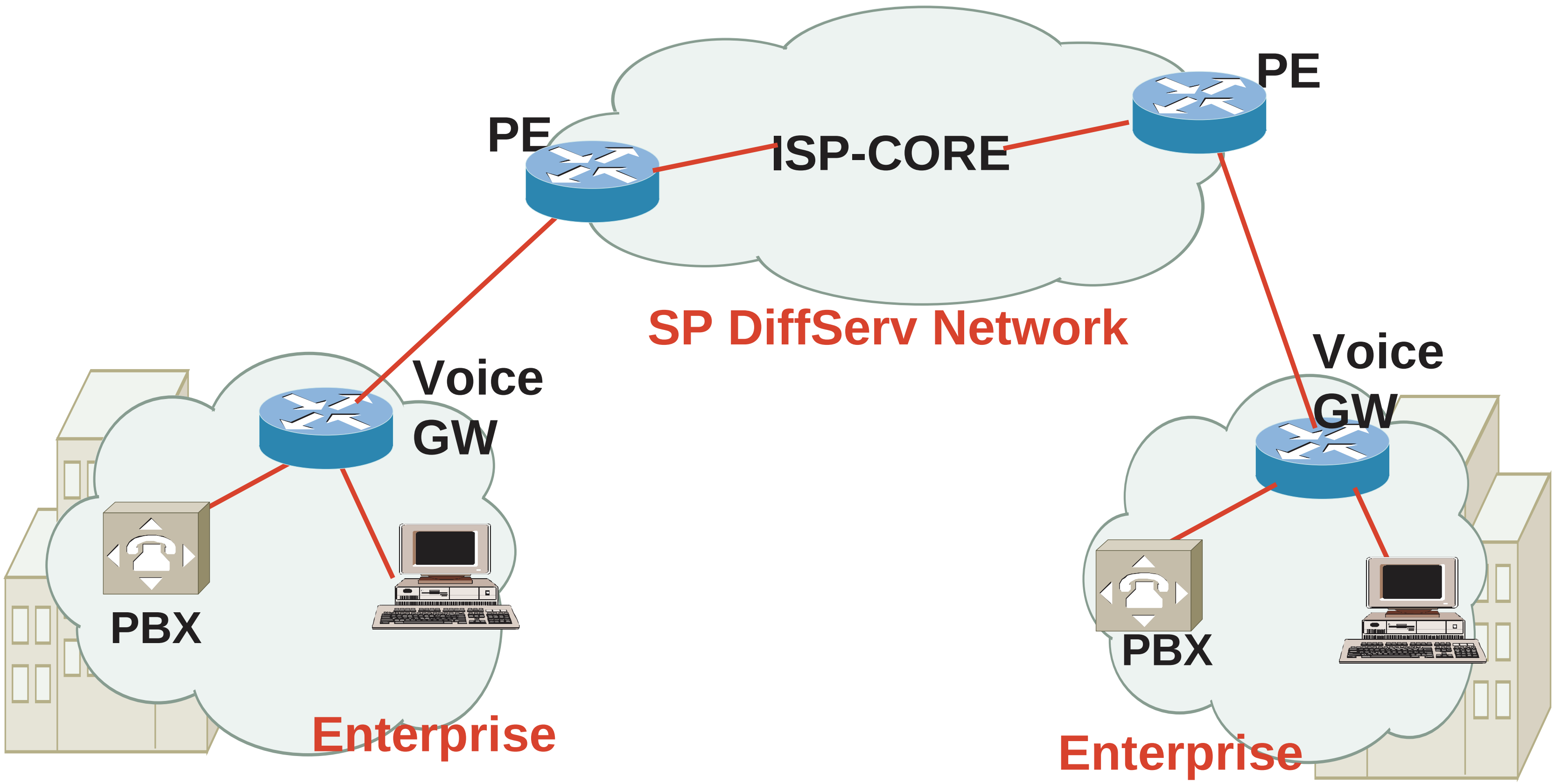

RSVP Enhancements
RSVP Scalability Enhancement

IntServ-DiffServ Integration for Voice

» **Handle similar flows on a per Class basis instead of a per Flow basis**

» **Disable data classification and have RSVP perform admission control only & reduce CPU consumption.**

RSVP Scalability Enhancements IntServ-DiffServ Integration



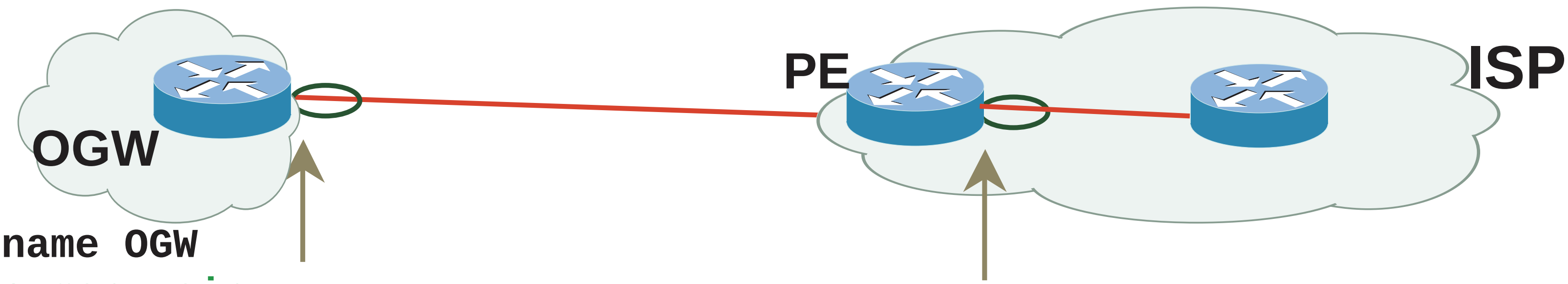
Voice Gateways and PE run classic RSVP, ISP core routers do NOT!

RSVP Scalability Enhancement IntServ-DiffServ Integration

- Enable RSVP on an interface
- Set the resource provider
- Disable data packet classification
- Configure class and policy maps
- Apply a policy to an interface

Sample Config w Enhancements

Cisco.com

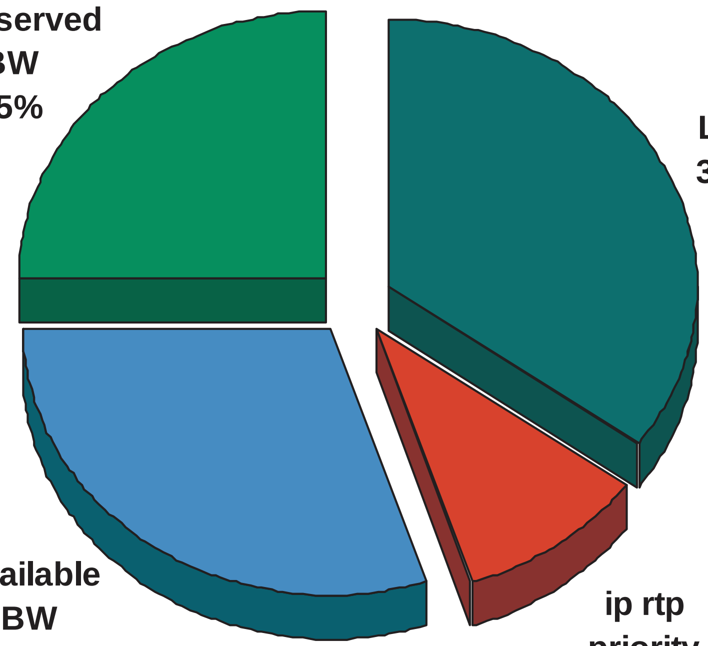



```
hostname OGW
class-map voip
match protocol 16383 16383
 !
 policy-map signalQoS
   class voip
    priority 240
    set ip dscp 46
   class class-default
    fair-queue
 !
call rsvp-sync
ip rsvp bandwidth 240 24
ip rsvp signaling dscp 46
ip rsvp data-classification none
ip rsvp resource-provider none
ip rsvp pq-profile voice-like
!
interface Serial0/0
service-policy output signalQoS
```

```
hostname PE
class-map voip
match ip dscp 46
policy-map signalQoS
   class voip
    priority 2400
!
ip rsvp bandwidth 2400 240
ip rsvp signaling dscp 46
ip rsvp data-classification none
ip rsvp resource-provider none
!
interface Serial0/0
service-policy output signalQoS
```


RSVP Enhancements
RSVP support on FR/ATM PVCs

- Per-PVC queuing
- BW Manager avoids oversubscription
- mincir for FR
- 75% of output-mcr, output-scr or average-rate for ATM



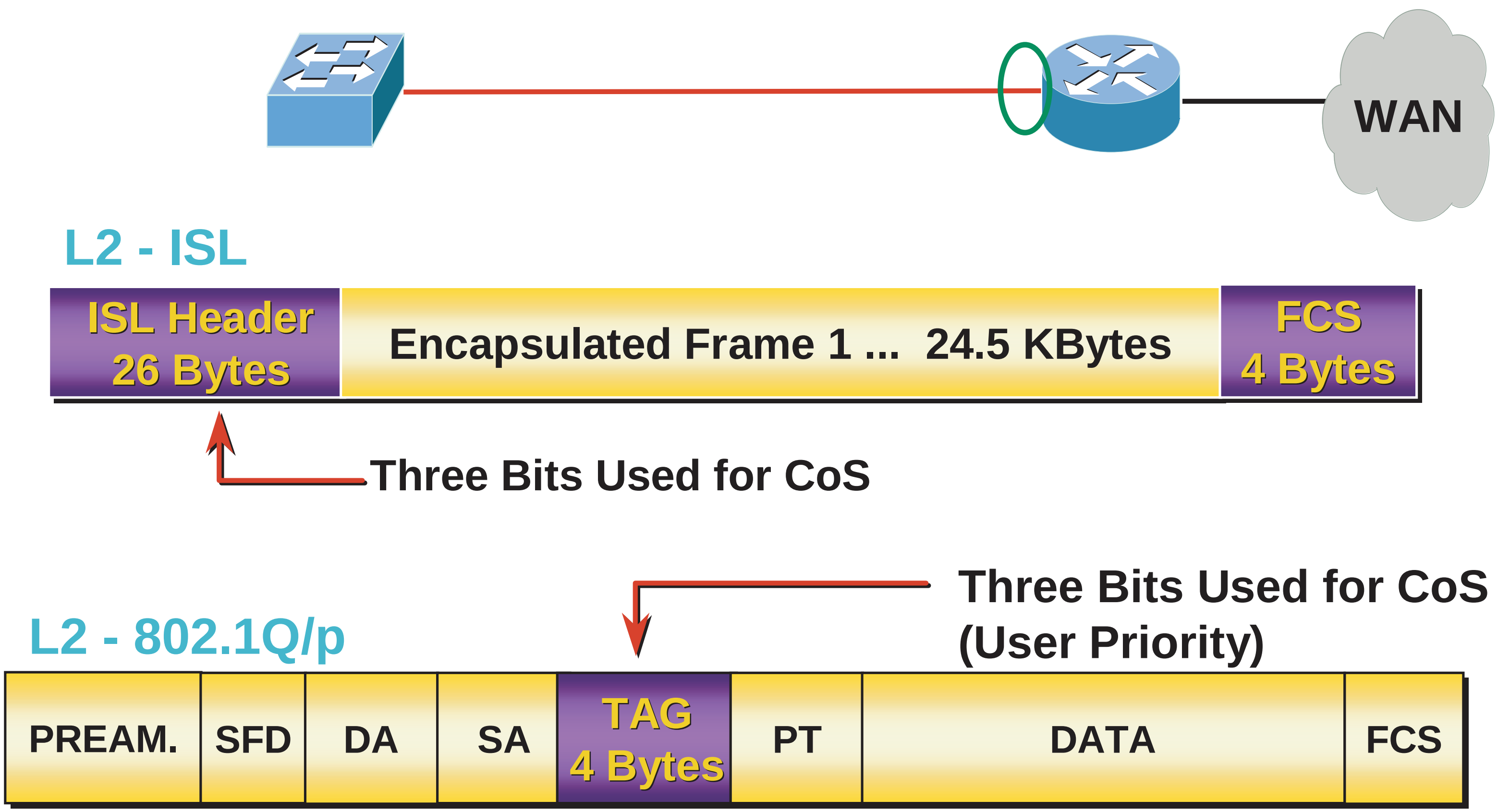
Agenda

- DiffServ QoS Feature Set
- Link Efficiency Mechanisms
- RSVP Feature Set
- QoS L2-L3 Interworkings

L2-L3 Interworkings

- LAN-WAN Network
- IP-MPLS Network
- IP-Frame Relay
- IP-ATM
- IP to ATM CoS

LAN-WAN Network



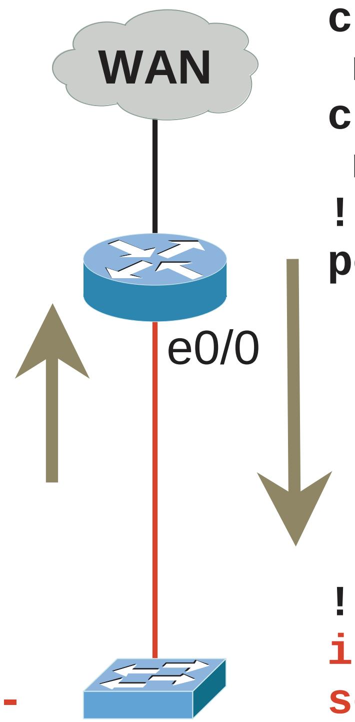
Layer 2 Mechanisms Are Not Assured End-to-End

LAN-WAN implementation using CoS Bits

Cisco.com

Input LAN Interface

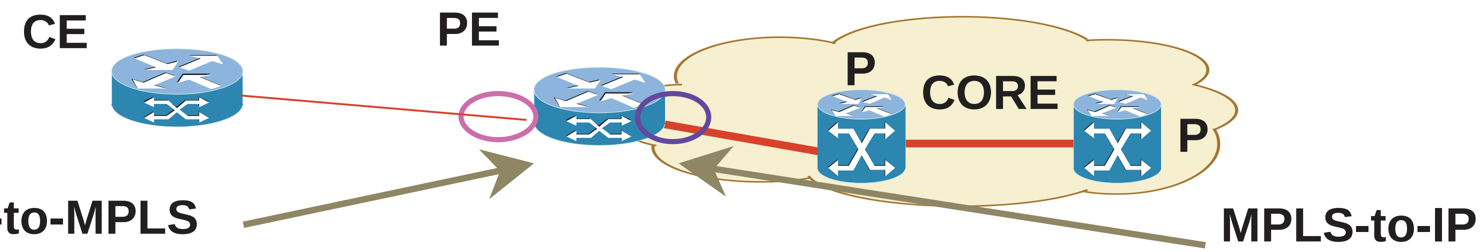
```
class-map l2-to-l3-high
 match cos 4 5
class-map l2-to-l3-med
 match cos 2 3
class-map l2-to-l3-low
 match cos 0 1
!
policy-map CoS-to-ToS
 class l2-to-l3-high
      set ip dscp AF11
 class l2-to-l3-med
      set ip dscp AF12
 class l2-to-l3-low
      set ip dscp AF13
!
interface e0/0
 service-policy input CoS-to-ToS
```



Output LAN Interface

```
class-map l3-to-l2-high
 match ip dscp AF11
class-map l3-to-l2-med
 match ip dscp AF12
class-map l3-to-l2-low
 match ip dscp AF13
!
policy-map ToS-to-CoS
 class l3-to-l2-high
      set cos 0
 class l3-to-l2-med
      set cos 3
 class l3-to-l2-low
      set cos 5
!
interface e0/0
service-policy output ToS-to-CoS
```


IP-MPLS implementation using EXP Bits




```
class-map PREMIUM-IP
  match ip dscp ef
class-map BUSINESS-IP
 match ip dscp af31 af32 af33
!
policy-map IP-to-MPLS
  class PREMIUM-IP
   set mpls experimental 5
  class BUSINESS-IP
   set mpls experimental 2
  class class-default
   set mpls experimental 0
!
interface Serial0/0
 service-policy in MPLS-to-IP
```

```
class-map PREMIUM-MPLS
  match mpls experimental 5
class-map BUSINESS-MPLS
  match mpls experimental 2
!
policy-map MPLS-to-IP
  class PREMIUM-MPLS
   set ip dscp ef
  class BUSINESS-MPLS
   set ip dscp af31
  class class-default
   set ip dscp 0
!
interface pos0/0
service-policy in MPLS-to-IP
```

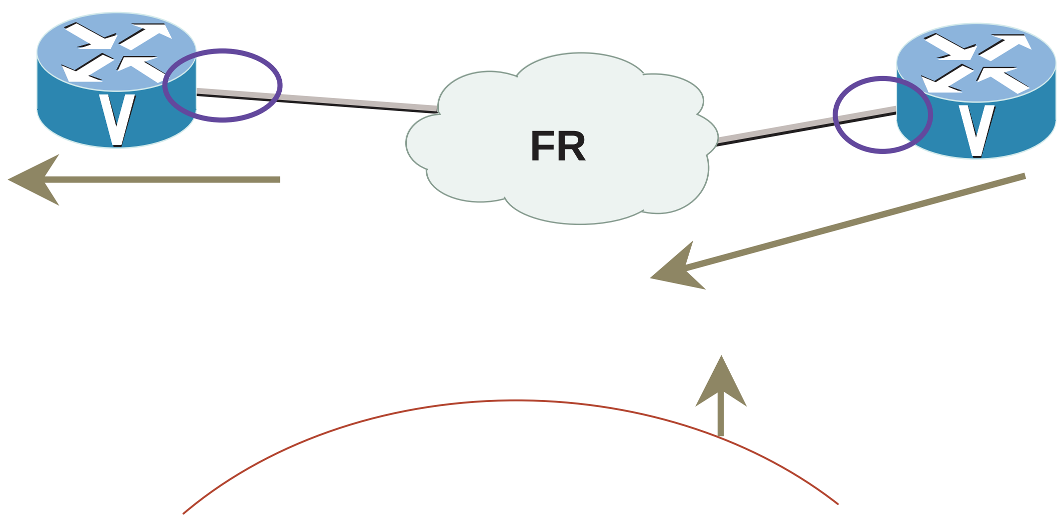

IP-FrameRelay implementation using DE Bit


```
class-map match-fr-de
   match fr-de

policy-map DE-ToS
  class match-fr-de
   set ip precedence 1

interface s4/0.1

service-policy input DE-ToS
```

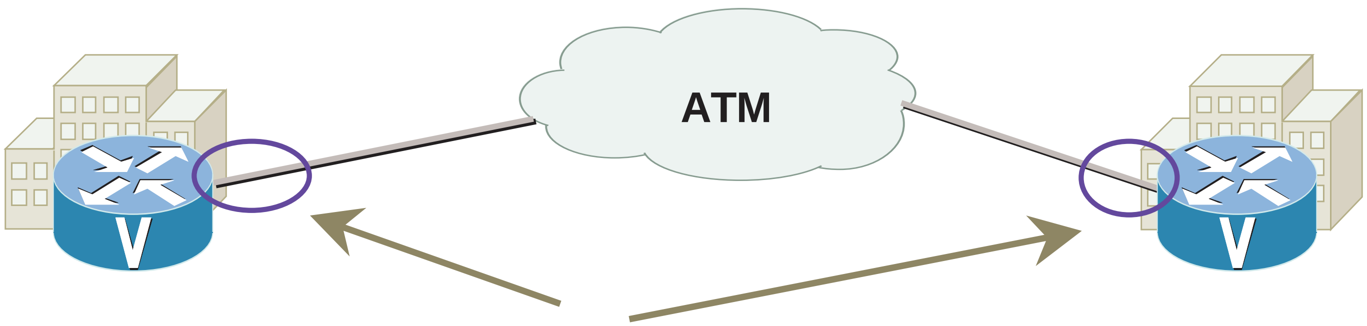



```
policy-map rate-limit
     class police
   police 512000 1500 1500
    conform-action transmit
    exceed-action set-frde-transmit
!
interface ser4/0.1
 service-policy output rate-limit
```

```
policy-map FRDE
     class class-default
       set  fr-de
!
 interface s4/0.1
 service-policy output FRDE
```


IP-ATM implementation using ATM CLP Bit

Cisco.com



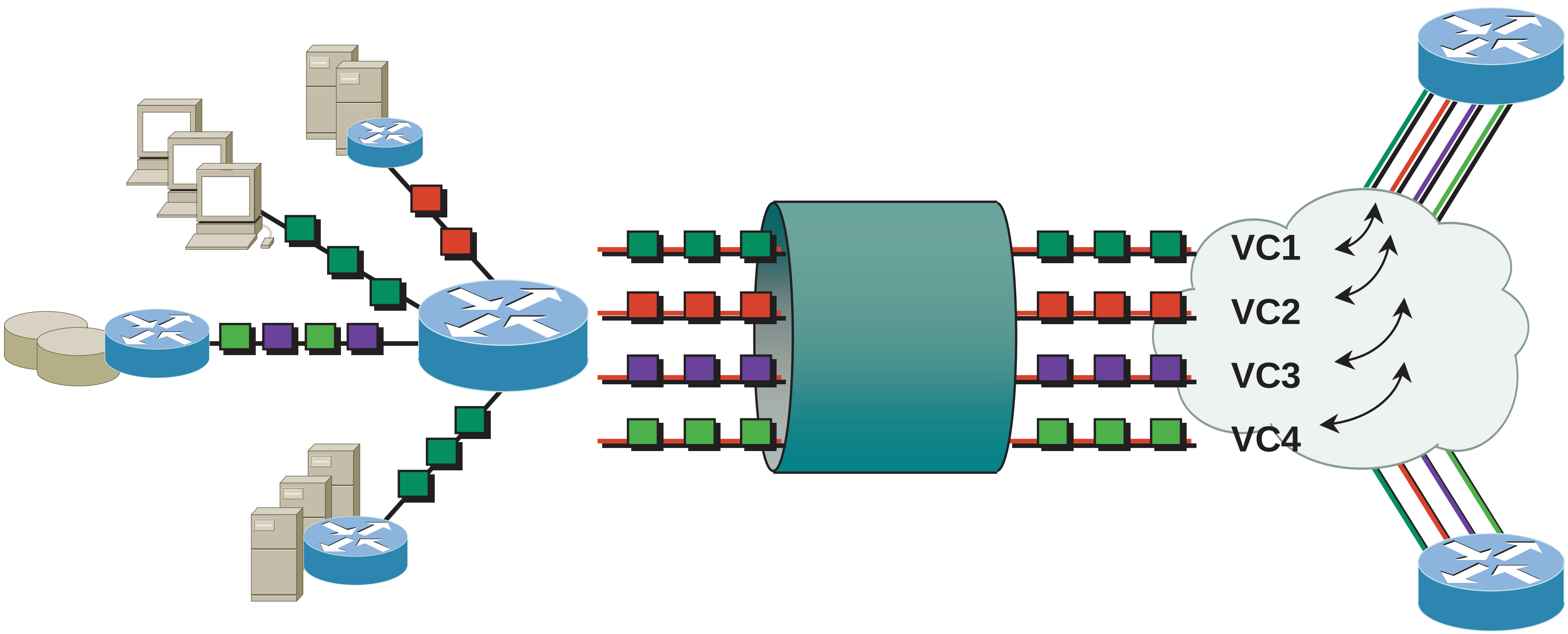

```
policy-map SETCLP
     class class-default
       set atm-clp
!
 interface atm1/0/0
 service-policy output SETCLP
```

```
policy-map rate-limit
     class police
   police 512000 1500 1500
     conform-action transmit
     exceed-action set-clp-transmit
!
interface atm1/0/0
 service-policy output rate-limit
```


L2-L3 Interworkings

- LAN-WAN Network
- IP-MPLS Network
- IP-Frame Relay
- IP-ATM
- IP to ATM CoS

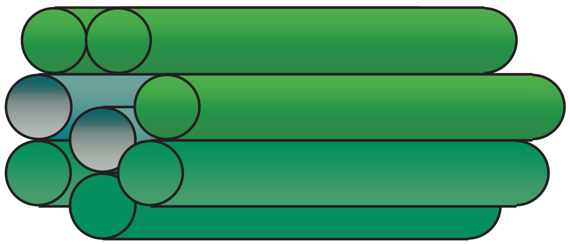
IP Precedence to ATM VC Mapping



- Multiple VCs for each source/destination
- Separate VC for each IP CoS
- RED (WRED) runs on each VC queue

ATM VC Bundling

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

PVC Bundle Config Procedure

- Construct VC classes
- Create a VC bundle
- Apply a bundle-level parameters or a class
- Commit PVCs to a bundle
- Configure a VC not to accept bumped traffic

ATM VC Bundle Config


```
vc-class atm voice
  precedence 5
  bump explicit 7
  no bump traffic
!
vc-class atm data
  precedence 0-4
  bump traffic
!
vc-class atm control
  precedence 6-7
  bump explicit 4
```

!Only carry traffic w Precedence 5. Only allow bumping of traffic to a VC w Precedence 7. Don't allow other traffic to be bumped onto it.

!Only carry traffic w Precedence 0-4. Allow any other traffic to be bumped onto it.

!Only carry traffic w Precedence 6-7. Allow bumping of traffic onto a VC w Precedence 4.

ATM VC Bundle Config


```
!
 interface ATM3/0.1 point-to-point
  ip address 10.10.106.2
255.255.255.0

bundle POLICY
   protocol ip 10.10.106.1 broadcast
   max-vcnum  0
   encapsulation aal5snap

   pvc-bundle control 0/34
    class-vc control
   pvc-bundle data 0/32
    class-vc data
   pvc-bundle voice 0/33
    class-vc voice
  !
```


References

QoS 12.2 Solutions/Command Reference Guides

http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fqos_c/index.htm

http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fqos_r/index.htm

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

http://www.cisco.com/public/support/tac/top_issues.shtml

VoIP Call Admission Control Using RSVP

http://www/univercd/cc/td/doc/product/software/ios121/121newft/121limit/121x/121xi/121xi_3/dt3trsvp.htm

RSVP Support for Low-Latency Queuing

http://www/univercd/cc/td/doc/product/software/ios121/121newft/121t/121t3/rsvp_llq.ht

RFCs

http://info.internet.isi.edu:80/in-notes/rfc/files/rfc2474.txt

http://www.ietf.org/rfc/rfc2475.txt

http://www.ietf.org/rfc/rfc2497.txt

http://www.ietf.org/rfc/rfc2498.txt

http://www.ietf.org/rfc/rfc2698.txt?number=2698

http://www.ietf.org/rfc/rfc2697.txt?number=2697

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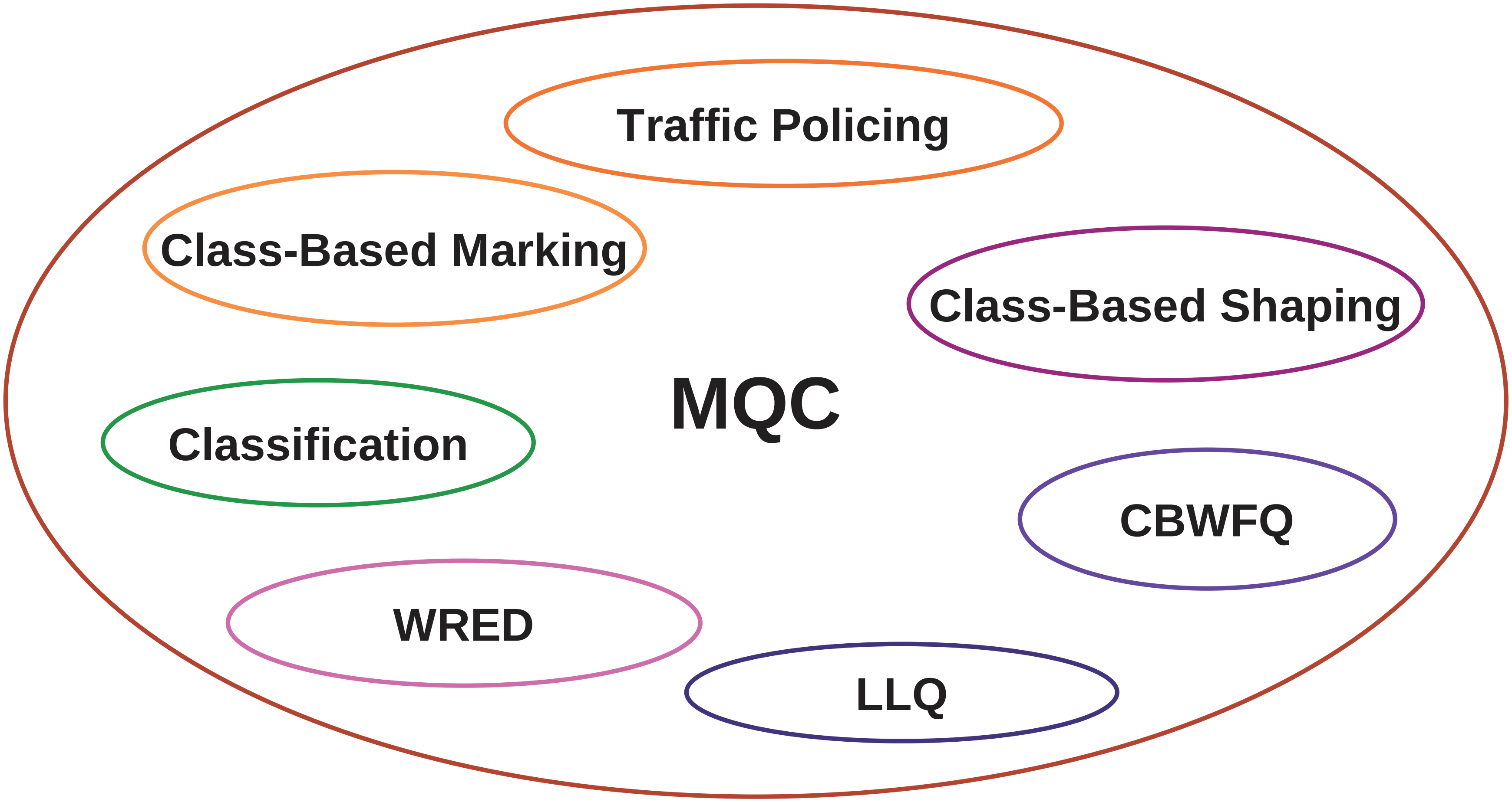
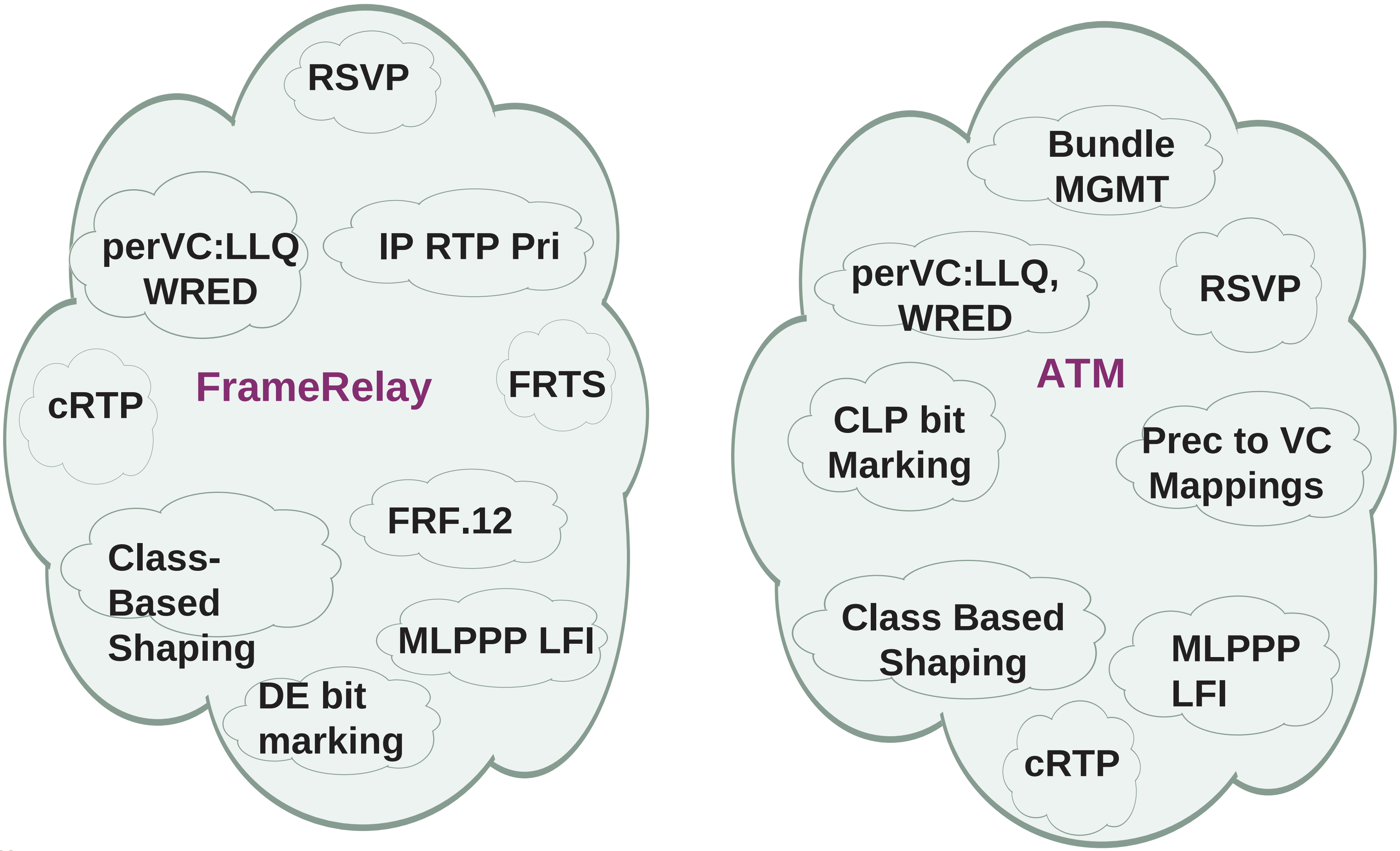
Appendix

QoS Tools Summary



CAR GTS WFQ WRED FRTS MLPPP-LFI Compression

QoS Tools Summary



Applications Supported by NBAR

Statefully Inspected Protocols

- FTP
- Exchange
- HTTP
  (URL and MIME)
- Netshow
- RealAudio
- r-commands
- Oracle SQL*NET
- SunRPC
- TFTP
- StreamWorks
- VDOLive

Static Protocols

- EGP
- GRE
- ICMP
- IPINIP
- IPSec
- EIGRP
- BGP
- CU-SeeMe
- DHCP/Bootp
- DNS
- Finger
- Gopher
- HTTP
- HTTPS
- IMAP
- IRC
- Kerberos
- L2TP
- LDAP
- MS-PPTP
- MS-SQLServer
- NetBIOS
- NFS
- NNTP
- Notes
- NTP
- PCAnywhere
- POP3
- PPTP
- RIP
- RSVP
- SFTP
- SHTTP
- SIMAP
- SIRC
- SLDAP
- SNNTP
- SMTP
- SNMP
- SOCKS
- SPOP3
- SSH
- STELNET
- Syslog
- Telnet
- X Windows

Applications Supported by NBAR (Cont.)

- AppleTalk
- ARP
- Bridge
- Bstun
- CDP
- Citrix
- CLNS
- CLNS_ES
- CLNS_IS
- CMNS
- DECNET
- DECnet_node
- DECnet_router_L1
- DECnet_router_L2
- DLSW
- IMAP
- IPX
- IRC
- LDAP
- llc2
- Novadigm
- PAD
- PCAnywhere
- PPPoE
- Printer
- QLLC
- RCMD
- RSRB
- SQLServer
- STUN
- VINES
- VOFR
- XNS

Fixed Frame Serialization Delay Matrix

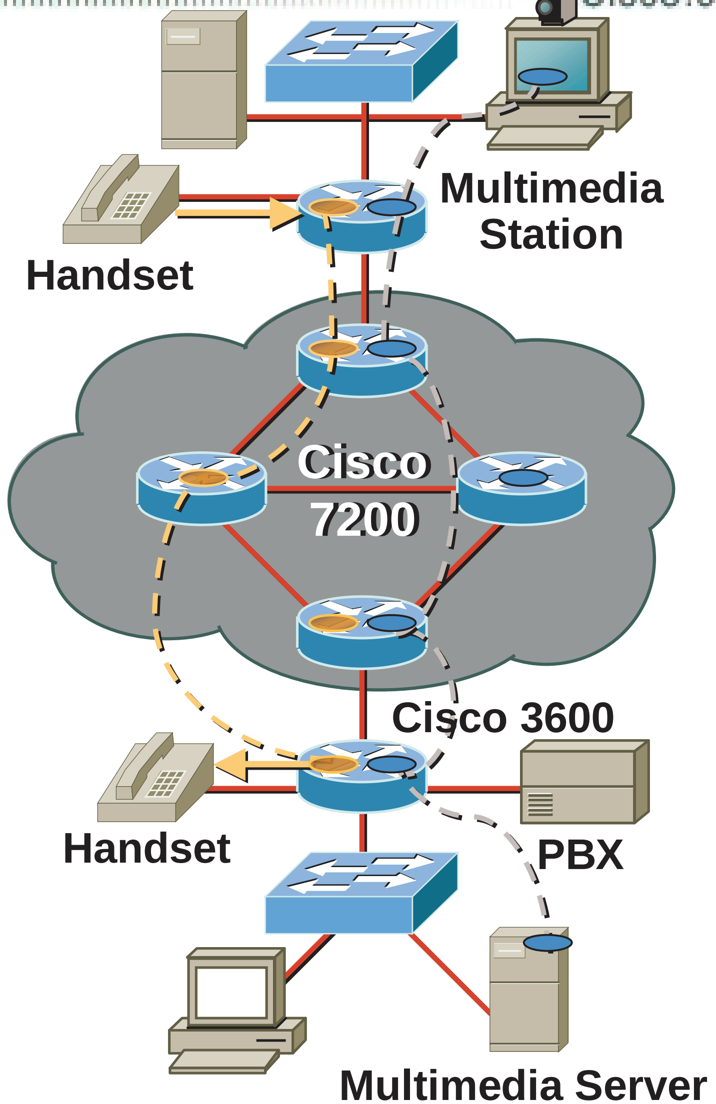
Cisco.com

Frame Size

Link Speed

Integrated Services/RSVP: Signaling

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



Configuring Call Rerouting in Case of RSVP CAC Failure


```
dial-peer voice 100 pots
 destination-pattern 2......
 no digit-strip
 direct-inward-dial
 port 1/0:23
!
dial-peer voice 300 voip
 preference 0
 destination-pattern 3......
 session target ipv4:10.77.39.129
 req-qos guaranteed-delay
 acc-qos guaranteed-delay
!
dial-peer voice 500 pots
 preference 5
 destination-pattern 3......
 no digit-strip
 direct-inward-dial
 port 1/1:23
```

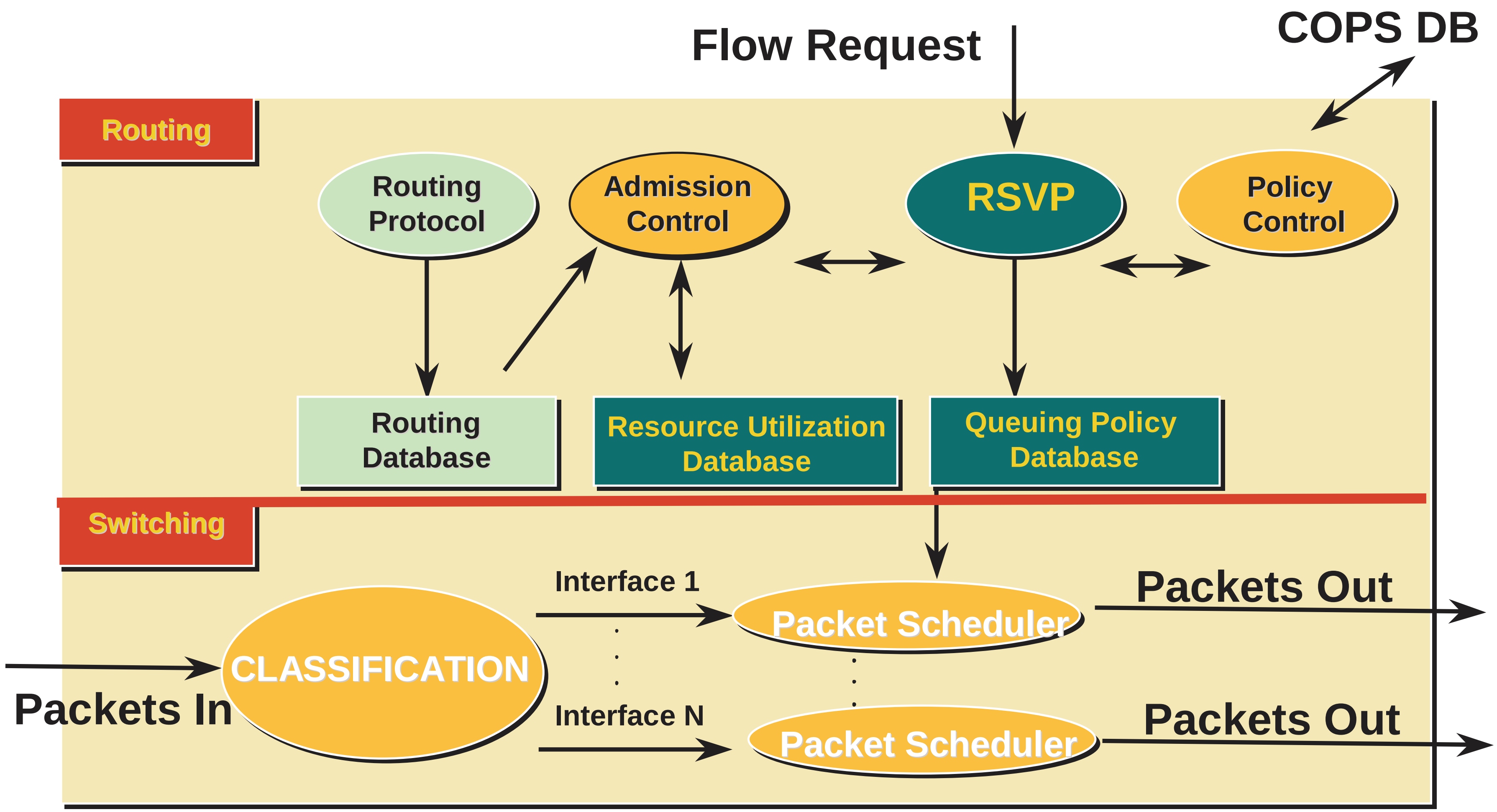

RSVP Definition

- RSVP is the signaling mechanism for per-flow guaranteed service, and controlled load
- In Cisco's implementation, RSVP also provides:
  - Admission control
  - Packet classification
  - Flow policing
  - Packet scheduling
- RSVP is activated when:
  - An application sets up a reservation
  - Congestion occurs on a router interface
  - An active reservation is refreshed

RSVP Attributes and Operations

- RSVP is simplex and receiver-oriented
- RSVP makes resource reservations for both unicast and many-to-many multicast applications
- RSVP provides several reservation models or "styles" to fit a variety of applications
- RSVP provides transparent operation through routers that do not support it
- RSVP maintains "soft" state in routers and hosts
- RSVP transports and maintains traffic control and policy control parameters that are opaque to RSVP
- RSVP supports both IPv4 and IPv6
- RSVP has no reliability mechanism

RSVP Operational Model



RSVP Components

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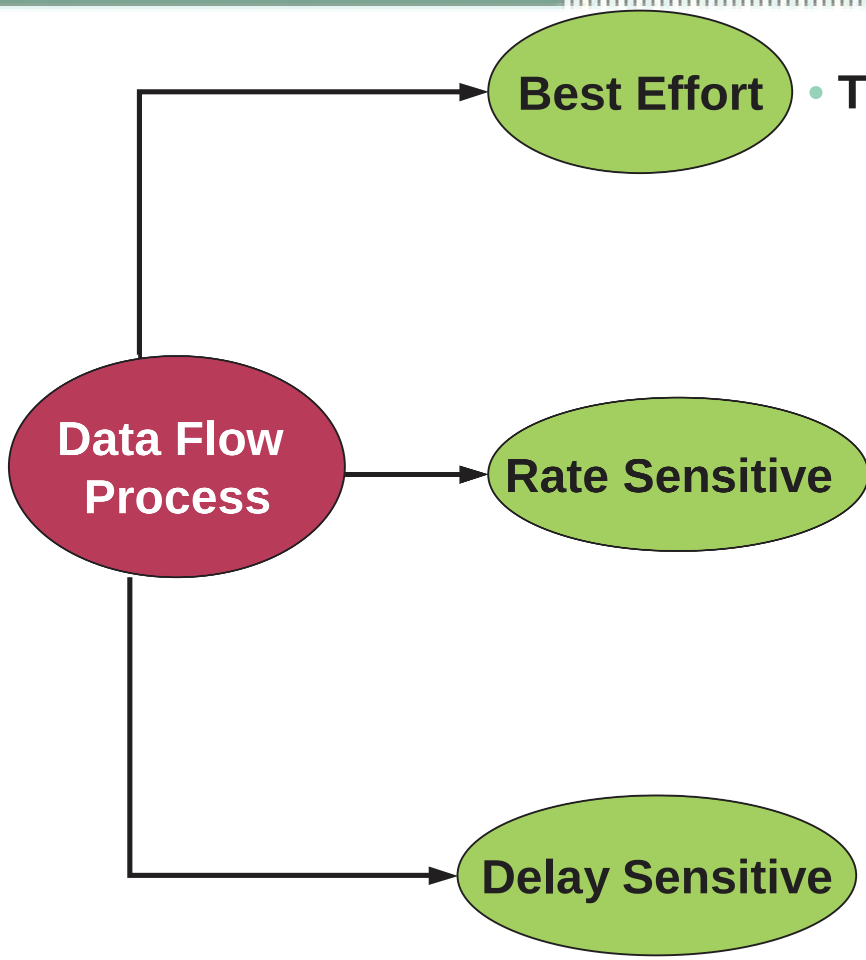
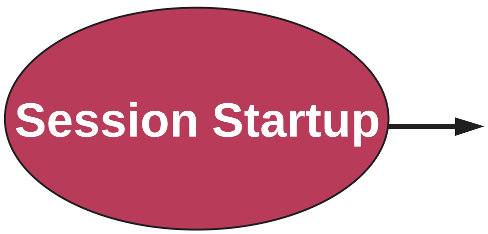


Best Effort
- Traditional first in first out treatment

Rate Sensitive
- Requires guaranteed bit-rate service
- Willing to give timeliness for a rate.
- Delay is accepted
- Example: H.323 video conferencing

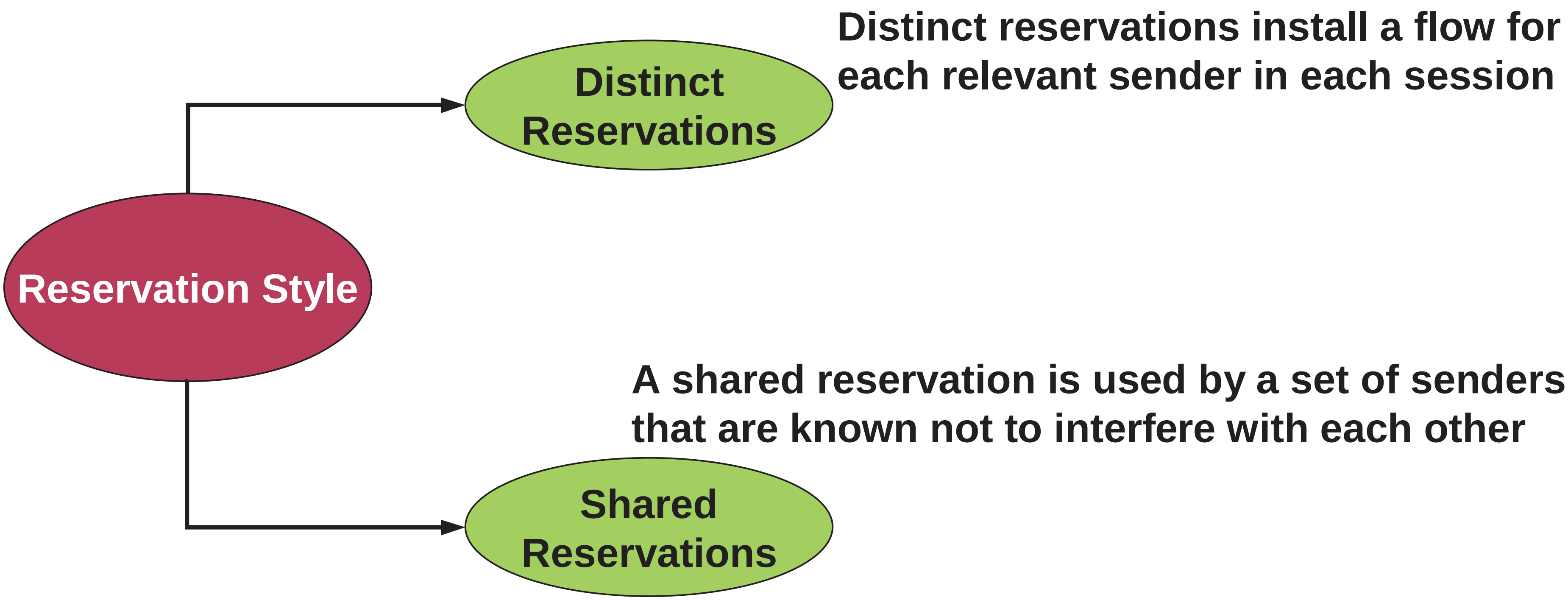
Delay Sensitive
- Requires timeliness of delivery
- RSVP services supporting delay-sensitive traffic are referred to as controlled-delay service (non-real time) and predictive service (real-time service).
- Application will vary it’s rate accordingly

RSVP Components



- The receiver joins a group
- A potential sender starts sending RSVP path messages to the IP destination address
- The receiver receives a path message and sends appropriate reservation-request messages specifying the desired flow descriptors using RSVP
- After the sender receives a reservation-request message, it starts sending data packets

RSVP Components



It is not possible to merge shared reservations with distinct reservations

RSVP Components

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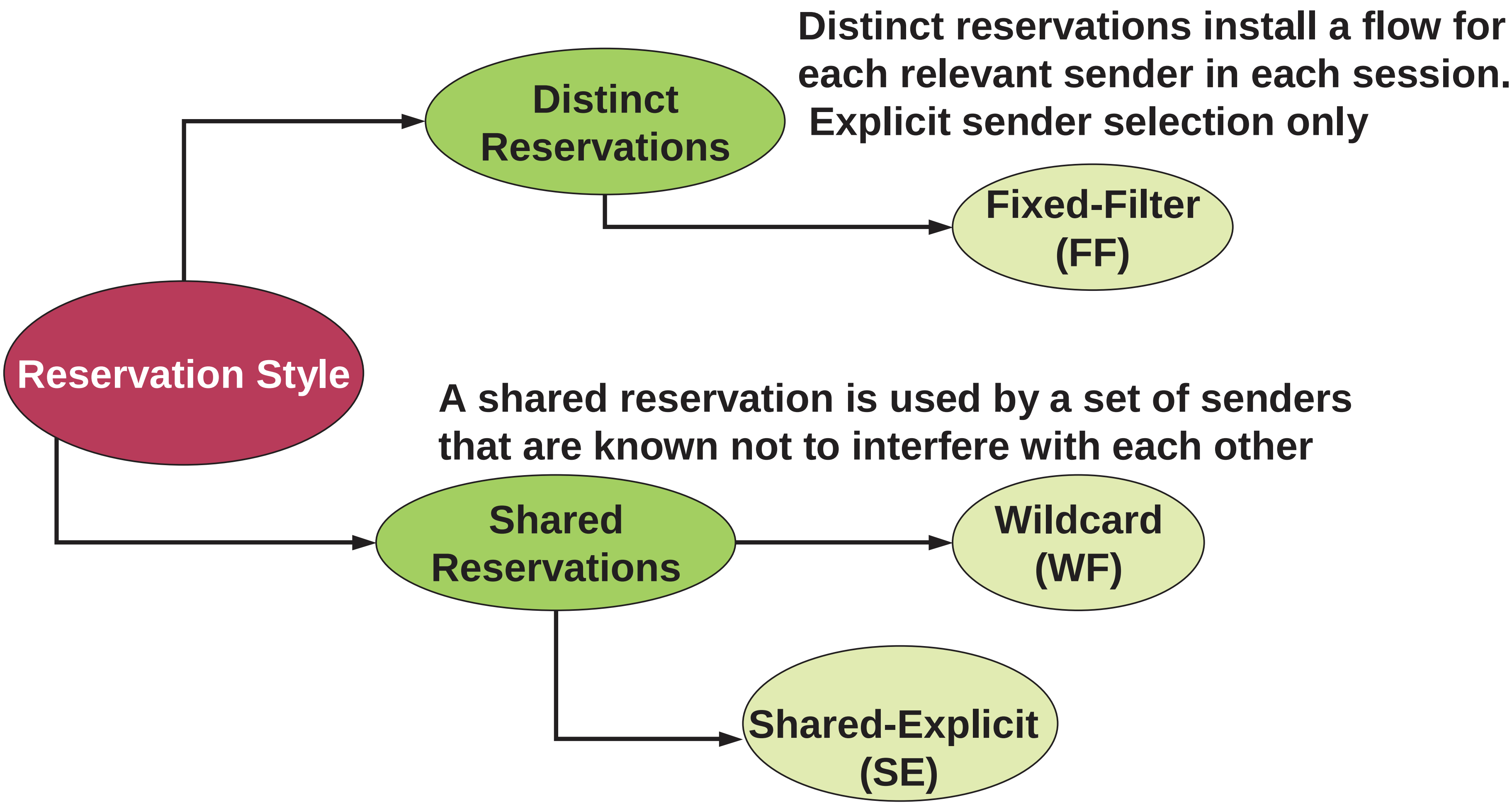

! It is not possible to merge shared reservations with distinct reservations

RSVP Components

QoS

Quality of Service (QOS) is an attribute specified in flow specifications that is used to determine the way in which data interchanges are handled by participating entities such as routers, receivers, and senders

QoS Essentials: Network Design and Best Practices

Section 3

QoS Architecture

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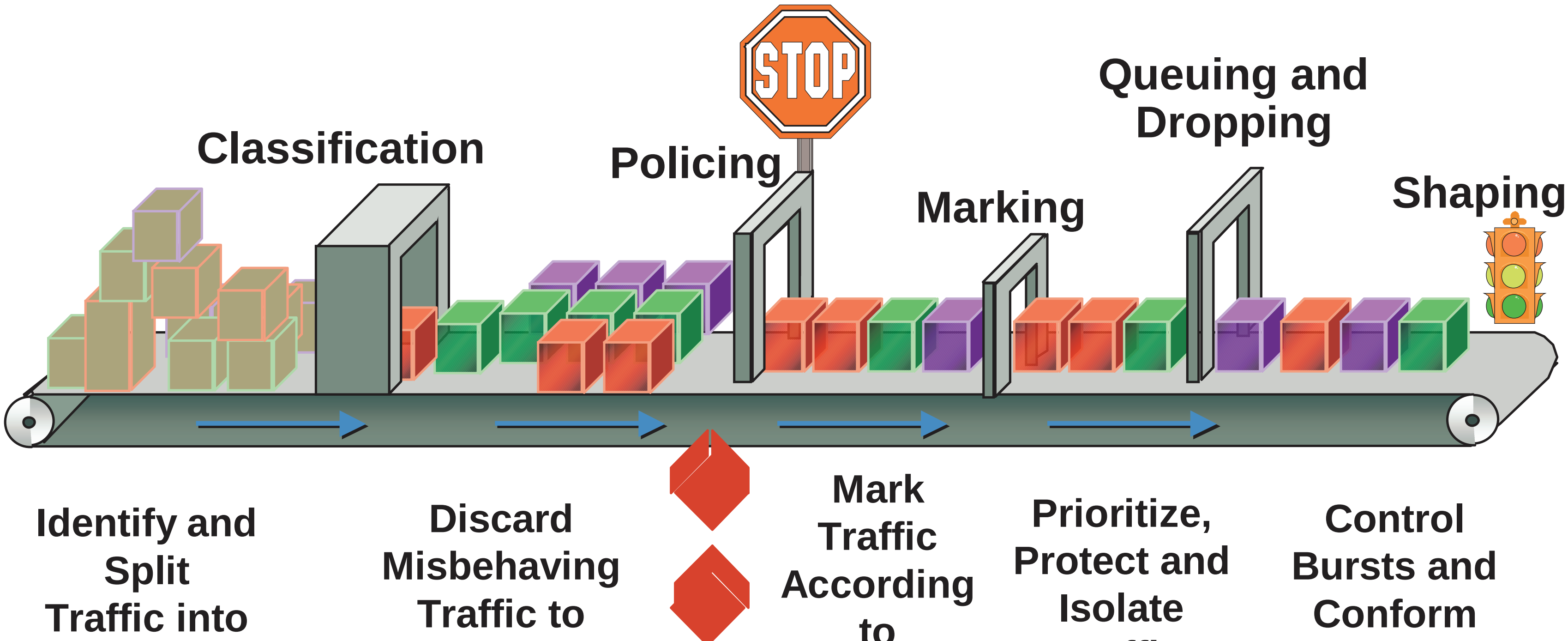


Identify and Split Traffic into Different Classes

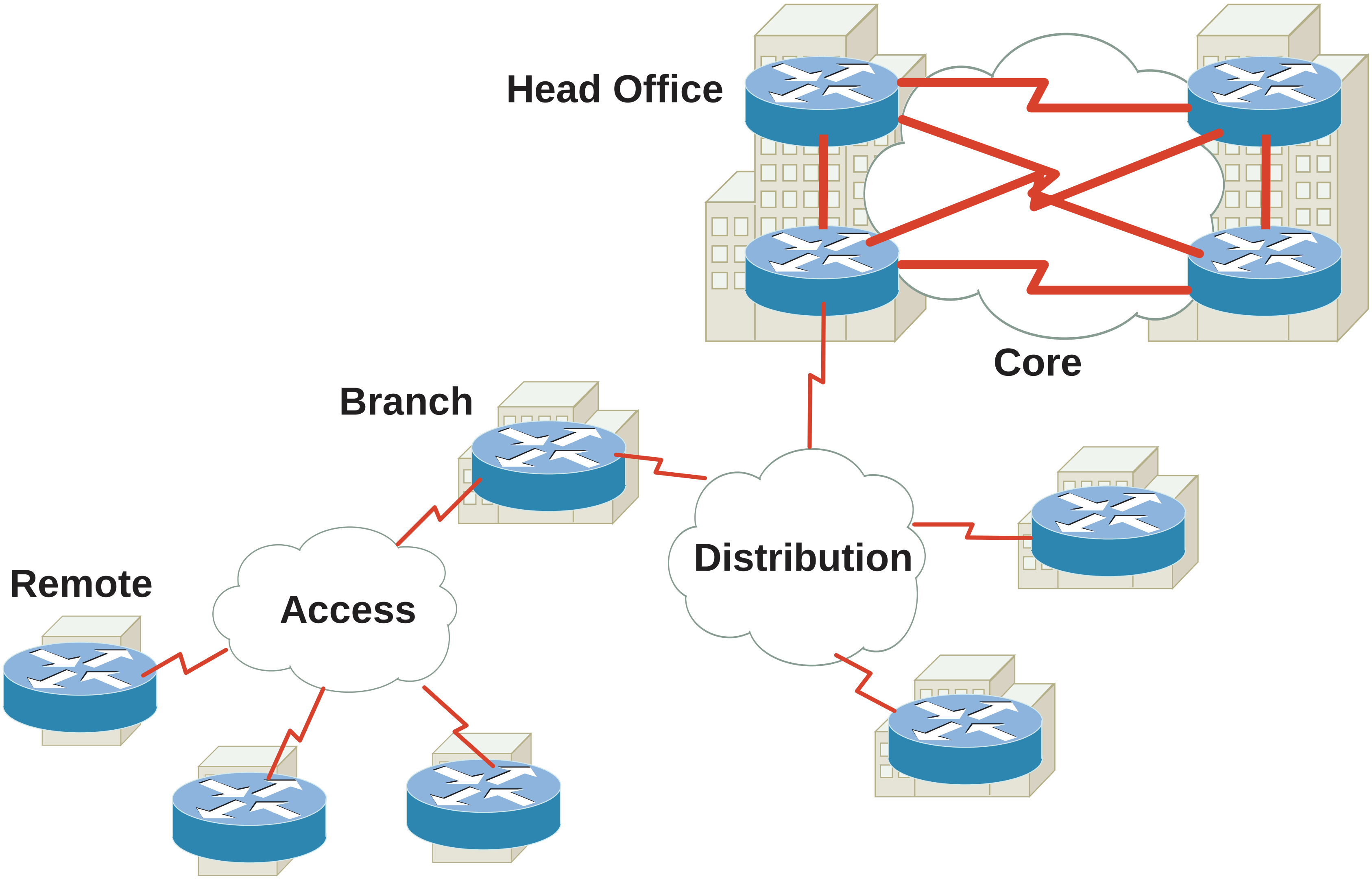
Discard Misbehaving Traffic to Maintain Network Integrity

Mark Traffic According to Behavior and Business Policies

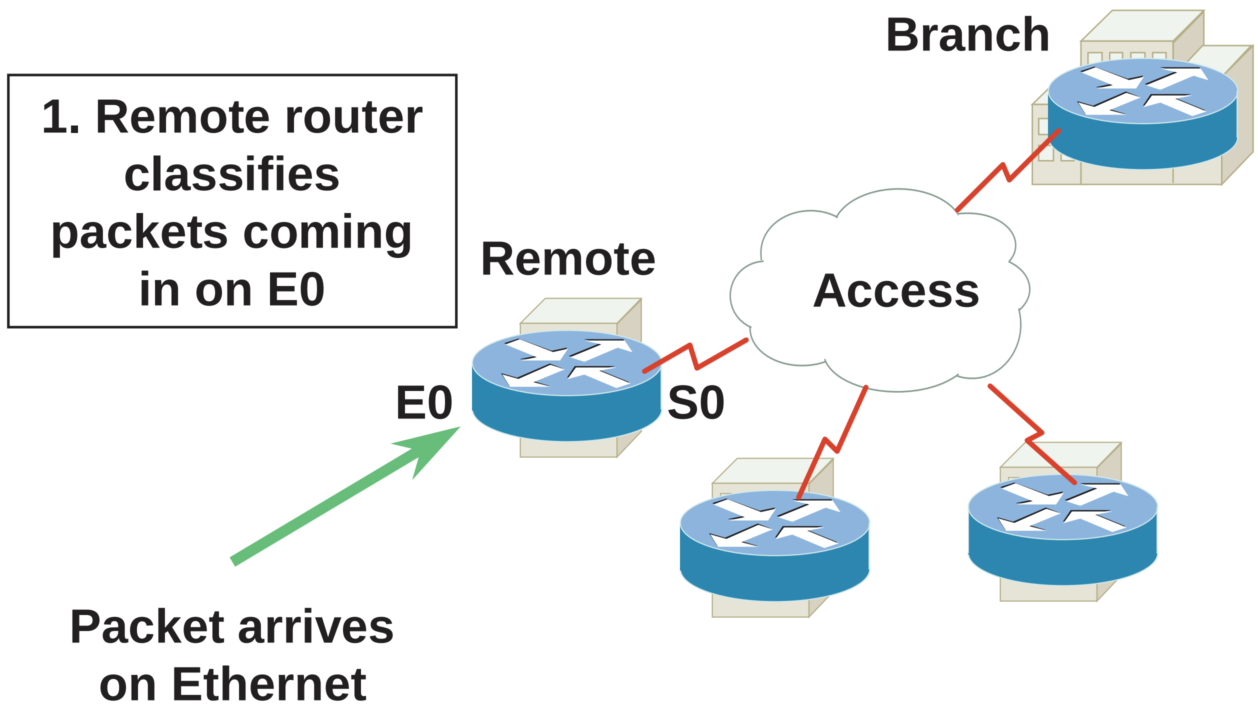
Prioritize, Protect and Isolate Traffic Based on Markings

Control Bursts and Conform Traffic

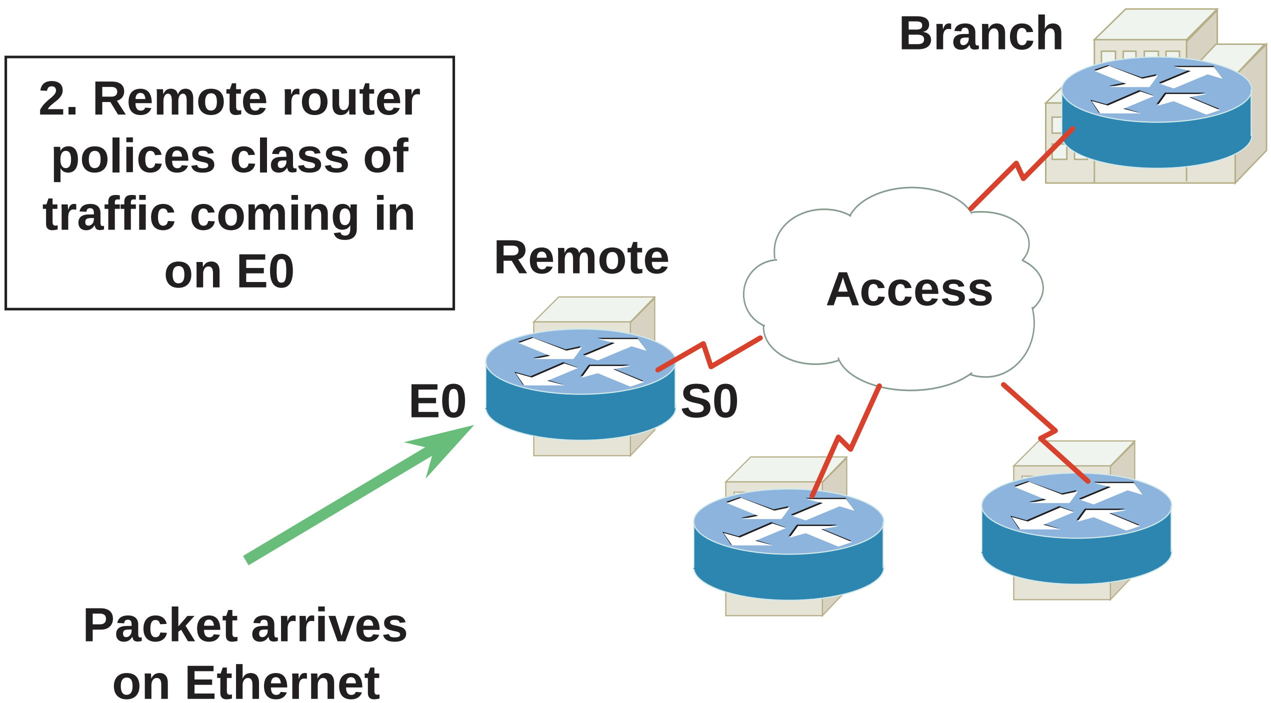
Typical Enterprise Network



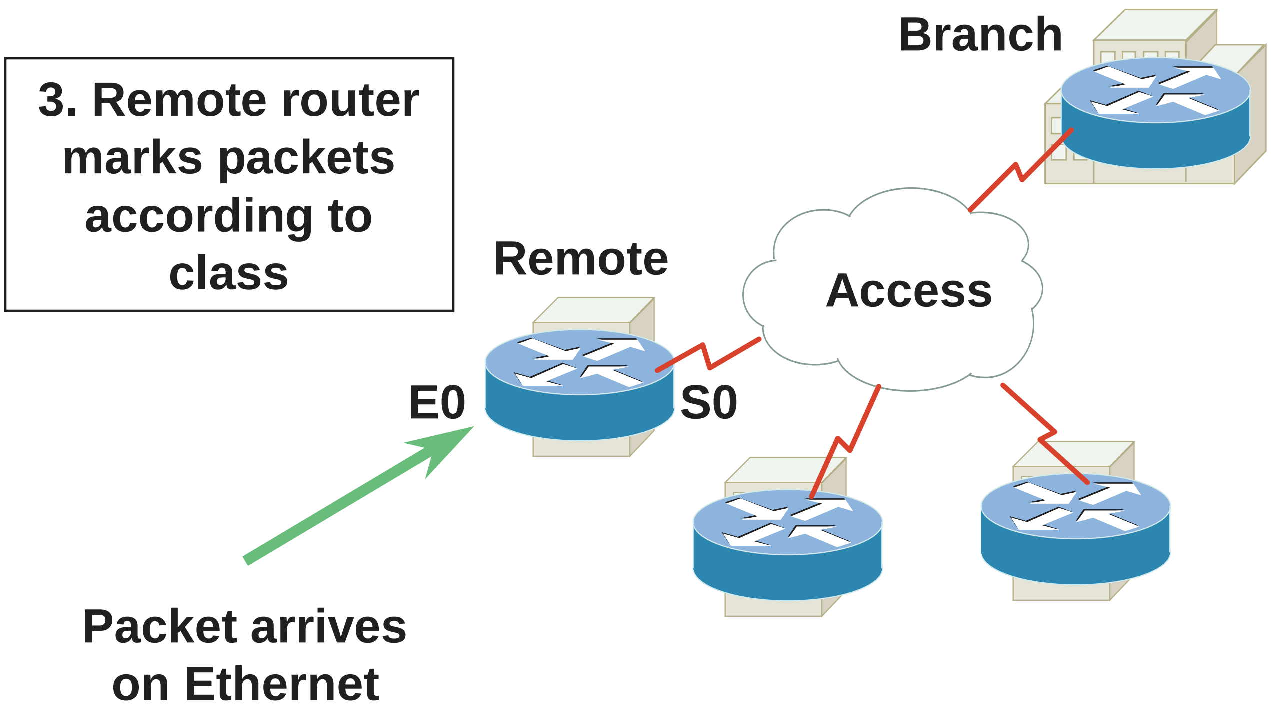
Access Layer: Traffic Conditioning



Access Layer: Traffic Conditioning



Access Layer: Traffic Conditioning



Access Layer: Traffic Conditioning

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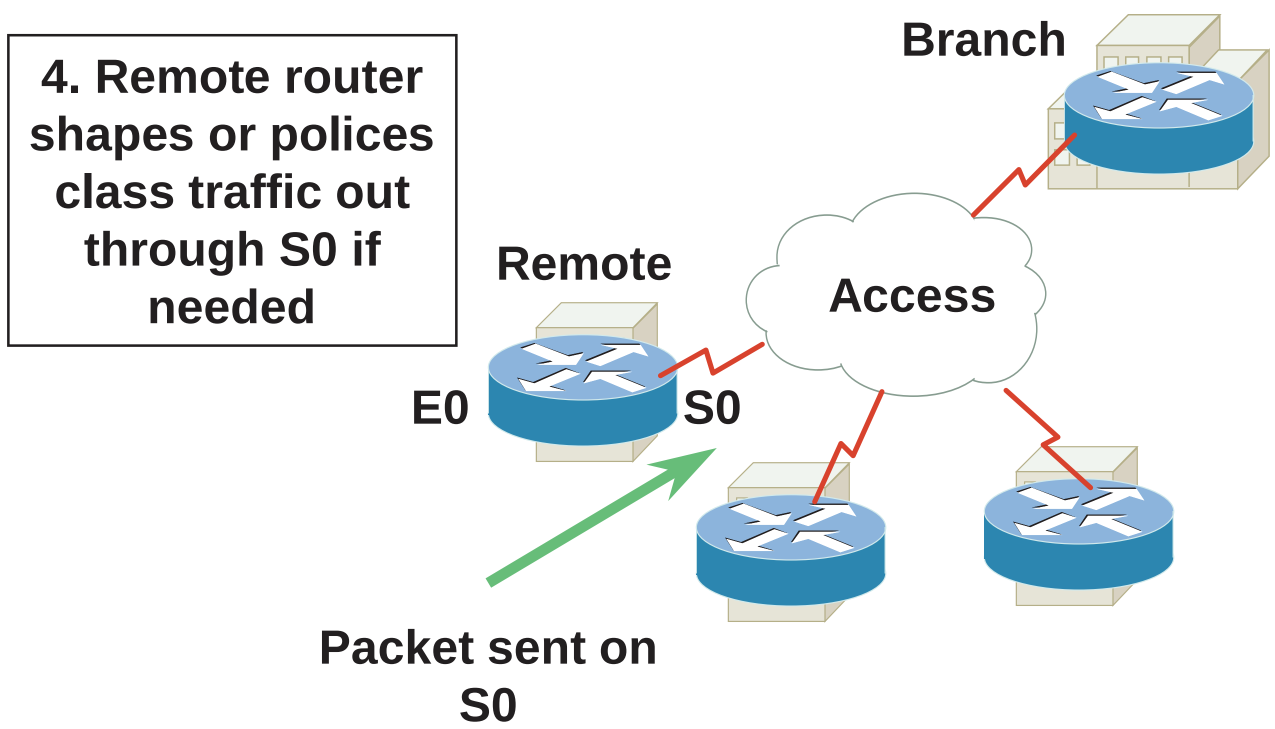
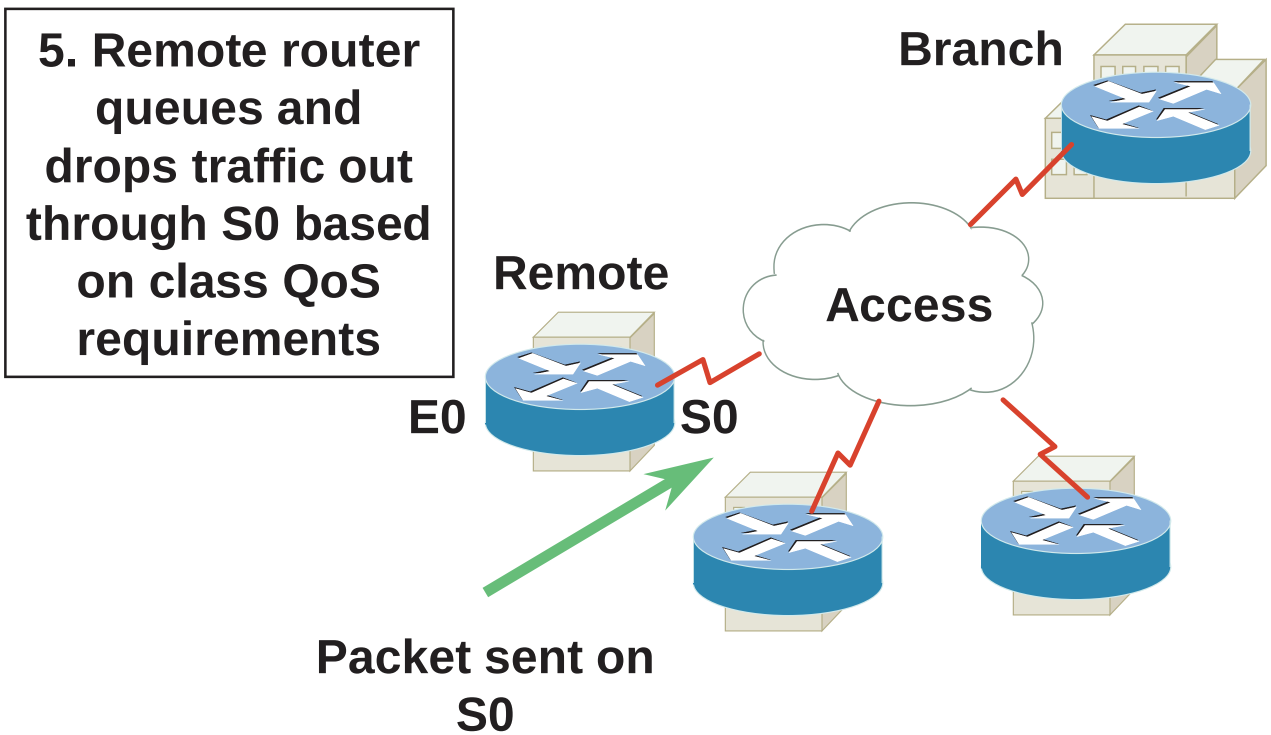
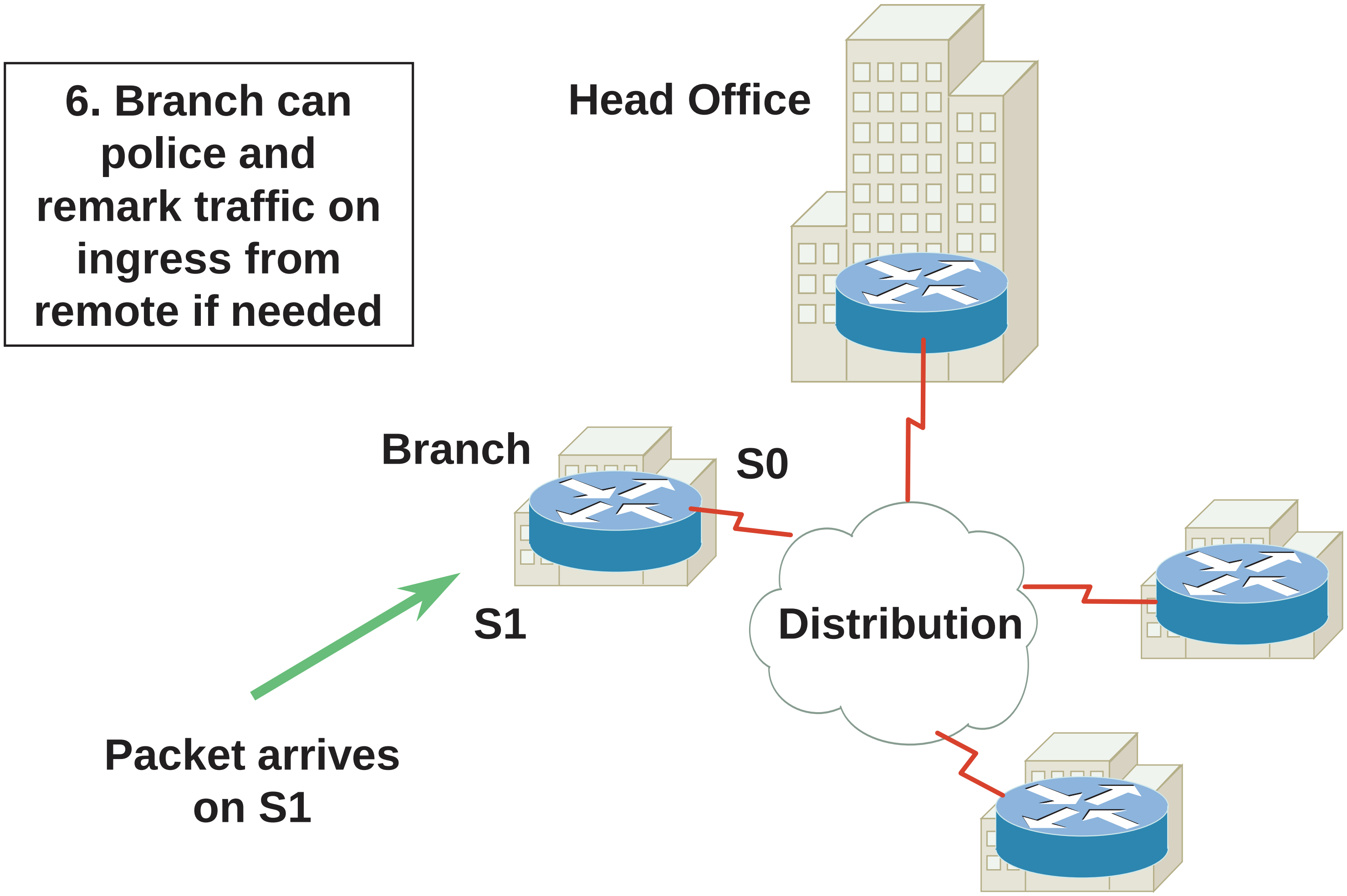


Access Layer: Handling Congestion



Distribution Layer

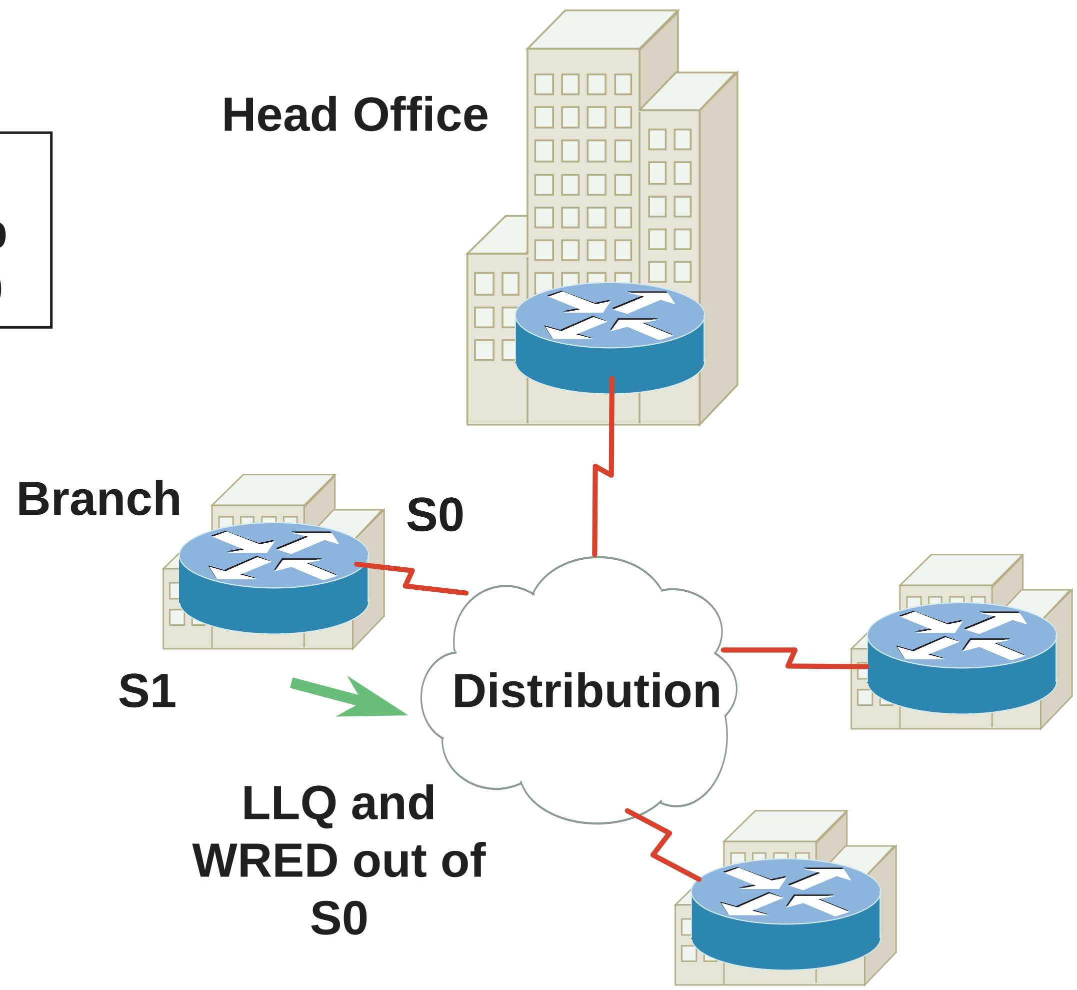
Cisco.com



Distribution Layer

Cisco.com

7. Branch will queue and drop traffic out of S0

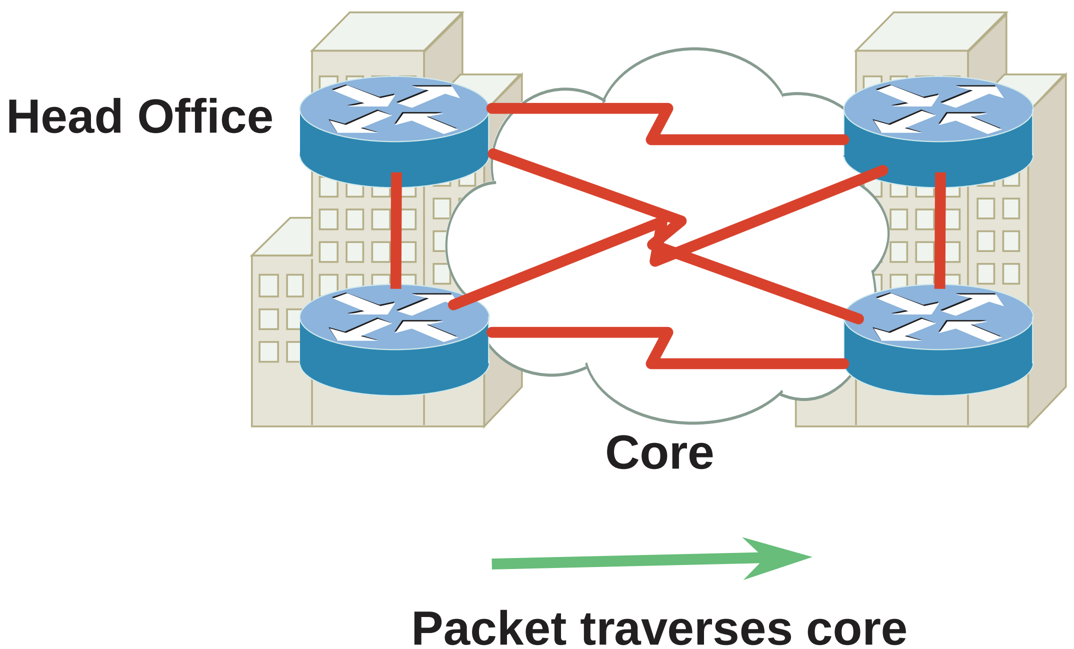


Core Layer

8. Only high-speed queuing and intelligent dropping in the core!

LLQ, distributed LLQ (7500), or MDRR (GSR);

WRED to drop lower priority traffic if queues filling up



Case Studies

Cisco.com

- **Protect My Voice!**
  - Also admission control?
- **University Scenario**
  - Need multicast QoS, limit MP3
- **IP VPN Service**
  - QoS end-to-end through SP network
- **Voice, Video, ERP, Bulk, Other**
  - Put it all together
- **Service Provider QoS Generic**
- **Service Provider Customer Examples**

Case Study
Protect My Voice!

Protect My Voice!—Links

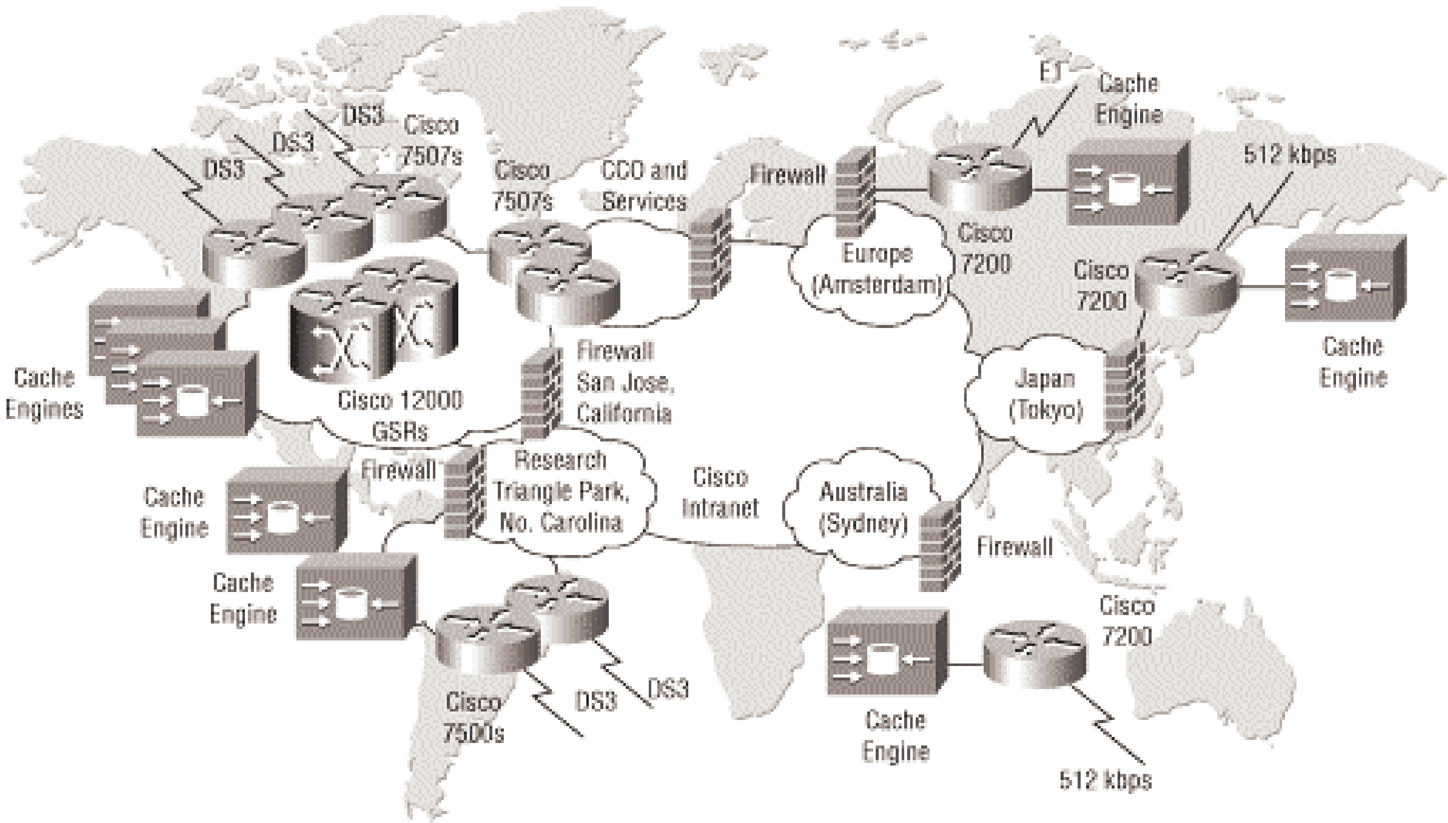
- Enterprise network with frame relay and leased line access links ranging from 64 kbps to T1 speeds
- Distribution layer ranges from T1 to DS3 speeds, IP or ATM
- Core has some DS3 and OC3 POS connections
- 60 remote sites; 15,000 VoIP users

Protect My Voice!—Requirements

- Do everything needed to make sure Voice over IP quality is consistently good
- There is also vital internal applications traffic for back office systems
- Everything else can be best-effort for now

Protect My Voice!—Topology Cisco's Global Internetwork

Cisco.com



Source: Cisco IOS® 12.0 Customer Profile

http://www.cisco.com/warp/public/cc/pd/iosw/profiles/csco_cp.htm

Protect My Voice!—Questions

- Do you know how to recognize the voice traffic?
- How much voice traffic will there be on average? As a maximum?
- How much bandwidth do the internal business applications need?

General VoIP QoS Design Guidelines

- Generally:

  Use Cisco IOS 12.0(7)T or later to get the latest QoS features

  Set IP Precedence = 5 on the dial-peer

  Do NOT use WRED on voice queues

  Do NOT mark voice packets as DE or CLP=1

  Goal should be 150-200ms one-way delay

General VoIP QoS Design Guidelines

Cisco.com

- **Queuing:**

  LLQ—classify voice in a “priority” class

  Set bandwidth of the voice class to the aggregate voice bandwidth on the link or VC (plus allow for a little overhead)

  Alternatively, IP to ATM Class of Service can be used to carry VoIP on a separate ATM PVC

General VoIP QoS Design Guidelines

- **Link Efficiency (for link speeds < 1.2Mbps):**

  Fragment to 10ms delay—optimize size for backbone characteristics. Set fragment size so that voice packets do not get fragmented

  For leased lines, set "ppp multilink fragment-delay" on the multilink interface

  For frame relay, set "frame-relay fragment" in the frame-relay map-class. Fragment all PVCs carrying data on the interface if at least 1 PVC carries voice

  For ATM (especially in FR-ATM environments), use PPPoATM with Multilink PPP (MP) Link Fragmentation and Interleaving (LFI)

General VoIP QoS Design Guidelines

- Traffic Shaping (if FR is used as L2 technology):

  FRTS on the interface

  Set Bc to 10ms (1/100) of CIR

  Set mincir >= to voice bandwidth (if adaptive shaping is used)

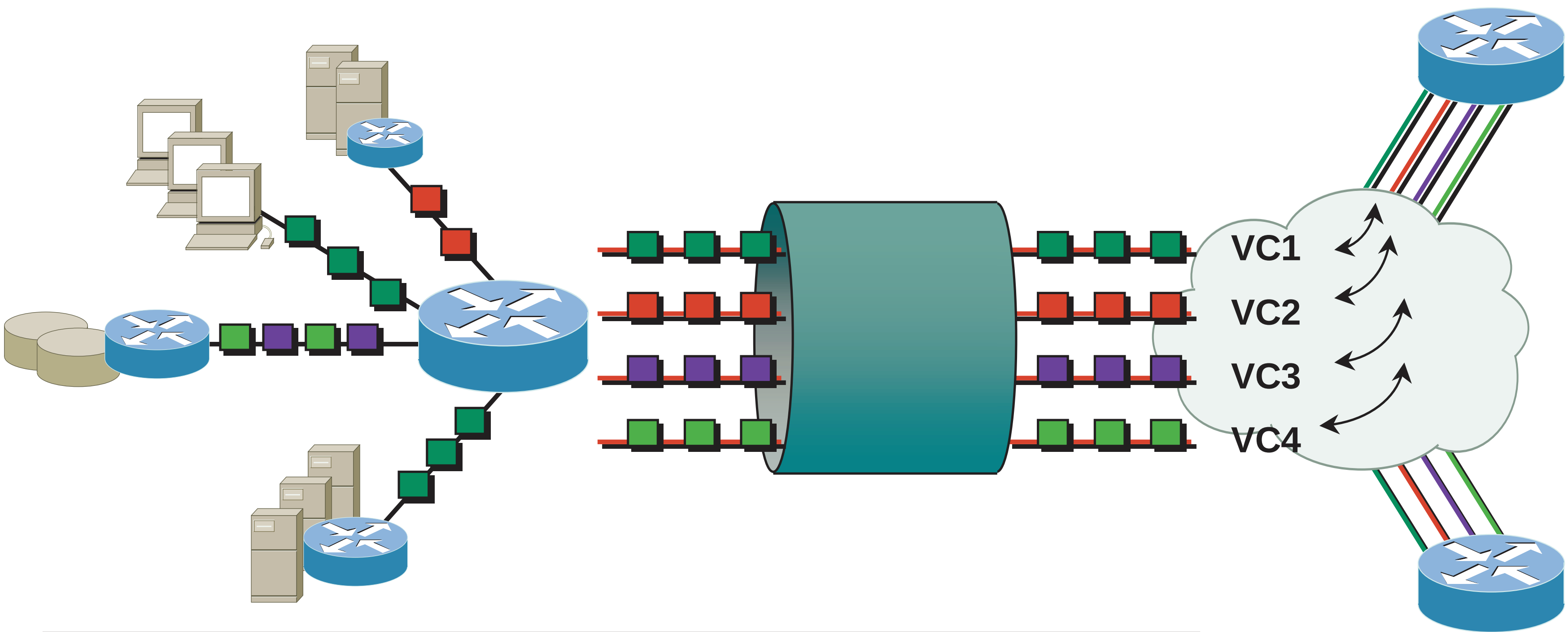
  Shape strictly to CIR one PVC carrying voice, don't burst

  Shape both sides of the VC to prevent egress blocking

Protect My Voice!—Network Design

- IP to ATM Class of Service
- Low Latency Queuing
- LFI on links below 1.2 Mbps
- FRTS on frame relay links

Precedence to VC Mapping



- Multiple VCs for each source/destination
- Separate VC for each IP CoS
- RED (WRED) runs on each VC queue

Multiple VC between Sites

- **Bundle of VCs**
  - **Single routing adjacency**
  - **VC can be of different ATM classes**
  - **Map different types of traffic to different VCs**
- **VC Bumping (Priority)**

PVC Bundle Configuration

Cisco.com

```
vc-class atm voice
  precedence 5
  bump explicit 7
  no bump traffic
!
vc-class atm data
  precedence 0-4
  bump traffic
!
vc-class atm control
  precedence 6-7
  bump explicit 4
```

Only carry traffic with IP Precedence 5. Only allow bumping of traffic to a VC with IP Precedence 7. Don’t allow other traffic to be bumped onto it.

Only carry traffic with IP Precedence 0-4. Allow any other traffic to be bumped onto it.

Only carry traffic with IP Precedence 6-7. Allow bumping of traffic onto a VC with IP Precedence 4.

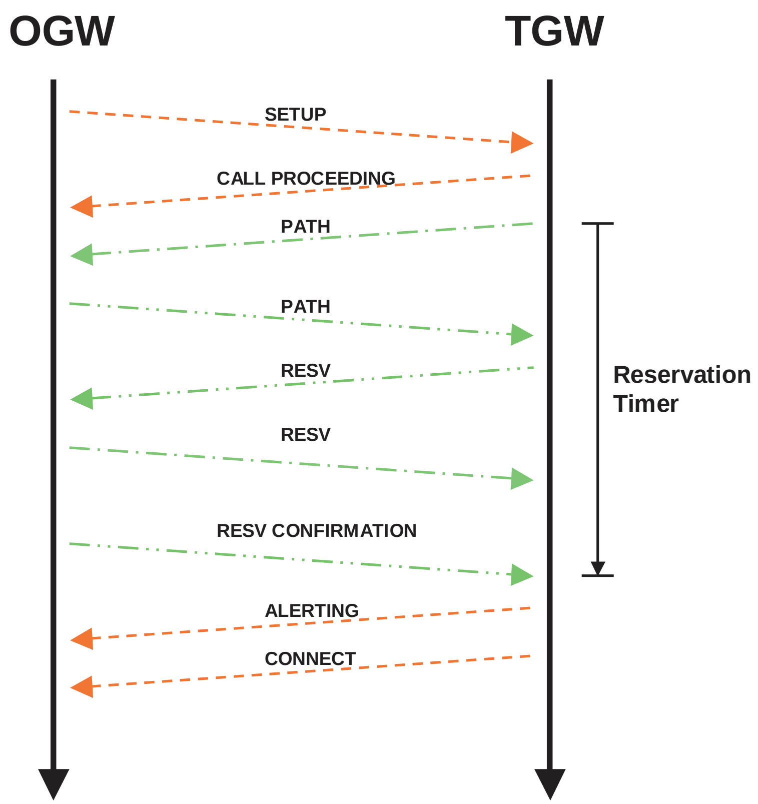
VoIP Call Admission Control (CAC)

- **Protect voice from voice!**
- **What if there is no more priority bandwidth available?**
  - **Need to signal H.323 gateway that enough QoS resources not available to guarantee good quality**
  - **Gateway can then re-route call or play appropriate tone**

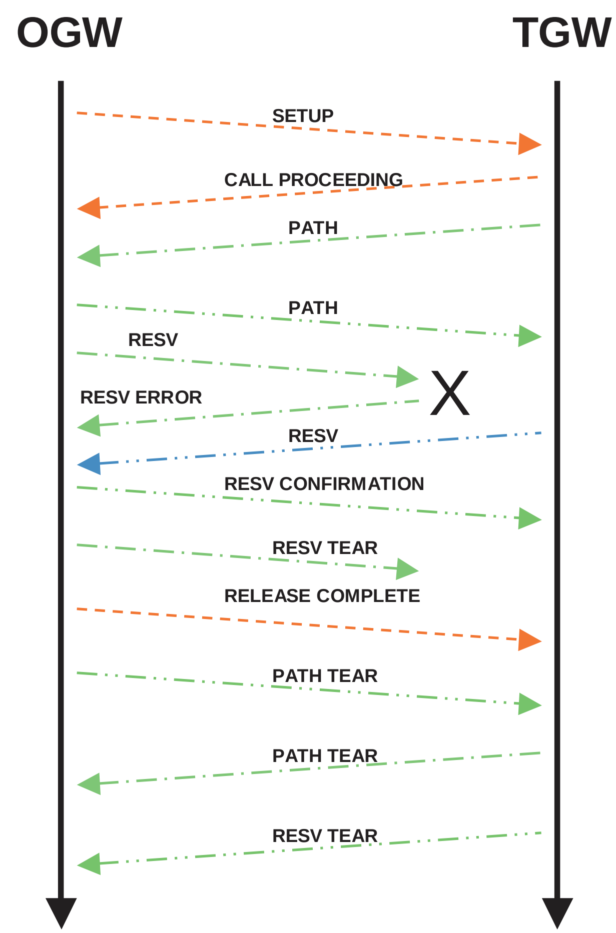
H.323 Synchronization with RSVP

Cisco.com

Call does not move to alerting until reservations are complete



Call is disconnected when reservation fails

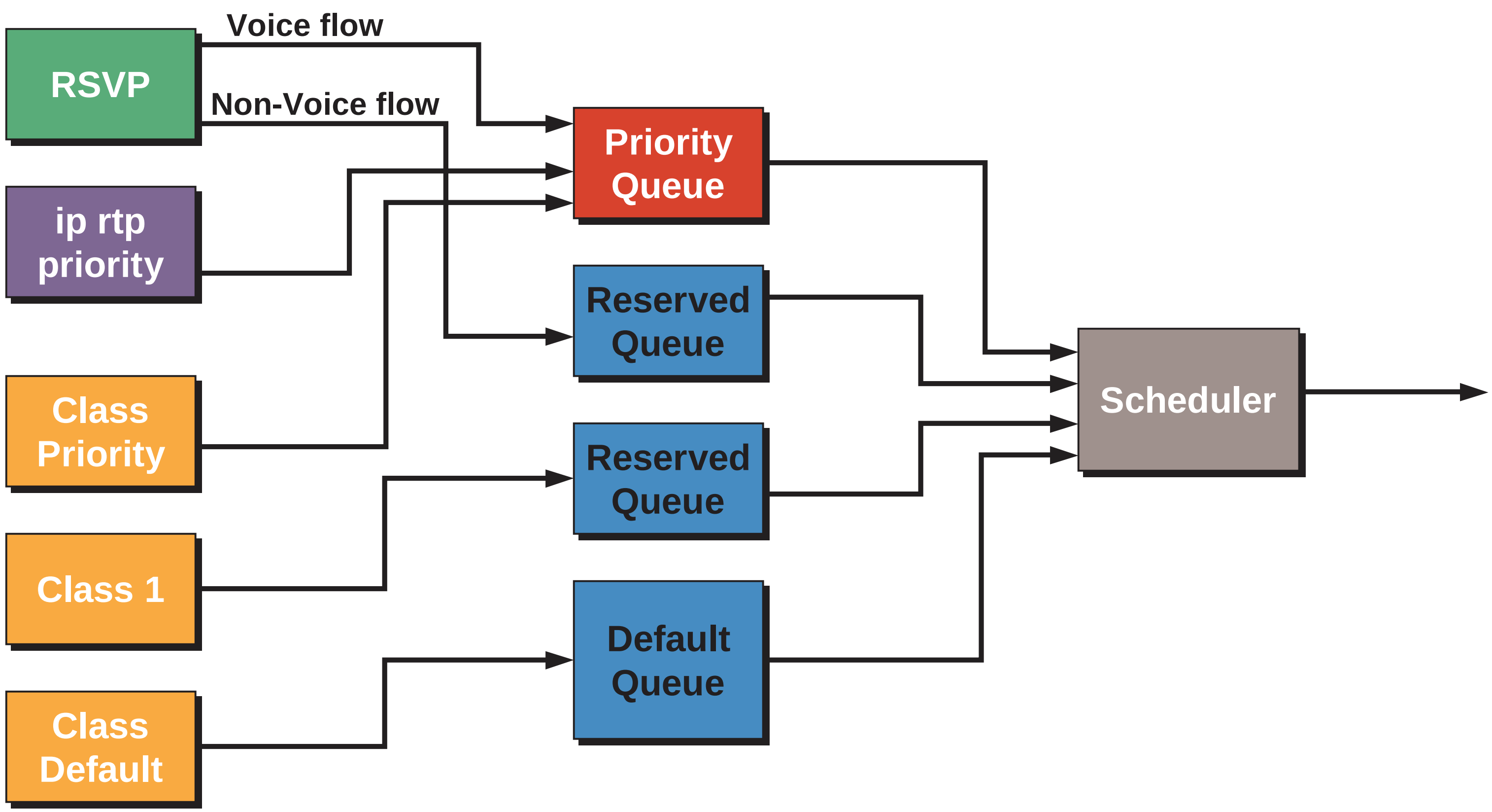


Configuring H.323 Synchronization with RSVP


```
Router(config)# call rsvp-sync
Router(config)# !
Router(config)# interface Serial0/0
Router(config-if)# bandwidth 1536
Router(config-if)# ip address 10.10.1.1 255.255.255.0
Router(config-if)# fair-queue
Router(config-if)# ip rsvp bandwidth 1152 24
Router(config-if)# !
Router(config)# dial-peer voice 300 voip
Router(config-dial-peer)# destination-pattern 3......
Router(config-dial-peer)# session target
ipv4:10.77.39.129
Router(config-dial-peer)# req-qos guaranteed-delay
Router(config-dial-peer)# acc-qos guaranteed-delay
```


RSVP Support for LLQ

Cisco.com



RSVP Support for LLQ

- The RSVP TSpec is compared with PQ profile
- Flows with TSpec within PQ profile use the PQ (no MQC configuration required)
- Flows with TSpec above PQ profile get a reserved queue within WFQ
- A voice-like PQ profile is enabled by default

Configuring RSVP Support for LLQ


```
Router(config)# interface Serial0/0
Router(config-if)# bandwidth 1536
Router(config-if)# ip address 10.10.1.1 255.255.255.0
Router(config-if)# encapsulation ppp
Router(config-if)# fair-queue
Router(config-if)# ip rsvp bandwidth 1152 256
Router(config)# !
Router(config)# ip rsvp pq-profile voice-like
```

Case Study
University Scenario

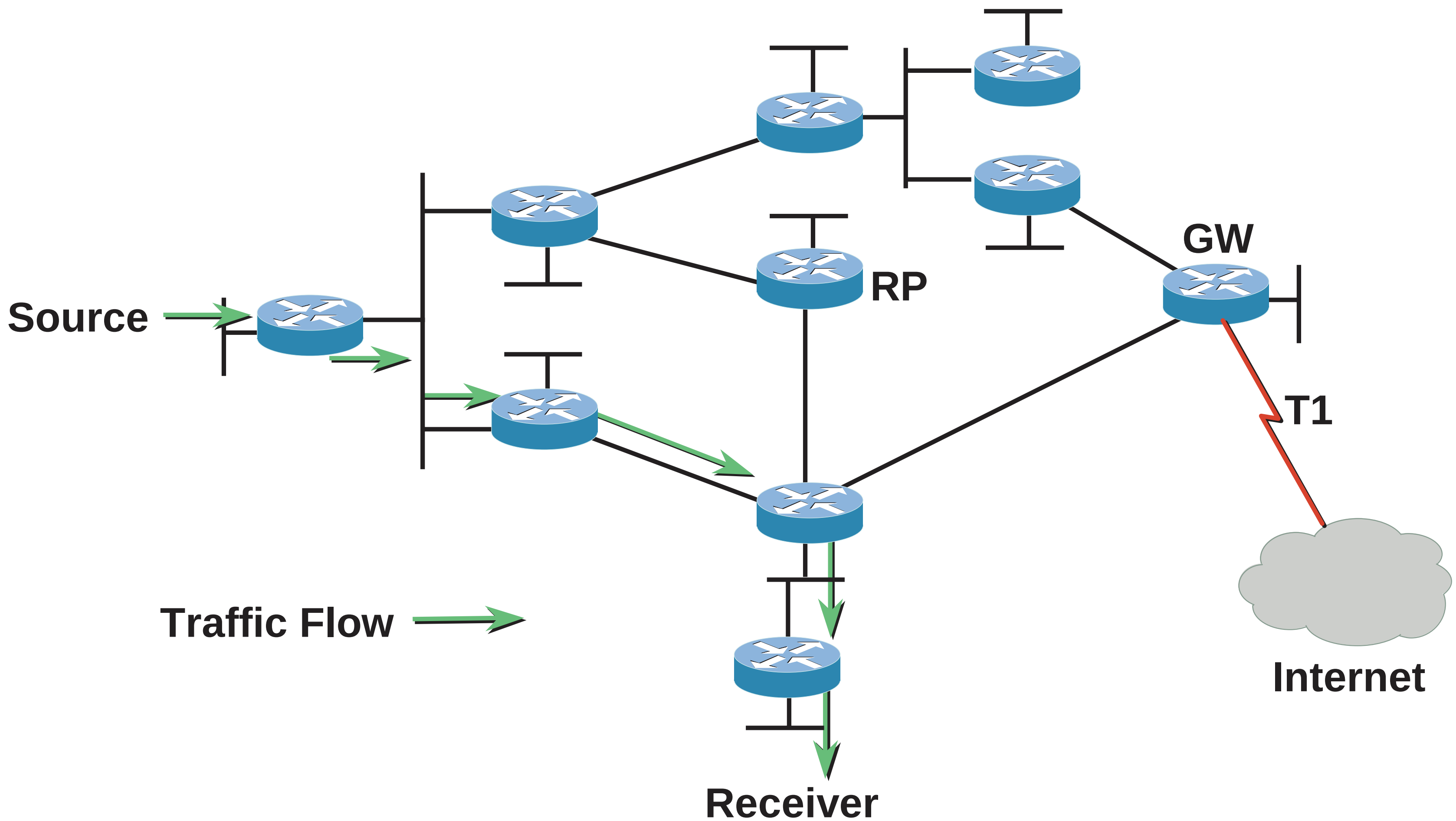
University Scenario—Requirements

- **Guarantee 512 kbps to multicast traffic across my campus**

  Application is video-on-demand—requires guaranteed bandwidth, low loss, bounded delay and jitter (but no need for priority service since not interactive)

- **Limit Napster to 10% of my Internet link (T1)**

University Scenario—Topology



University Scenario—Recommended Design

- Use Policy-Based Routing or Class-Based Marking to mark IP Precedence bits for multicast traffic as close to source as possible
- Use Class-Based Weighted Fair Queuing (CBWFQ) to guarantee bandwidth
- Can use QoS capabilities on switches as well (discussed in other sessions)
- Use NBAR to recognize Napster and then traffic policing to limit it to 10% of the T1 Internet link

University Scenario—Configuration

On router closest to source:

```
Router(config)# class-map ipmc
Router(config-cmap)# match access-group 100
Router(config)# policy-map markipmc
Router(config-pmap)# class ipmc
Router(config-pmap-c)# set ip precedence 4
Router(config)# interface ethernet0/0
Router(config-if)# service-policy input markipmc
Router(config-if)# !
Router(config)# access-list 100 permit udp any
224.0.0.0 31.255.255.255
```

Note: May also want to reset IP Precedence to 0 for all other traffic

University Scenario—Configuration

Queuing configuration for most routers:

```
Router(config)# class-map multicast
Router(config-cmap)# match ip precedence 4
Router(config)# policy-map univq
Router(config-pmap)# class multicast
Router(config-pmap-c)# bandwidth 512
Router(config-pmap-c)# !
Router(config)# interface ethernet0/0
Router(config-if)# service-policy output univq
```


University Scenario—Configuration

On gateway (GW) router:

```
Router(config)# class-map Napster
Router(config-cmap)# match protocol Napster
Router(config)# policy-map limitnapster
Router(config-pmap)# class Napster
Router(config-pmap-c)# police 153600
Router(config)# interface serial0
Router(config)# bandwidth 1536
Router(config-if)# service-policy input
limitnapster
Router(config-if)# service-policy output
limitnapster
```


Cisco.com

Case Study
IP VPN Service

IP VPN Service—Requirements

- Enterprise customer buying IP VPN Service (MPLS or otherwise) from Service Provider requires 3 classes of service:

  Gold (real-time voice): No loss, low latency, low jitter, guaranteed bandwidth (128 kbps)

  Silver (ERP application): Low loss, guaranteed bandwidth (128 kbps)

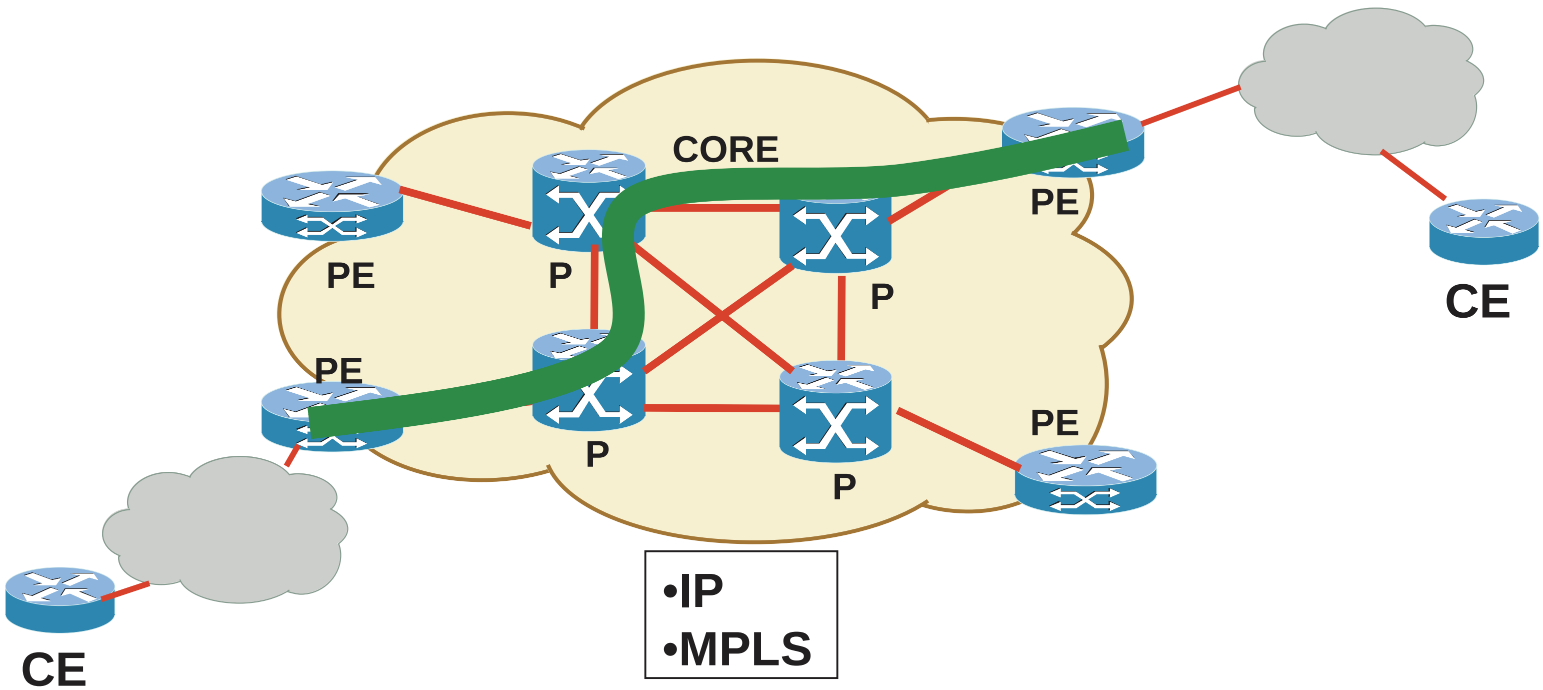
  Bronze (other traffic): Best Effort

- Link to SP is 512 kbps, simple 2 site example

IP VPN Service—Questions to Ask

- **Can Service Provider (SP) make SLA guarantees for the 3 classes?**
- **What happens to traffic that violates contract?**
- **Will IP Precedence or DSCP values be changed by SP network?**

IP VPN Service—Topology



Enterprise Customer Needs IP or MPLS VPN with Guaranteed QoS for 3 Classes of Traffic

IP VPN Service—Recommended Design

- **It's about control! Send traffic to the SP understanding how it will be treated**
  - Make sure Gold class never violates contract
  - Police Silver class to agreed rate, with some bursting capability
  - Allow Bronze traffic to use rest of available bandwidth
- **SP is likely to police the 3 classes and may re-mark or drop exceeding or violating packets**

IP VPN Service—Configuration

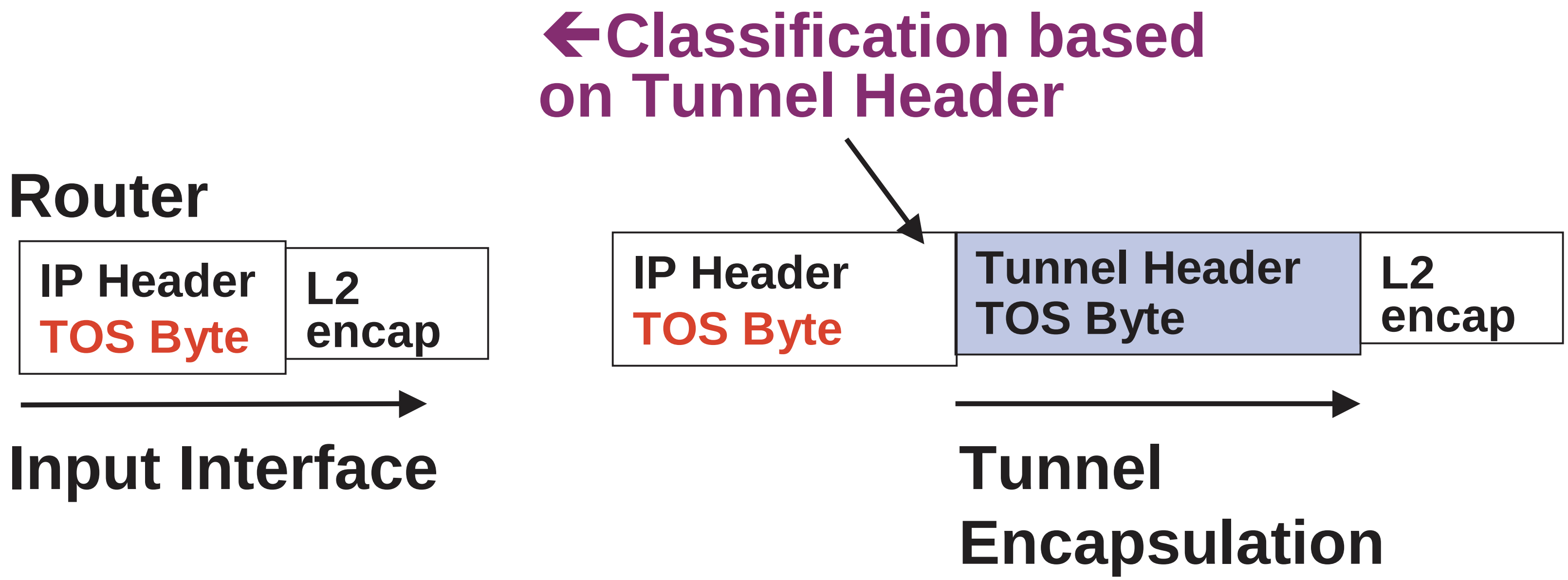

```
Router(config)# class-map Gold
Router(config-cmap)# match ip rtp 16384 17383
Router(config-cmap)# exit
Router(config)# class-map Silver
Router(config-cmap)# match access-group 101
Router(config-cmap)# exit
```


IP VPN Service—Configuration

Cisco.com

```
Router(config)# policy-map ipvpn
Router(config-pmap)# class Gold
Router(config-pmap-c)# priority 128
Router(config-pmap)# class Silver
Router(config-pmap-c)# bandwidth 128
Router(config-pmap-c)# police 128000 16000 16000
conform-action set-dscp-transmit 26 exceed-action
set-dscp-transmit 30 violate-action drop
Router(config-pmap)# class class-default
Router(config-pmap-c)# set ip dscp 0
Router(config-pmap-c)# fair-queue
```

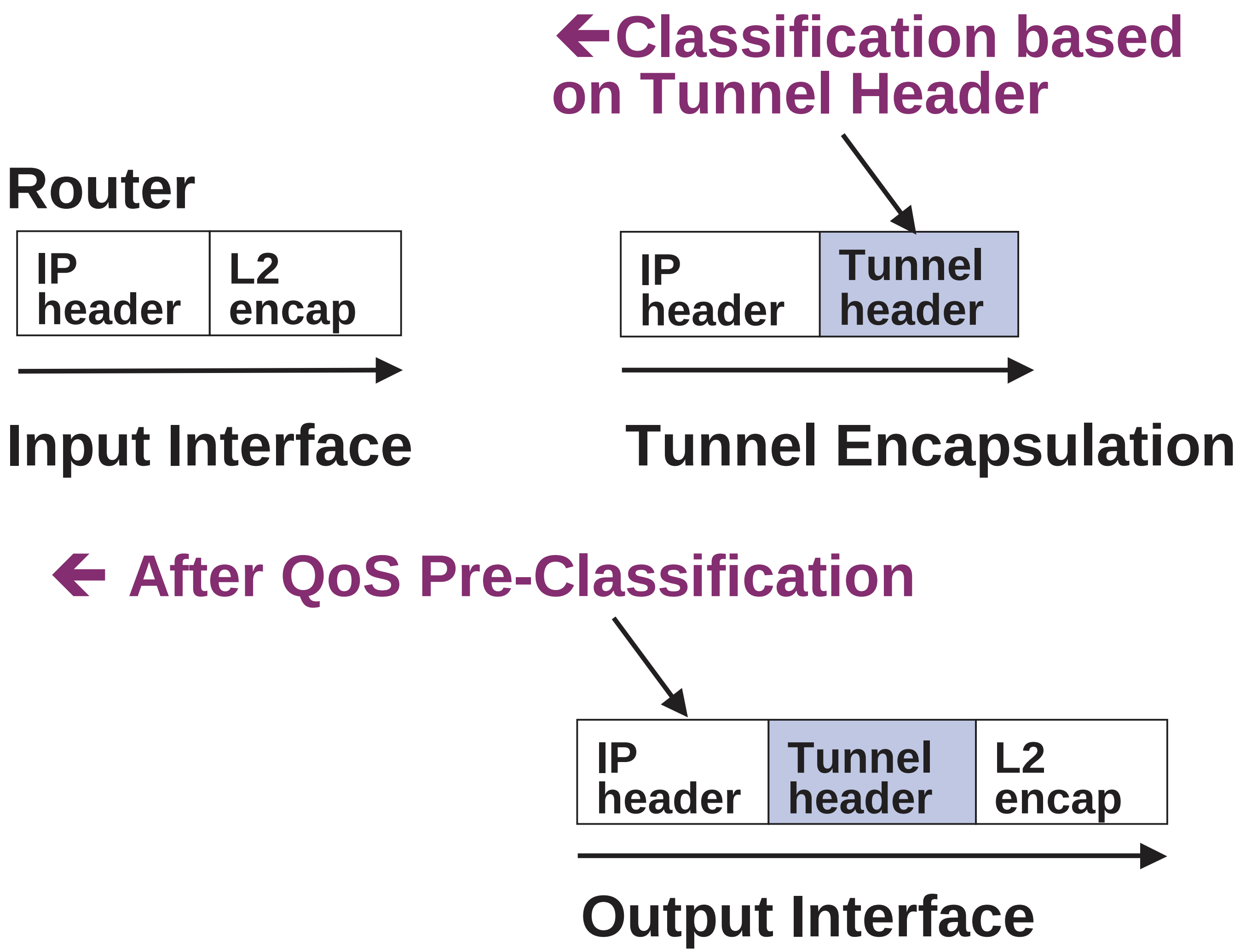

VPN QoS: ToS Field Copy



Copy ToS from original IP header to the Tunnel header:

Done by default for GRE and IPsec

VPN QoS: Pre-Classification



Configuring QoS for VPNs

- **GRE and IPIP Tunnels**

```
Router(config)# interface tunnel0
Router(config-if)# qos pre-classify
```

- **IPsec Tunnels**

```
Router(config)# crypto map secured-partner-X
Router(config-crypto-map)# qos pre-classify
```


Case Study
The Works!

The Works!—Description

- Large finance company based in New York but with branches all over the US
- 150 sites connected via Frame Relay to a hub in NY
  - All circuits are T1 with 768 kbps or 384 kbps CIR
  - Central site uses 2 T3 to connect to Frame Relay network
- Currently have 100 sites with VoIP gateways and 5 users per site, assume 12 kbps per call (with cRTP)
- Have separate satellite network for corporate video communications—want to use IPTV

The Works!—Requirements

- VoIP (UDP)—must sound crystal clear
- Video (multicast UDP) corporate communications—100 kbps needed, will use 239.200.x.x address space
- Telnet (TCP)—needs guaranteed bandwidth, represents ERP application
- Bulk Transfers (TCP)—need guaranteed bandwidth, must be policed
- Other Traffic—flows get equal share of remaining bandwidth

The Works!—Configuration Classification


```
Router(config)# class-map voip
Router(config-cmap)# match ip rtp 16384 17383
Router(config)# class-map video
Router(config-cmap)# match access-group 100
Router(config)# class-map erp
Router(config-cmap)# match access-group 101
Router(config)# class-map bulk
Router(config-cmap)# match access-group 102

Router(config)# access-list 100 permit udp any 239.200.0.0
0.0.255.255
Router(config)# access-list 101 permit tcp any any eq 23
Router(config)# access-list 102 permit tcp any any eq 20
Router(config)# access-list 102 permit tcp any any eq 21
```


The Works!—Configuration Policing and Marking

Cisco.com

```
Router(config)# policy-map access-in
Router(config-pmap)# class voip
Router(config-pmap-c)# set ip dscp 46
Router(config-pmap)# class video
Router(config-pmap-c)# set ip dscp 34
Router(config-pmap)# class erp
Router(config-pmap-c)# set ip dscp 26
Router(config-pmap)# class bulk
Router(config-pmap-c)# police 128000 conform-
action set-dscp-transmit 18 exceed-action set-
dscp-transmit 22 violate-action drop
Router(config-pmap)# class class-default
Router(config-pmap-c)# set ip dscp 0
```


The Works!—Configuration DSCP-Based Classification

Cisco.com

```
Router(config)# class-map platinum
Router(config-cmap)# match ip dscp 46
Router(config)# class-map gold
Router(config-cmap)# match ip dscp 34
Router(config)# class-map silver
Router(config-cmap)# match ip dscp 26
Router(config)# class-map bronze
Router(config-cmap)# match ip dscp 18 22
```


The Works!—Configuration Queuing and Dropping


```
Router(config)# policy-map 384out
Router(config-pmap)# class platinum
Router(config-pmap-c)# priority 64
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth 128
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth 32
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth 64
Router(config-pmap-c)# random-detect dscp-based
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue
```


The Works!—Configuration Queuing and Dropping


```
Router(config)# policy-map 768out
Router(config-pmap)# class platinum
Router(config-pmap-c)# priority 64
Router(config-pmap)# class gold
Router(config-pmap-c)# bandwidth 128
Router(config-pmap)# class silver
Router(config-pmap-c)# bandwidth 64
Router(config-pmap)# class bronze
Router(config-pmap-c)# bandwidth 128
Router(config-pmap-c)# random-detect dscp-based
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue
```


The Works!—Configuration FRTS

Cisco.com

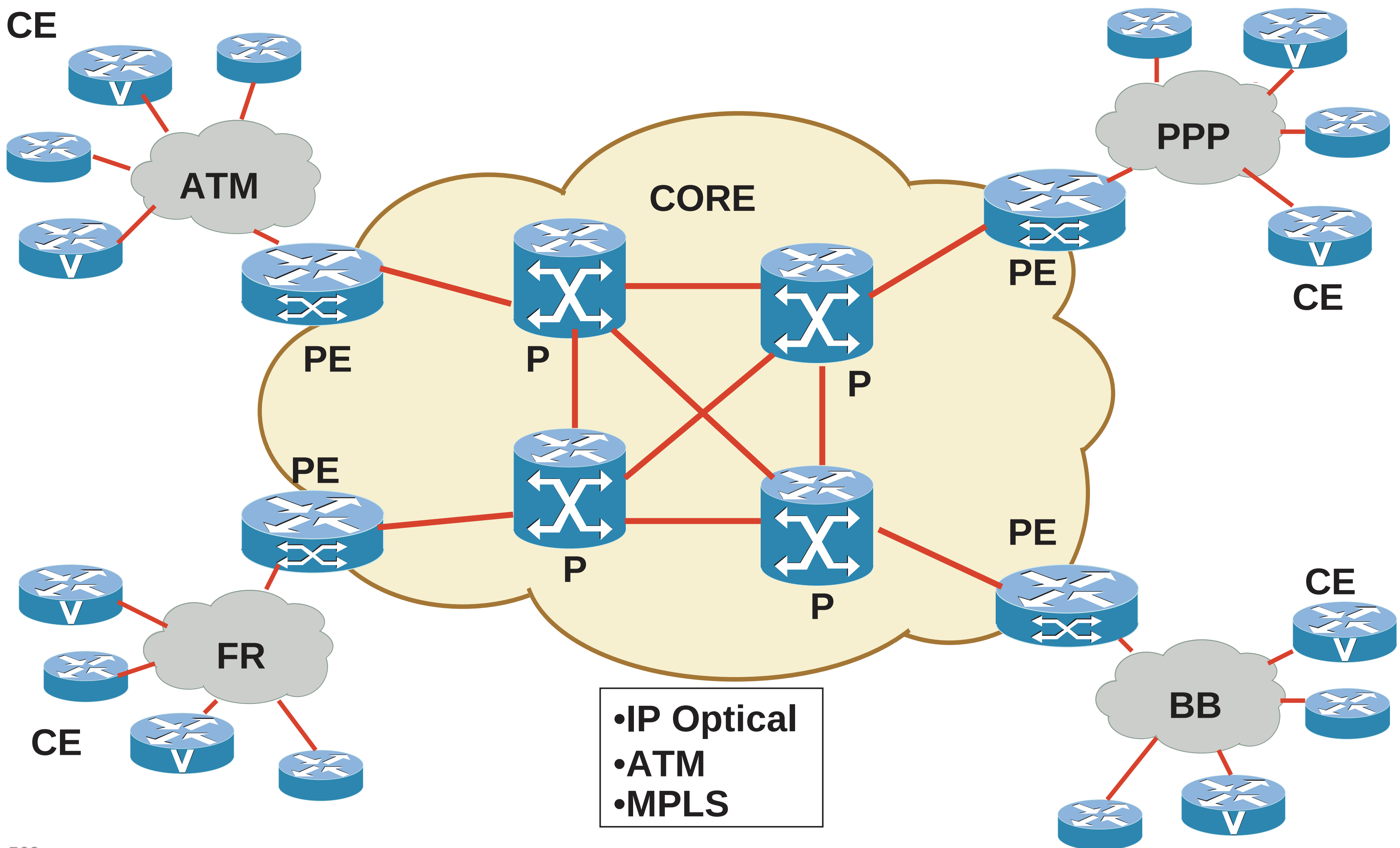
```
Router(config)# map-class frame-relay 384k
Router(config-map-class)# frame-relay cir 384000
Router(config-map-class)# frame-relay bc 3840
Router(config-map-class)# frame-relay be 0
Router(config-map-class)# frame-relay mincir 384000
Router(config-map-class)# no frame-relay adaptive-shaping
Router(config-map-class)# frame-relay fragment 480
Router(config-map-class)# service-policy output 384out
Router(config)# map-class frame-relay 768k
Router(config-map-class)# frame-relay cir 768000
Router(config-map-class)# frame-relay bc 7680
Router(config-map-class)# frame-relay be 0
Router(config-map-class)# frame-relay mincir 768000
Router(config-map-class)# no frame-relay adaptive-shaping
Router(config-map-class)# frame-relay fragment 960
Router(config-map-class)# service-policy output 384out
```


Case Studies—Other Considerations

- Transmit queue limits
- Over-subscription
- Performance
- Multiple routes
- End-to-end
- Cisco IOS version

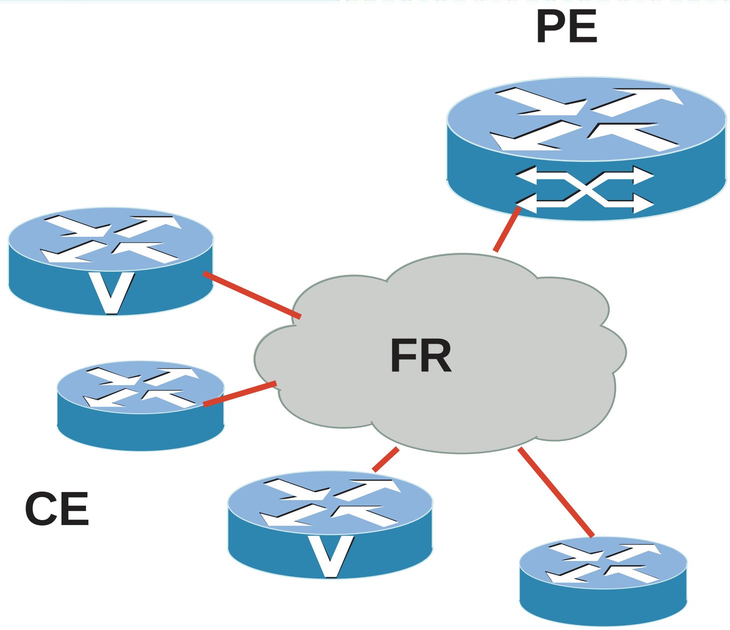
Case Study
SP QoS Generic

SP Network Diagram



QoS for Frame Relay CE-PE

Cisco.com

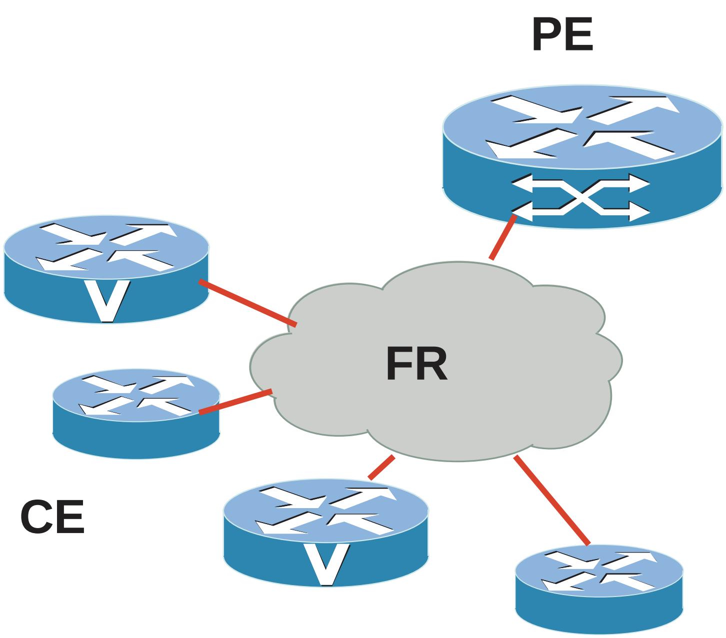


PE Inbound	PE Outbound
Police	FR TS
Marking	LLQ
	WRED
	FRF. 12
	cRTP

CE Inbound	CE Outbound
Police	FR TS
Marking	LLQ
	WRED
	FRF. 12
	cRTP

CE		PE	
	2500 Series		7200 Series
	3640 Series		7500 Series
	7200 Series		10000 ESR

QoS for Frame Relay CE-PE
CE Inbound



CE Inbound

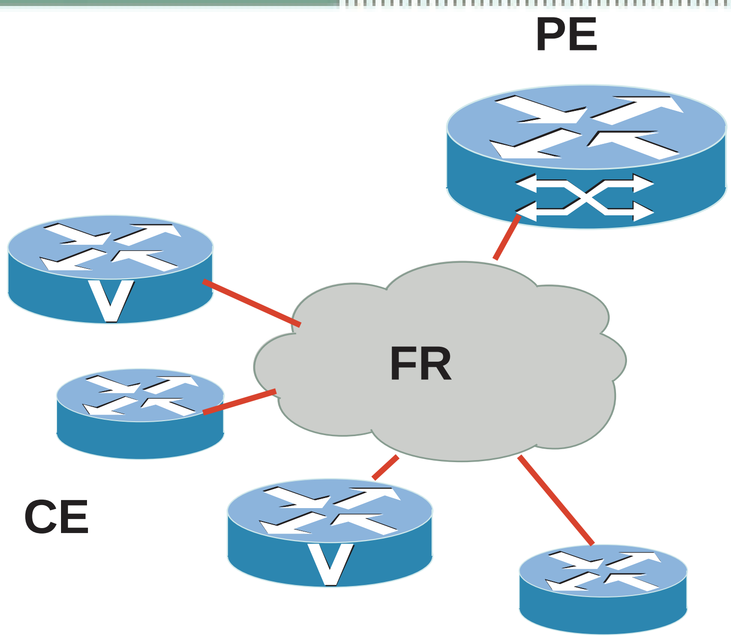
Police

Marking

- Customer defined policy
- CE may police and mark

QoS for Frame Relay CE-PE
CE Outbound

Cisco.com



CE Outbound

FR TS

LLQ

WRED

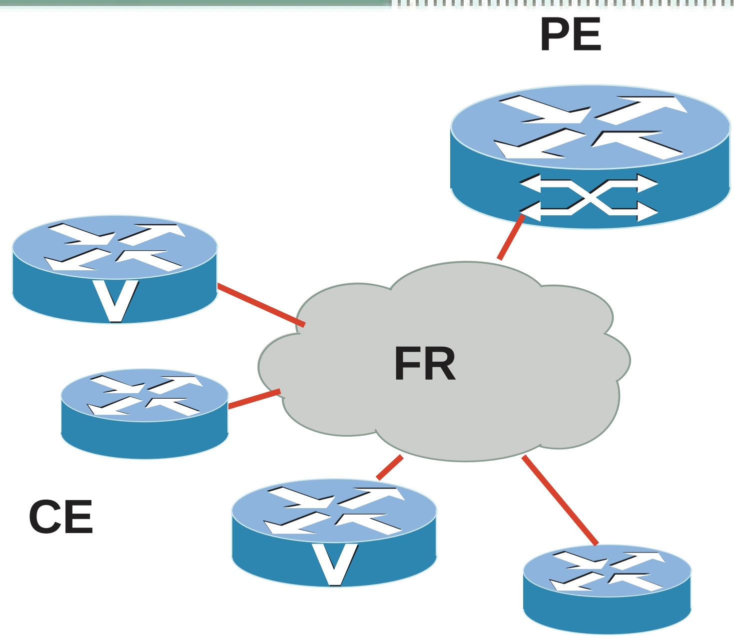
FRF. 12

cRTP

- Customer defined policy
- Limit bursting above CIR
- LLQ for min BW guarantees
- Fragmentation and cRTP on slow links

QoS for Frame Relay CE-PE
CE Outbound (cont.)

Cisco.com



CE Outbound

FR TS

LLQ

WRED

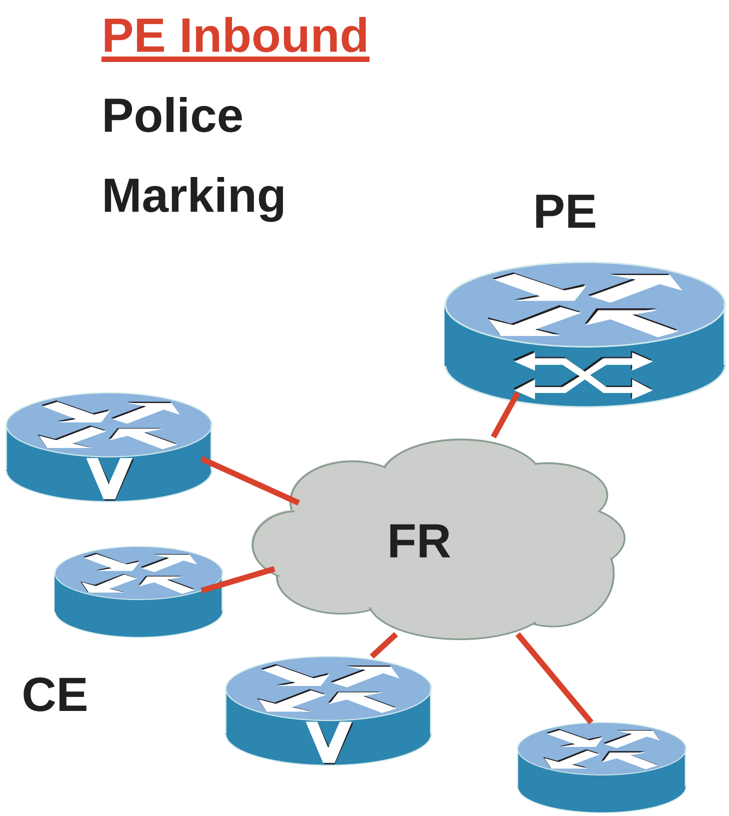
FRF. 12

cRTP

```
class-map match-all VOICE
 match ip rtp 16384 16383
!
policy-map OUT-POLICY
  class VOICE
    priority 128
    set ip dscp ef
  class class-default
   fair-queue
 !
 interface Serial0/0.1 point-to-point
  ip address 10.10.1.2 255.255.255.0
  frame-relay interface-dlci 16
   class FR-class
 !
 map-class frame-relay FR-class
  frame-relay cir 256000
  frame-relay bc 256
  frame-relay mincir 256000
  frame-relay fair-queue
  service-policy output OUT-POLICY
  frame-relay fragment 256
 !
```


QoS for Frame Relay CE-PE
PE Inbound

- Mark and police traffic according to contract
- P routers will service traffic based on marking



QoS for Frame Relay CE-PE
PE Inbound (cont.)

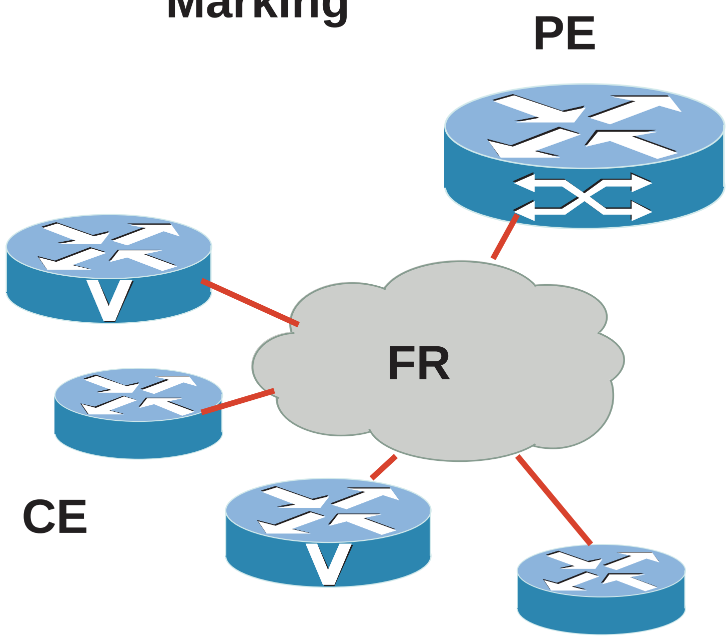
Cisco.com

```
class-map match-all GOLD
 match ip dscp ef
!
policy-map IN-POLICY
  class GOLD
   police 256000 4000 4000 conform-action
    transmit exceed-action drop
  class class-default
   set ip dscp af31
 !
 interface Serial0/0.1 point-to-point
  ip address 10.32.14.2 255.255.255.0
  frame-relay interface-dlci 16
   class FR-class
 !
 map-class frame-relay FR-class
  no frame-relay adaptive-shaping
  frame-relay cir 512000
  frame-relay bc 512
  frame-relay mincir 512000
  frame-relay fair-queue
  service-policy input IN-POLICY
 !
```

PE Inbound

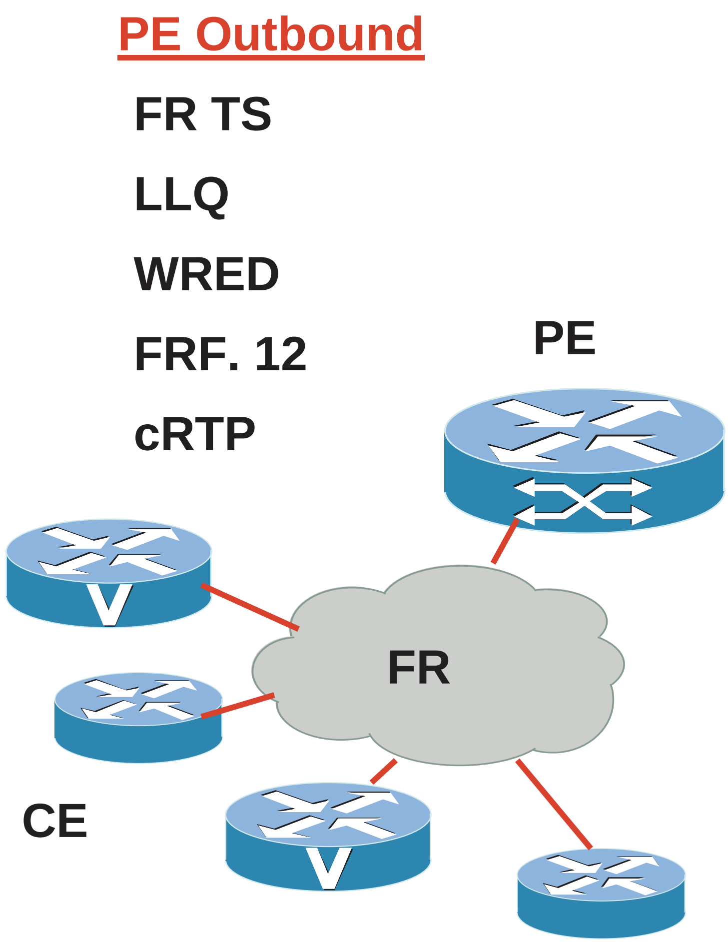
Police

Marking



QoS for Frame Relay CE-PE
PE Outbound

- Shape traffic due to CE-PE speed mismatch
- Per-PVC LLQ for min BW guarantees
- Fragmentation and cRTP on slow links



QoS for Frame Relay CE-PE
PE Outbound (cont.)

Cisco.com

```
class-map match-all GOLD
 match ip dscp ef
!
class-map match-all SILVER
 match ip dscp af31
!
policy-map OUT-POLICY
  class GOLD
    priority 128
  class SILVER
    bandwidth 256
    random-detect
  class class-default
   fair-queue
 !
 interface Serial0/0.1 point-to-point
  ip address 10.10.1.2 255.255.255.0
  frame-relay interface-dlci 16
   class FR-class
 !
 map-class frame-relay FR-class
  frame-relay cir 512000
  frame-relay bc 5120
  frame-relay mincir 512000
  frame-relay fair-queue
  service-policy output OUT-POLICY
 !
```

PE Outbound

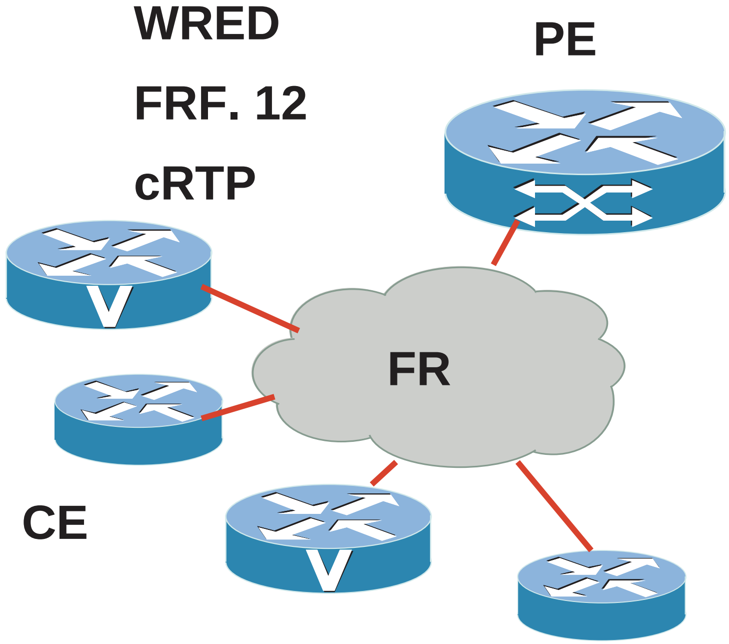
FR TS

LLQ

WRED

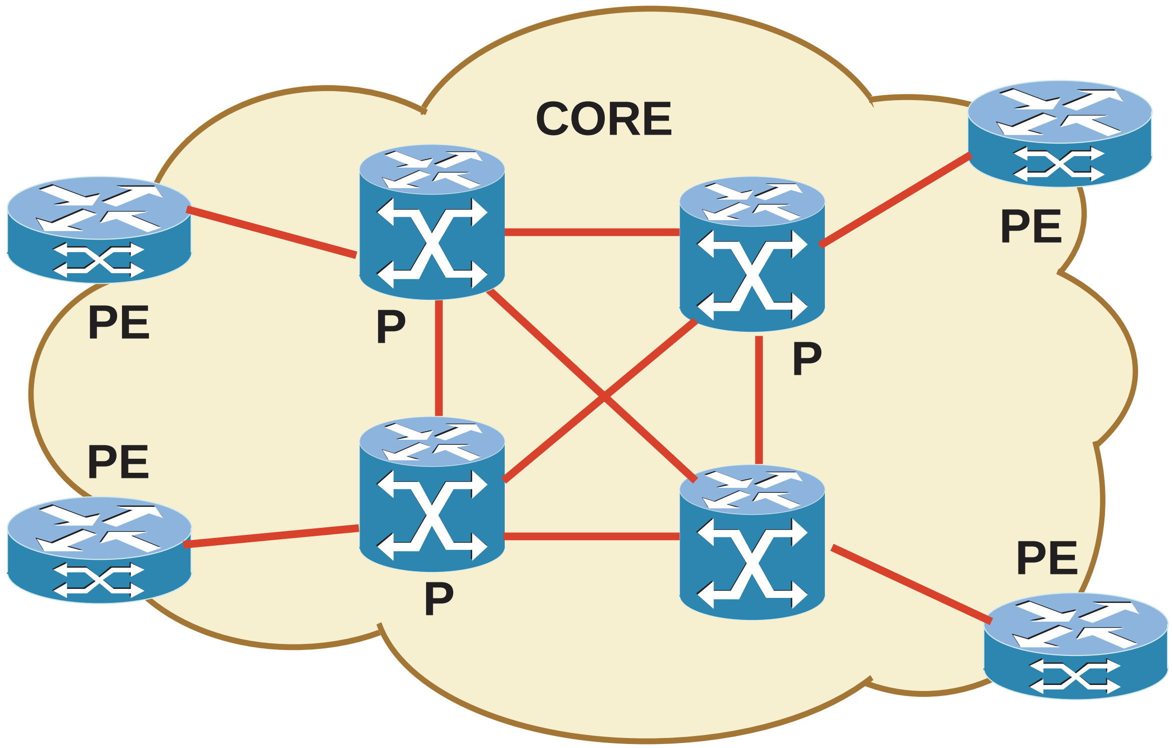
FRF. 12

cRTP



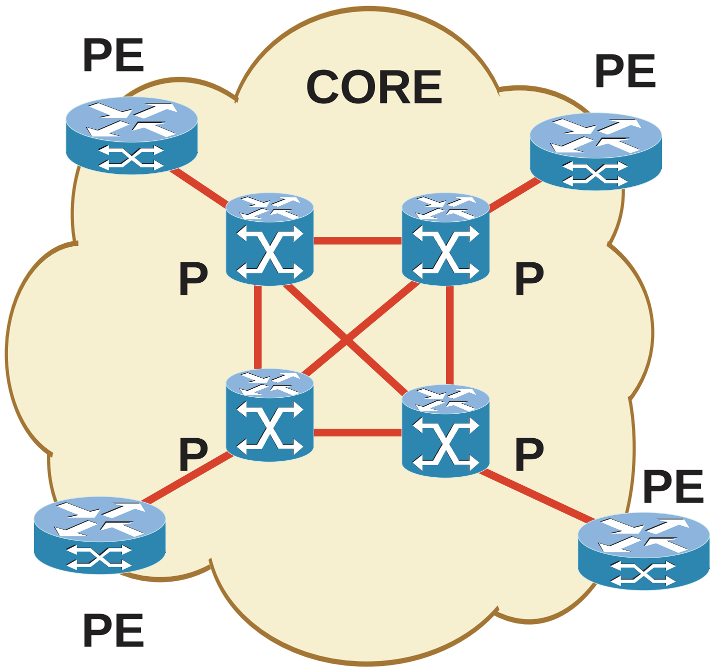
PE out to P QoS

7200 Series
7500 Series
10000 ESR
12000 GSR



POS	ATM	MPLS
LLQ	LLQ	LLQ
	VC Bundling	Marking
WRED	WRED	WRED

PE out to P QoS
POS



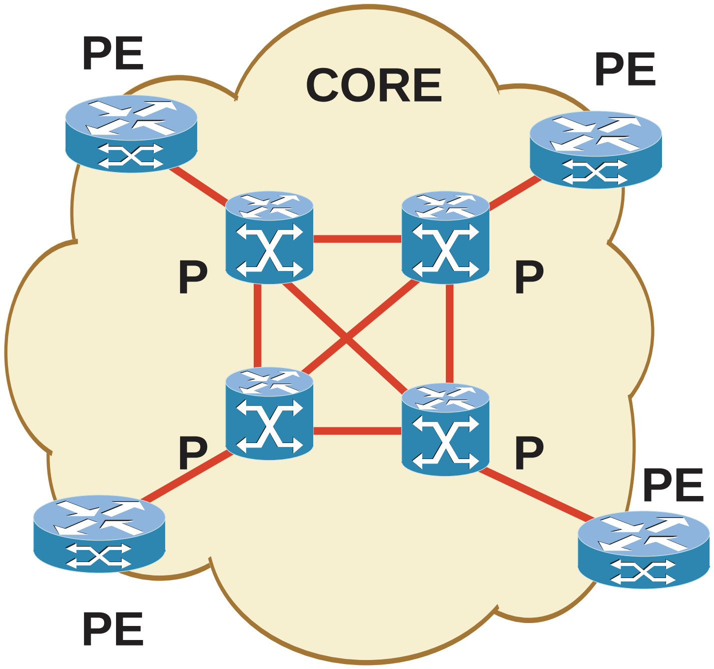
POS

LLQ

WRED

- LLQ for min BW guarantees and congestion management
- WRED to increase link utilization
- Packets should be marked before leaving the PE

PE Out to P QoS POS (Cont.)



POS

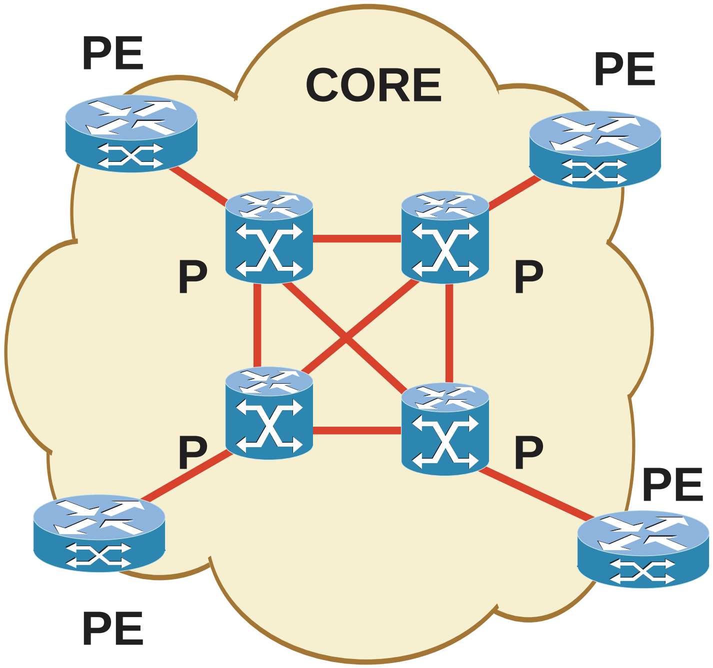
LLQ

WRED

```
class-map match-all GOLD
 match ip dscp ef
!
class-map match-all SILVER
 match ip dscp af31
!
policy-map OUT-POLICY
  class GOLD
    priority 16384
  class SILVER
    bandwidth 65536
    random-detect
  class class-default
   fair-queue
!
interface POS1/0
 ip address 10.150.1.1 255.255.255.0
 service-policy output OUT-POLICY
!
```


PE Out to P QoS ATM

- Per-PVC LLQ for min BW guarantees and congestion management
- ATM PVC bundling to take advantage of ATM CoS
- WRED to increase link utilization
- Packets should be marked before leaving the PE



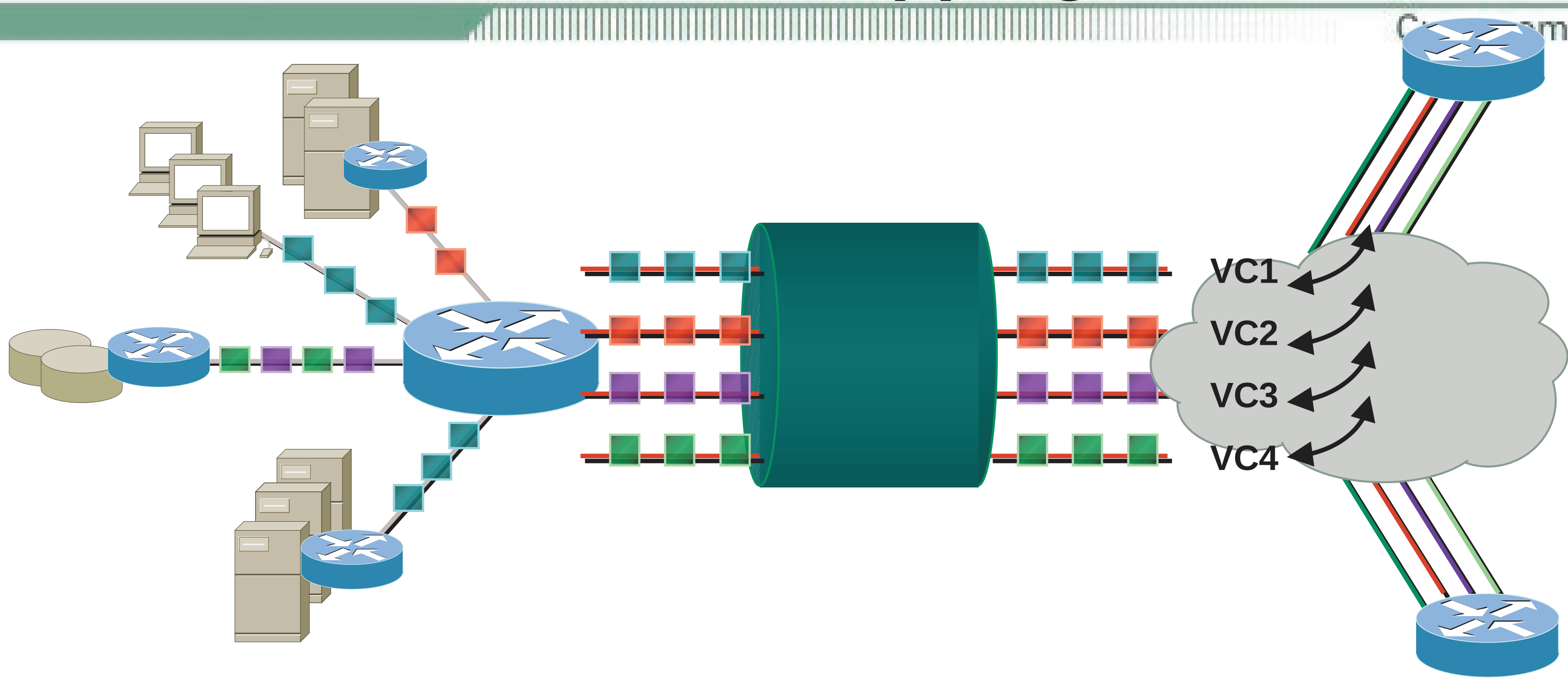
ATM

LLQ

VC Bundling

WRED

IP Precedence to VC Mapping

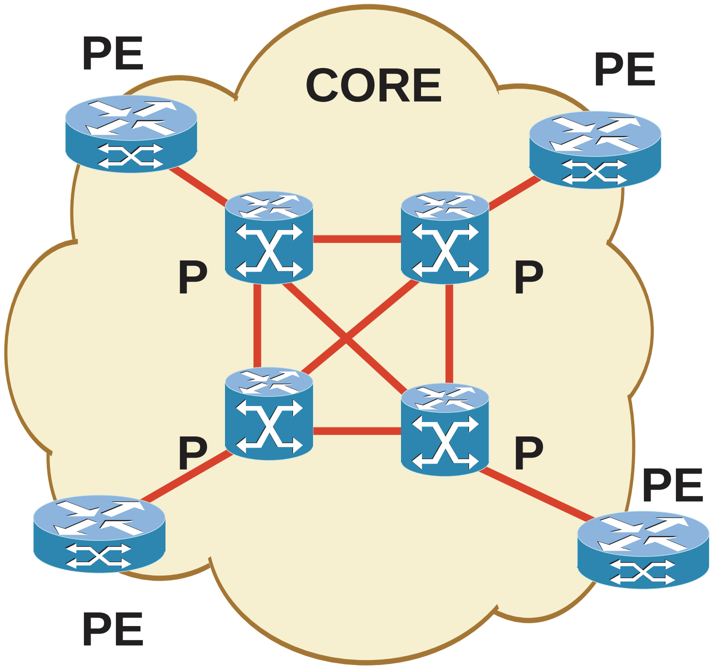


- Multiple VCs for each source/destination
- Separate VC for each IP CoS
- A service policy runs on each VC queue

PE Out to P QoS ATM (Cont.)

Cisco.com

```
!
interface ATM1/0/0
 ip address 10.23.45.1 255.255.255.0
 bundle BOSTON
  protocol ip 10.23.45.2 broadcast
  encapsulation aal5snap
  pvc-bundle 0/35
   service-policy output GOLD
   vbr-nrt 5000 3000 500
   precedence 4-7
  pvc-bundle 0/34
   service-policy output SILVER
   vbr-nrt 4000 3000 500
   precedence 2-3
  pvc-bundle 0/33
   service-policy output BRONZE
   precedence other
 !
```



ATM

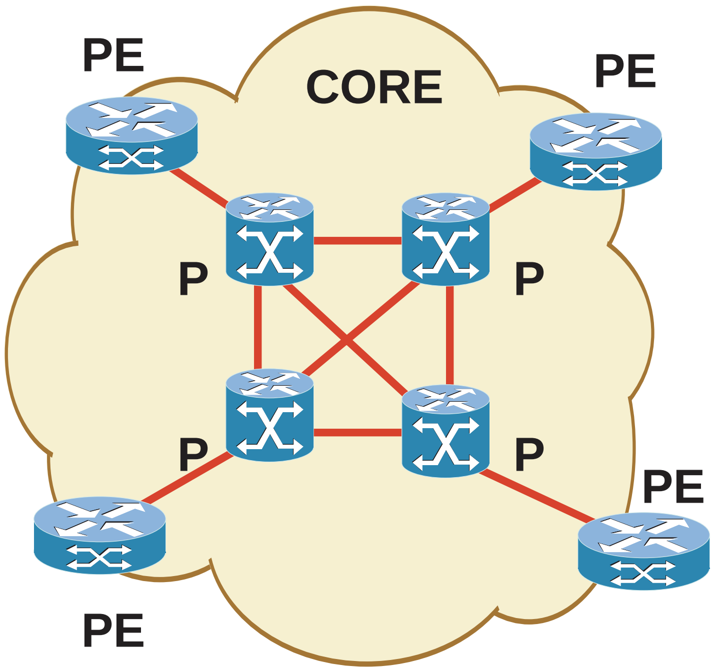
LLQ

VC Bundling

WRED

PE Out to P QoS MPLS

Cisco.com



MPLS

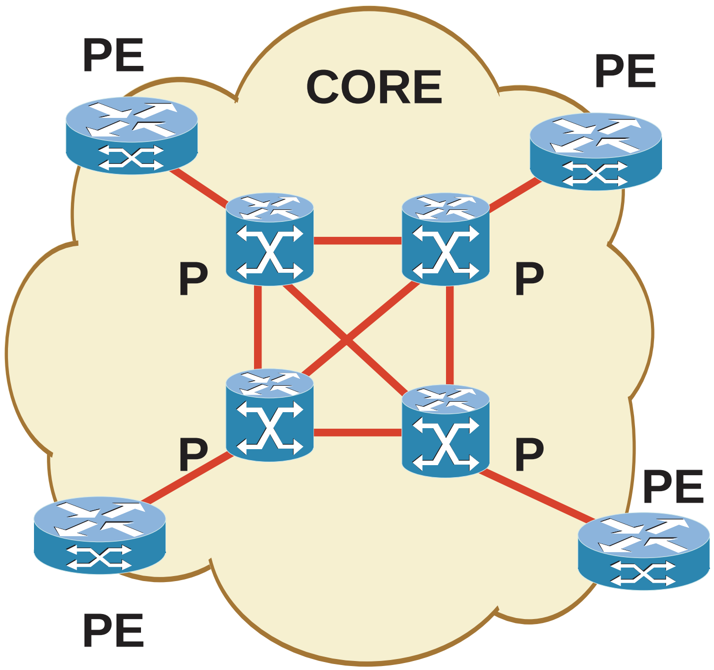
LLQ

Marking

WRED

- LLQ for min BW guarantees and congestion management
- DSCP values mapped to EXP bits (E-LSP)
- P routers will service packets based on EXP bits
- DSCP values are preserved
- WRED to increase link utilization

PE Out to P QoS MPLS (Cont.)



MPLS

LLQ

Marking

WRED

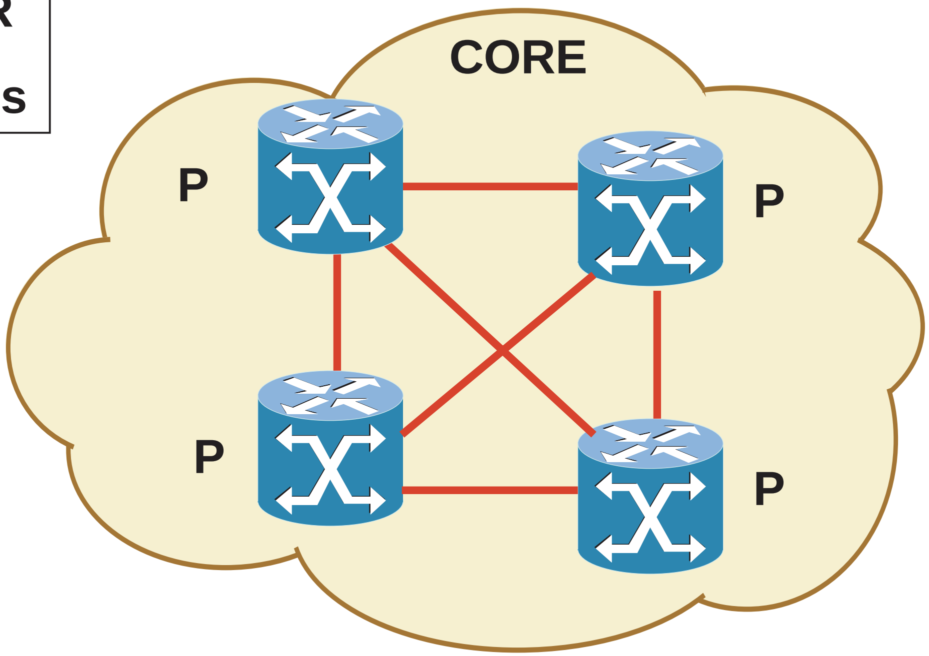
```
!
class-map match-all GOLD
  match access-group 166
class-map match-all SILVER
  match access-group 101
class-map match-all MPLS-GOLD
  match qos-group 46
class-map match-all MPLS-SILVER
  match qos-group 26
!
policy-map IN-POLICY
  class GOLD
   set qos-group 46
   police 100000 3000 3000 conform-action
    transmit exceed-action drop
  class SILVER
   set qos-group 26
!
policy-map OUT-POLICY
  class MPLS-GOLD
   set mpls experimental 5
   bandwidth 16384
  class MPLS-SILVER
   set mpls experimental 3
   bandwidth 65536
   random-detect
  class class-default
   set mpls experimental 0
   fair-queue
!
```


P Router QoS

Cisco.com

12000 GSR

7500 Series



•IP Optical
•ATM
•MPLS

P Router

LLQ or MDRR

WRED

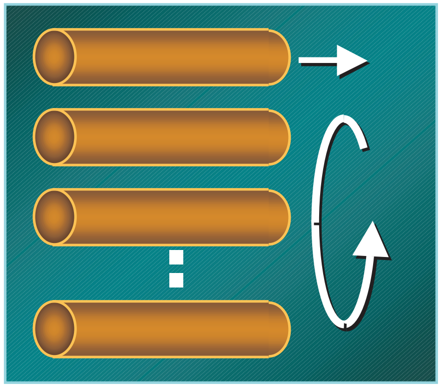
MDRR Queuing on the 12000

- 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:

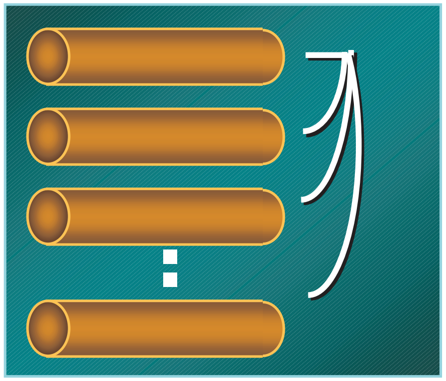
  Strict priority mode

  Alternate priority mode

Strict Priority

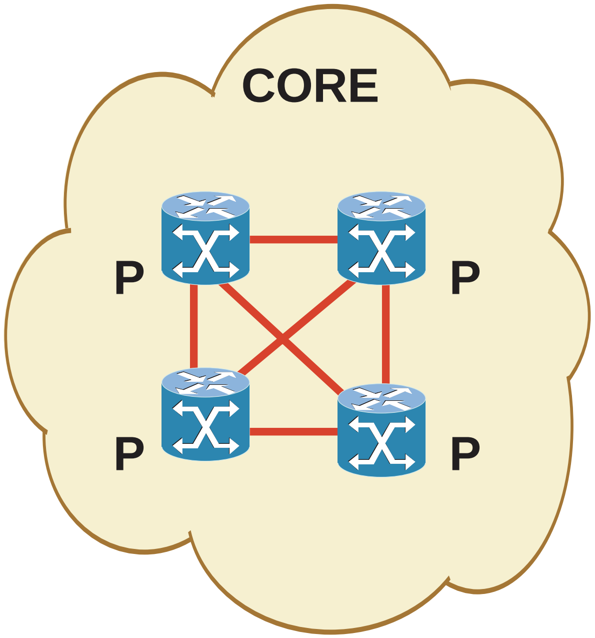


Alternate Priority



P Router QoS

- **Maximum performance environment with simpler QoS configuration**
- **MDRR for congestion management on 12000 platform**
- **LLQ for congestion management on 7500 platform**
- **WRED to increase link utilization on high speed links**



P Router

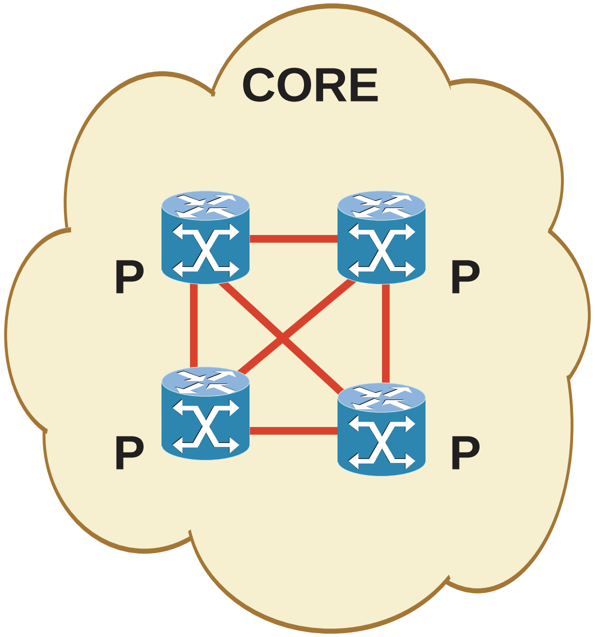
LLQ or MDRR

WRED

P Router QoS

Cisco.com

```
interface POS2/0
 ip add 10.64.12.1 255.255.255.252
 tx-cos NEWYORK-TX
!
cos-queue-group NEWYORK-TX
 precedence 0 queue 1
 precedence 0 random-detect-label 0
 precedence 1 queue 1
 precedence 1 random-detect-label 0
 precedence 2 queue 1
 precedence 2 random-detect-label 0
 precedence 3 queue 2
 precedence 3 random-detect-label 1
 precedence 4 queue 2
 precedence 4 random-detect-label 1
 precedence 5 queue low-latency
 precedence 6 queue low-latency
 precedence 7 queue low-latency
 random-detect-label 0 3000 5000 1
 random-detect-label 1 6000 8000 1
 queue 1 5
 queue 2 20
 queue low-latency strict-priority 9
!
```



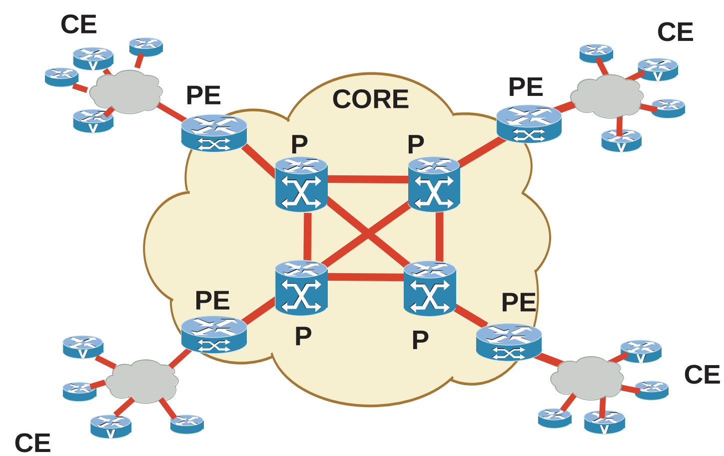
P Router

LLQ or MDRR

WRED

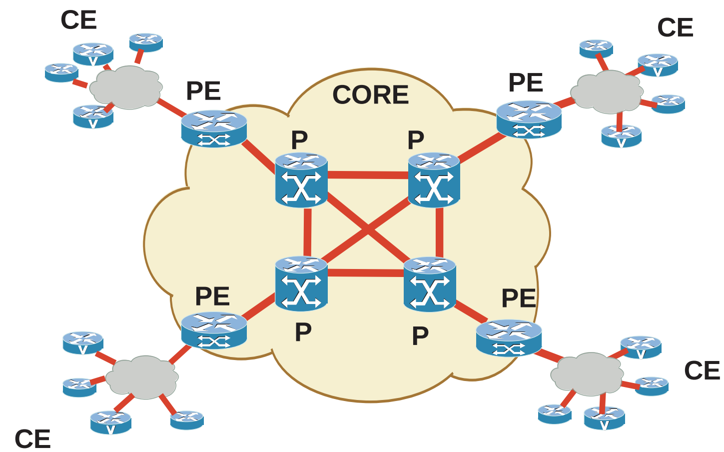
QoS High Level View

- Marking, policing and shaping should be done at the edges of the network
- Queuing and dropping done in the core based on packet marking
- One class for low latency traffic
- A small number of additional classes to implement SLAs



Platform Dependent Features

- QoS features are implemented in a distributed fashion on the 7500
- PIRC available on the 12000 for higher policing performance
- MDRR queuing on the 12000 only, not configured through the MQC
- Policing and other features in PXF path for 7200, 10k and OSR



Case Study
SP Customer Examples

SP Customer Examples

Slides will be provided as handout during session

QoS Management

Section 4

Outline

- QoS Management—Need + Overview
- QoS Device Manager (QDM) Overview
- QoS Policy Manager (QPM) Overview
- Monitoring and Trending Overview
- White Papers + Case Studies
- Methodology + Best Practices

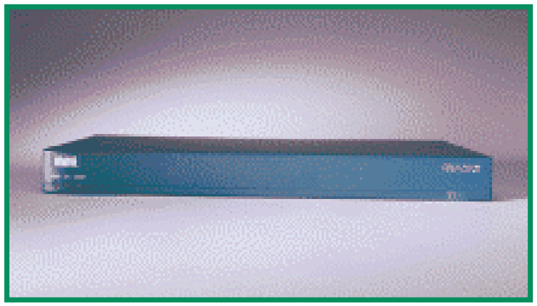
ftp://ftpeng.cisco.com/szigeti/NW2001-PS560/

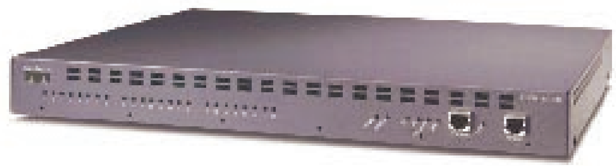
QoS Is an Enabling Technology for AVVID

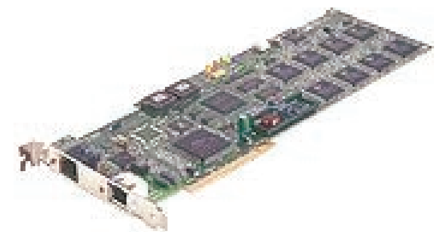
Cisco.com

Cisco **AVVID**
Architecture for Voice, Video and Integrated Data

VoIP







- Toll-Bypass
- IP Phones

Video

- IP/TV
- IP/VC

Data: Mission Critical Applications

- SAP
- Oracle
- PeopleSoft
- SNA

Data: Entertainment Applications

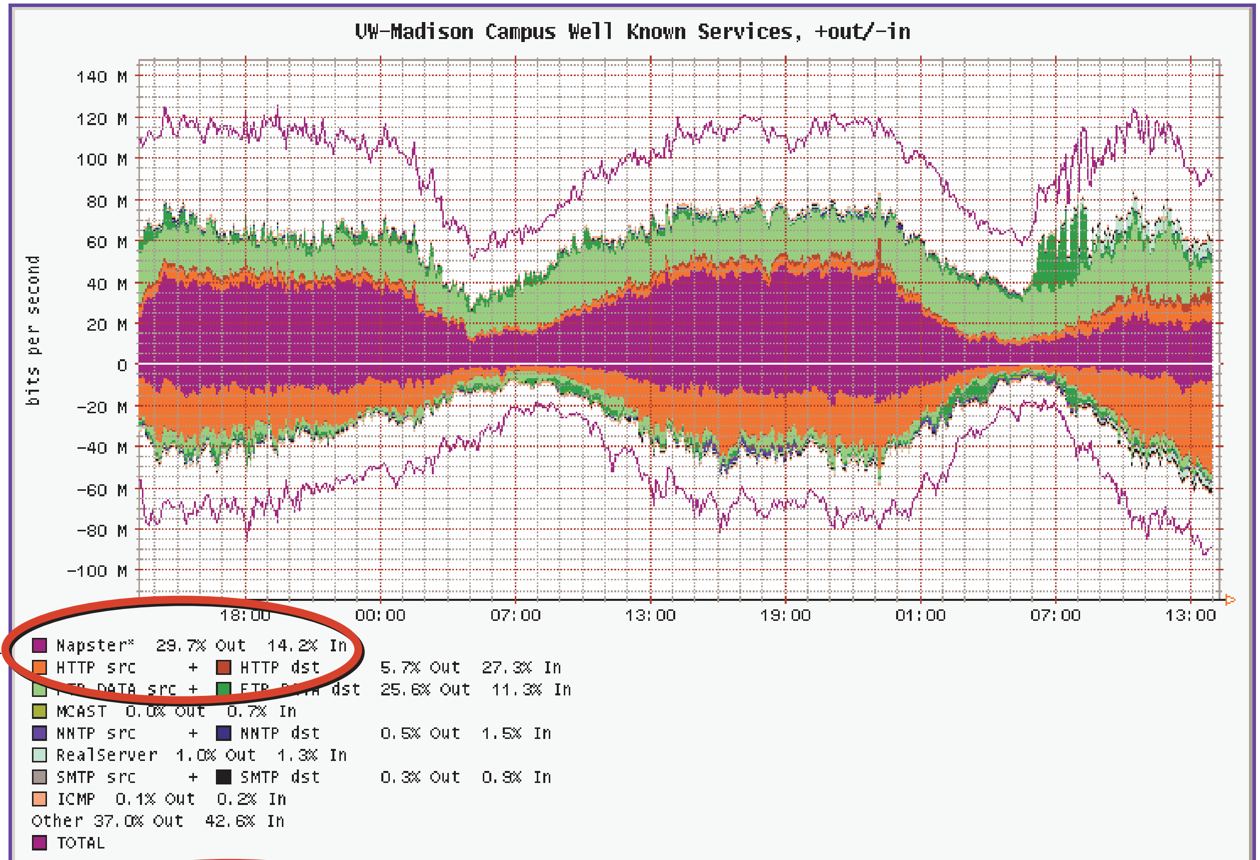
Is Napster Dead?

Popular Current Example:

NAPSTER

- **Because it's difficult to identify, it's hard to measure and challenging to control**
- **Many enterprises would be surprised to realize the extent of rogue applications on their networks**

- **Napster is a dominant application on many typical University and Enterprise Networks**
- **Napster is most accurately identified at the Application Layer**



University of Wisconsin—Madison: April 2001: http://wwwstats.net.wisc.edu/
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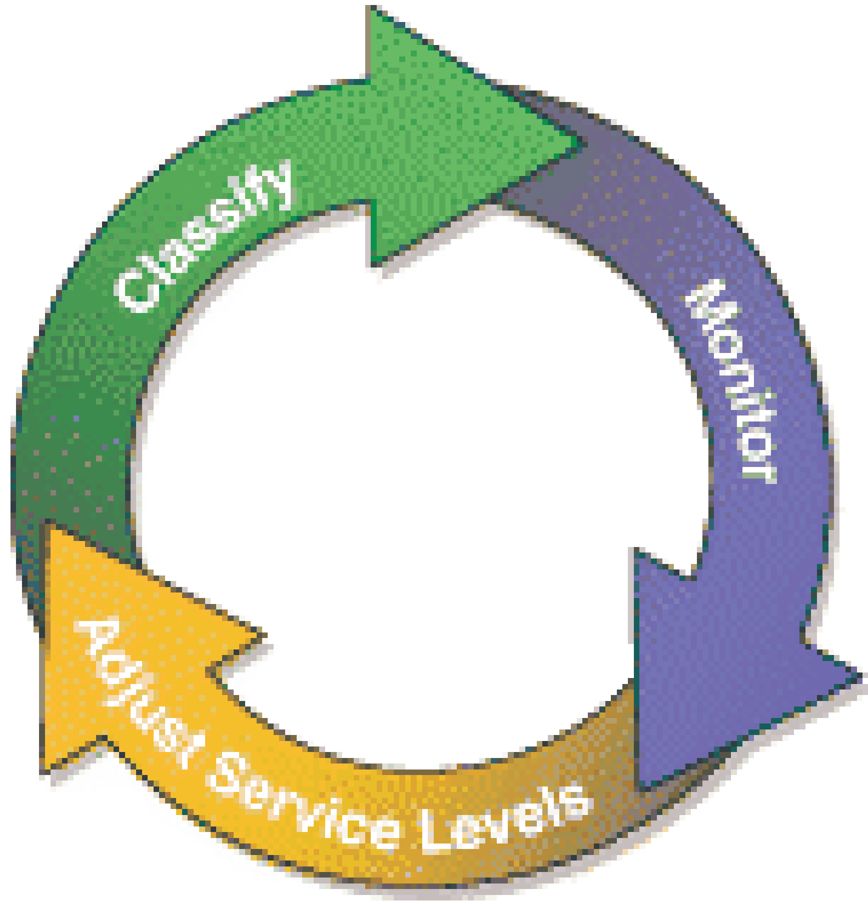
QoS Management Circle



Outline

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- QoS Management—Need + Overview
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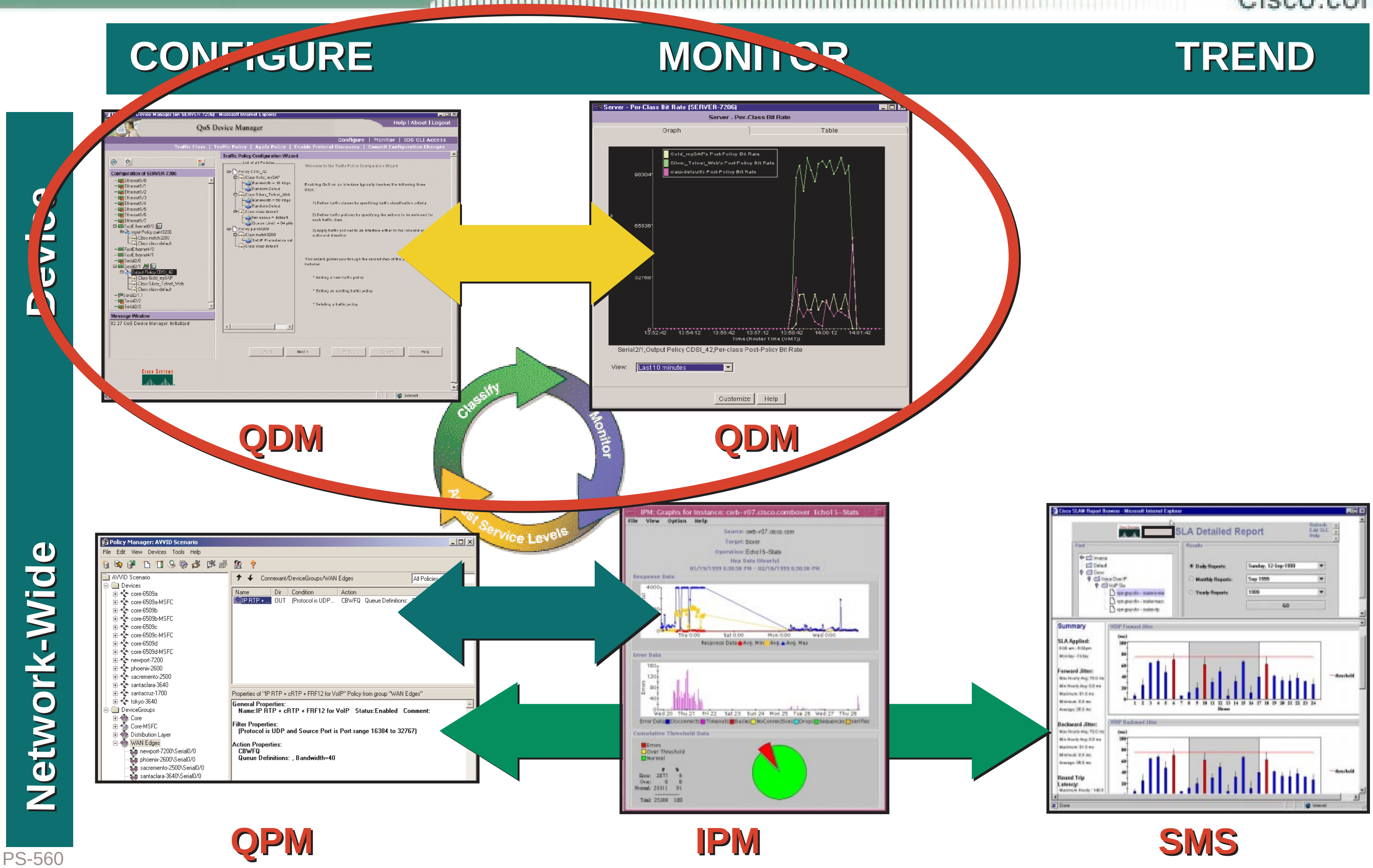
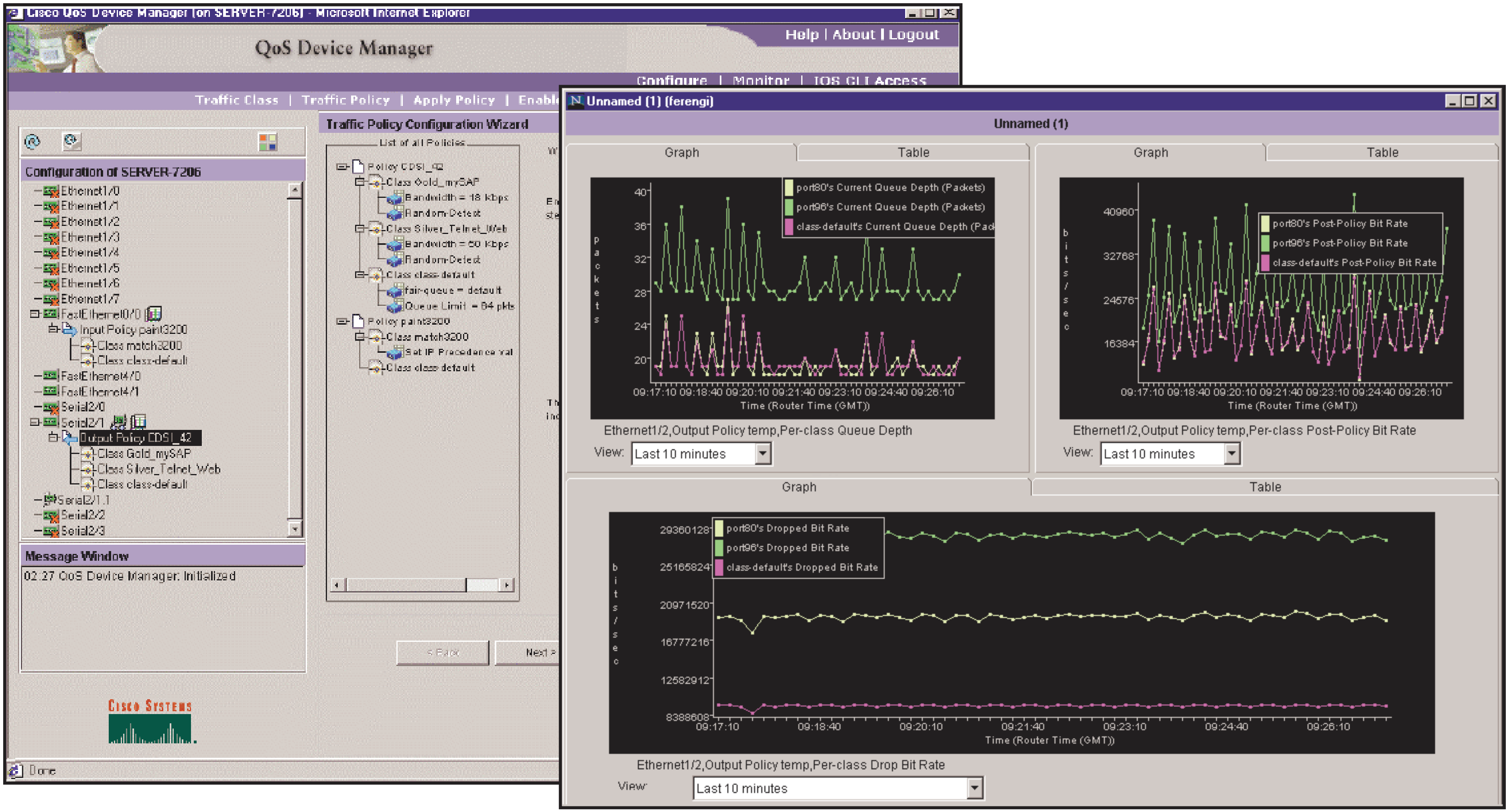
Complete QoS Management



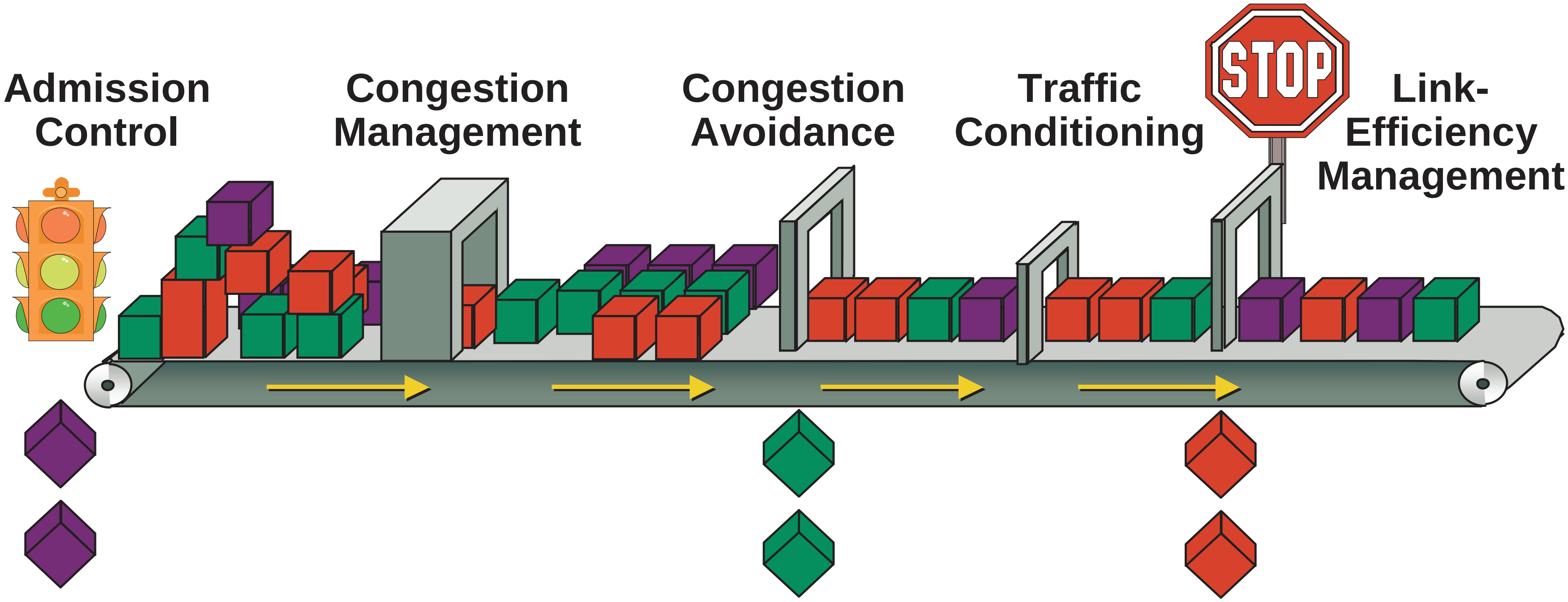
QDM 2.0



http://www.cisco.com/univercd/cc/td/doc/product/rtrmgmt/qdm/qdmrn20.pdf

What QoS Mechanisms Does QDM Support?

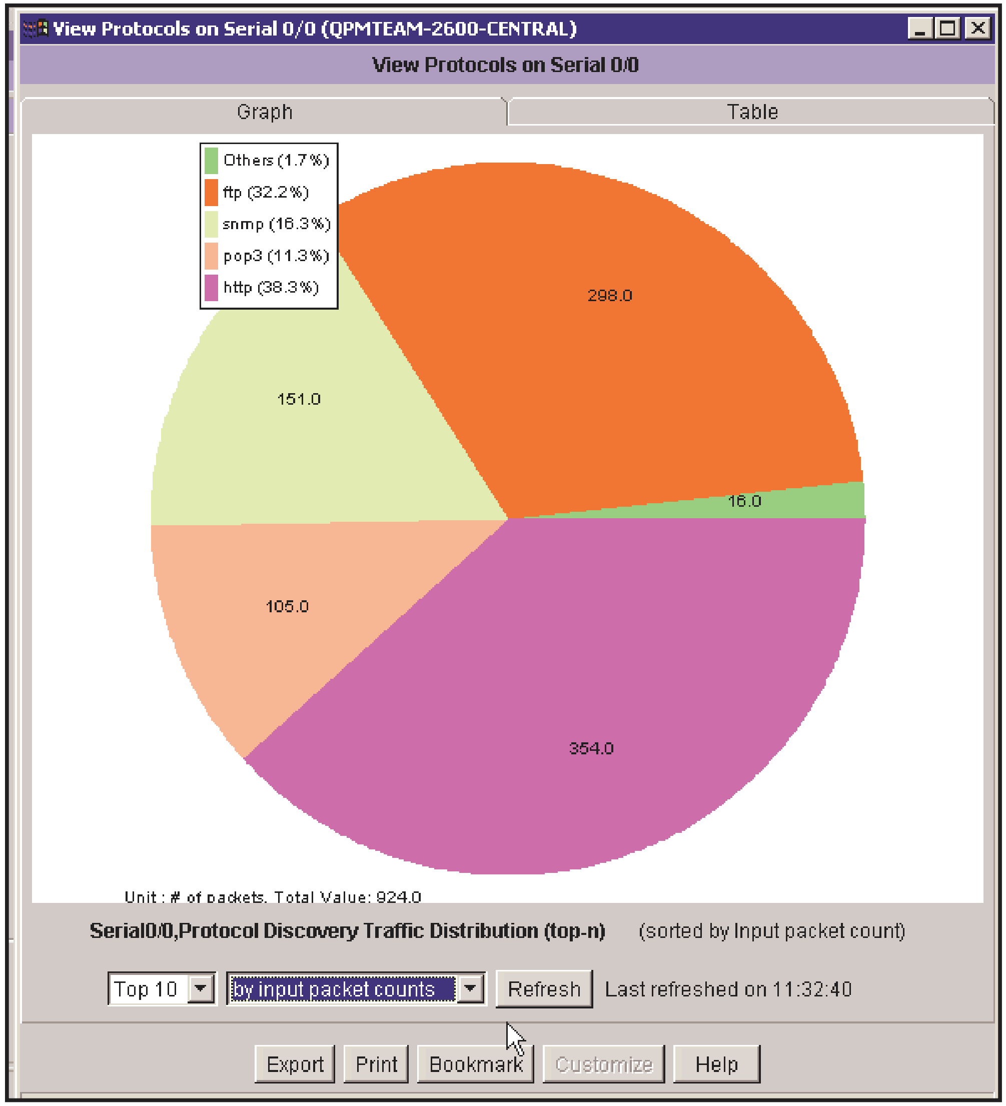
Admission Control	Congestion Management	Congestion Avoidance	Traffic Conditioning	Link-Efficiency Management



CLASSIFYING	QUEUEING	DROPPING	POLICING	FRAG/COMPR
ACLs	CBWFQ/LLQ	TAIL	POLICING	
IPP/DSCP		WRED	SHAPING	
MAC/CoS			MARKING	
NBAR				
MPLS EV				

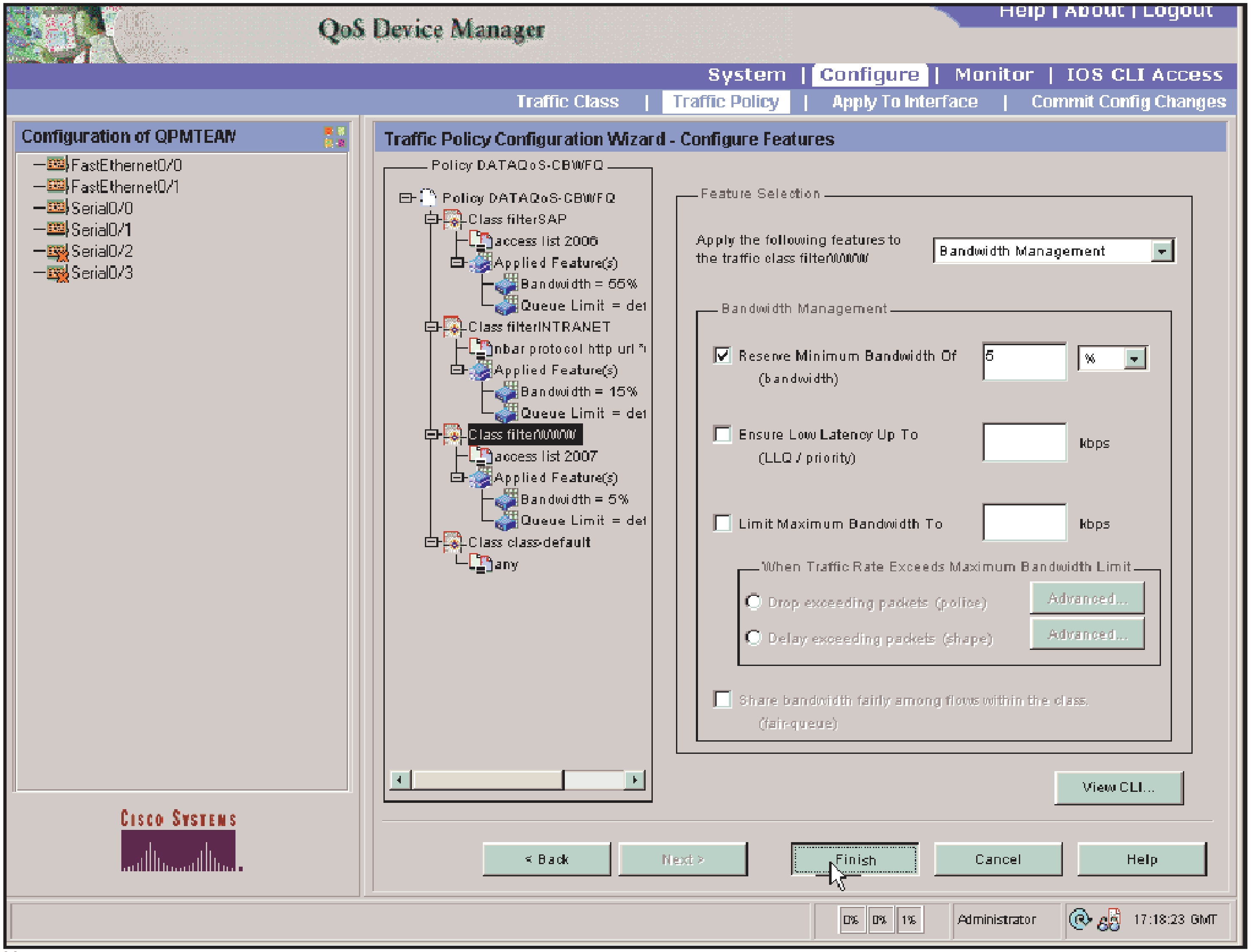
QDM/NBAR Protocol Discovery

Cisco.com



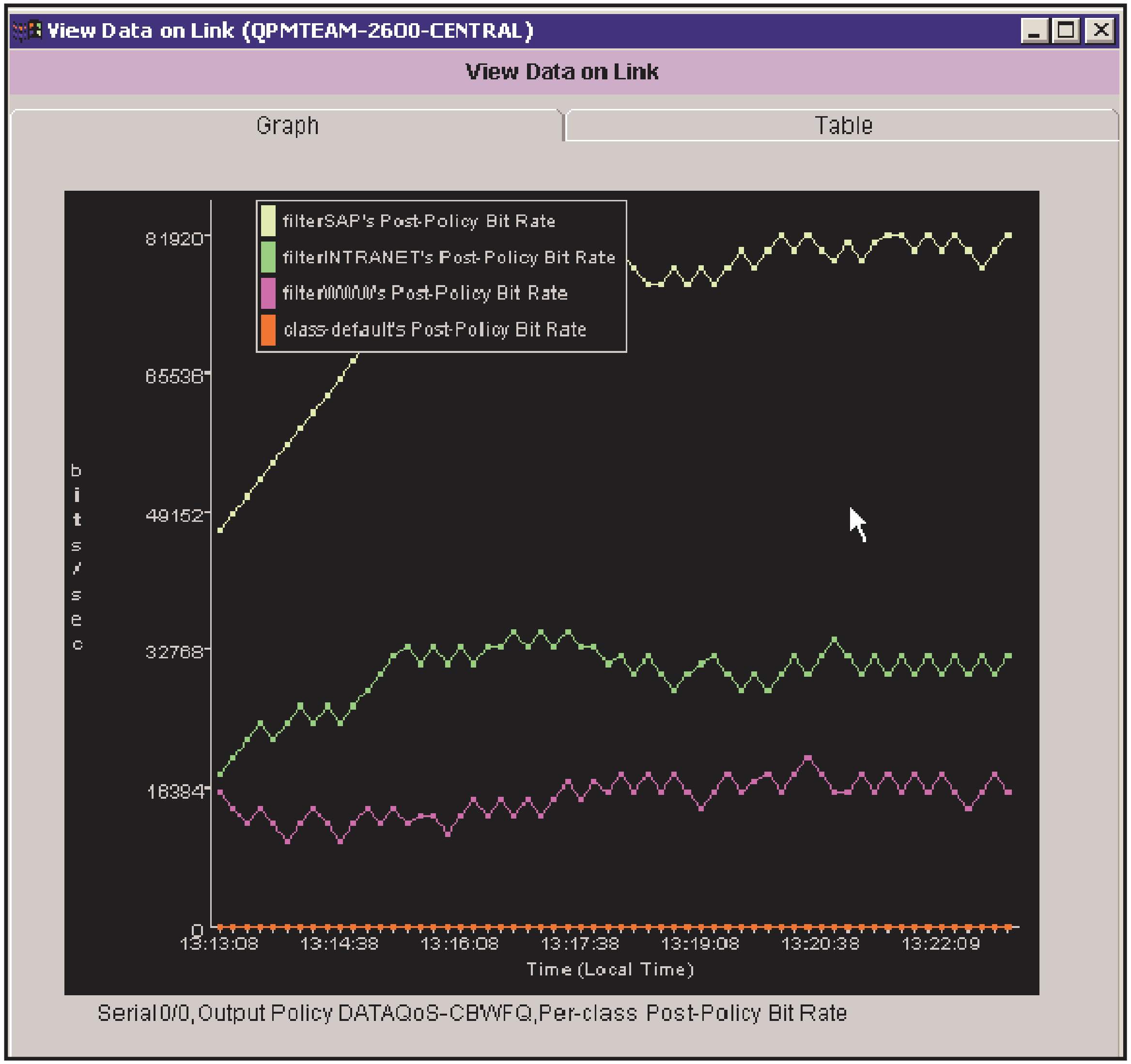
QDM Policy Configuration

Cisco.com

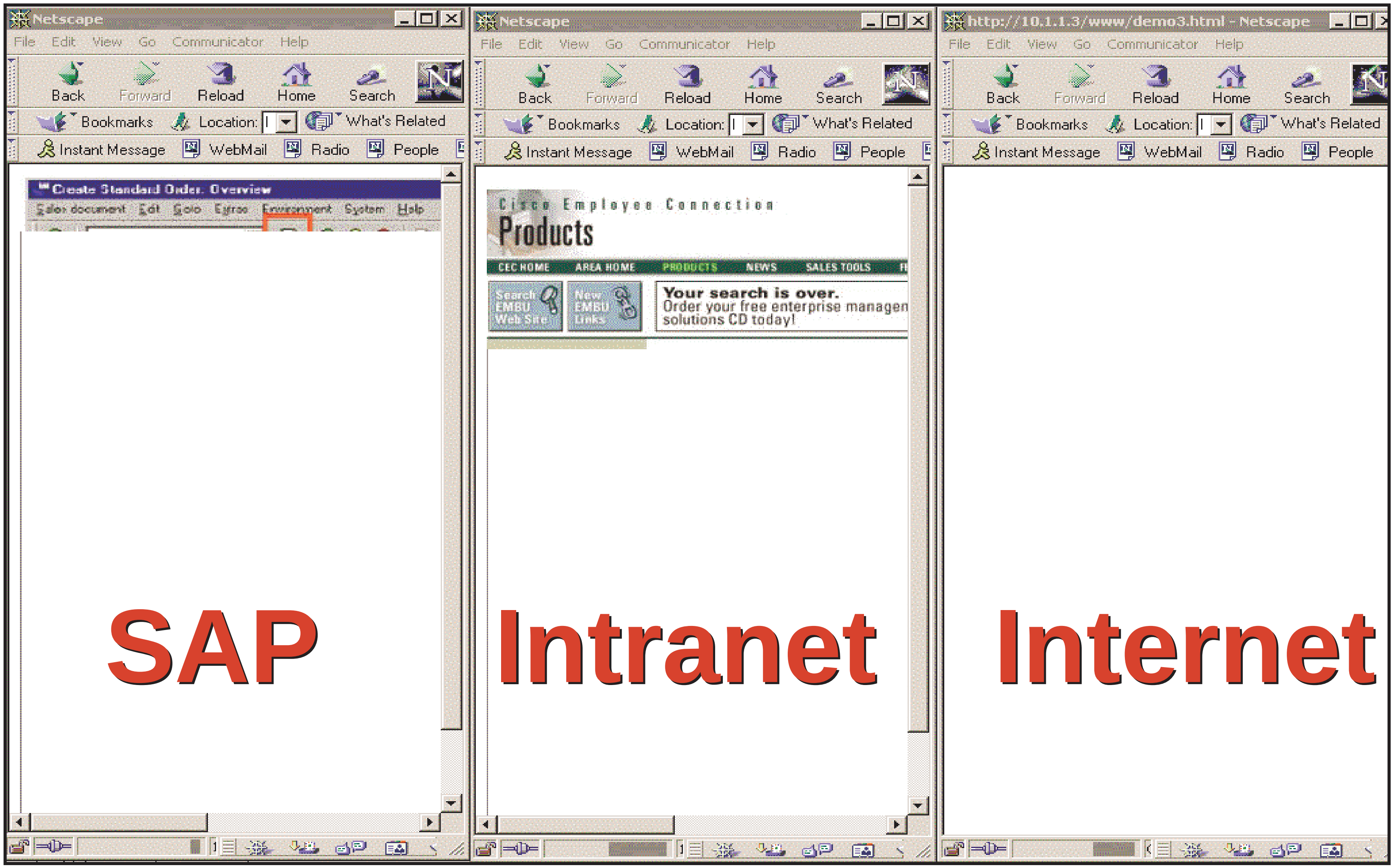


QDM Traffic Monitoring

Cisco.com

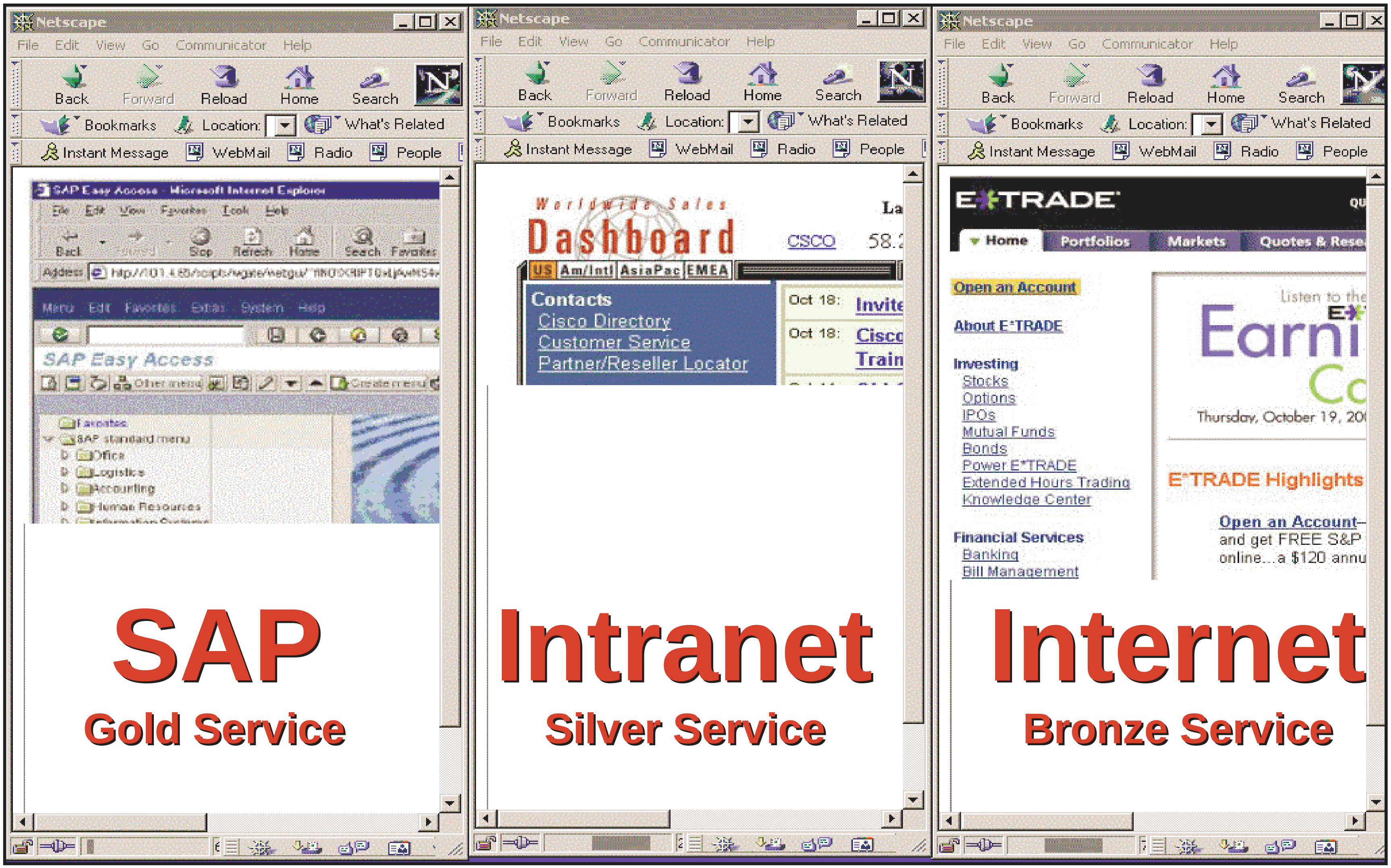


End-User's Point-of-View—Before QoS Policy

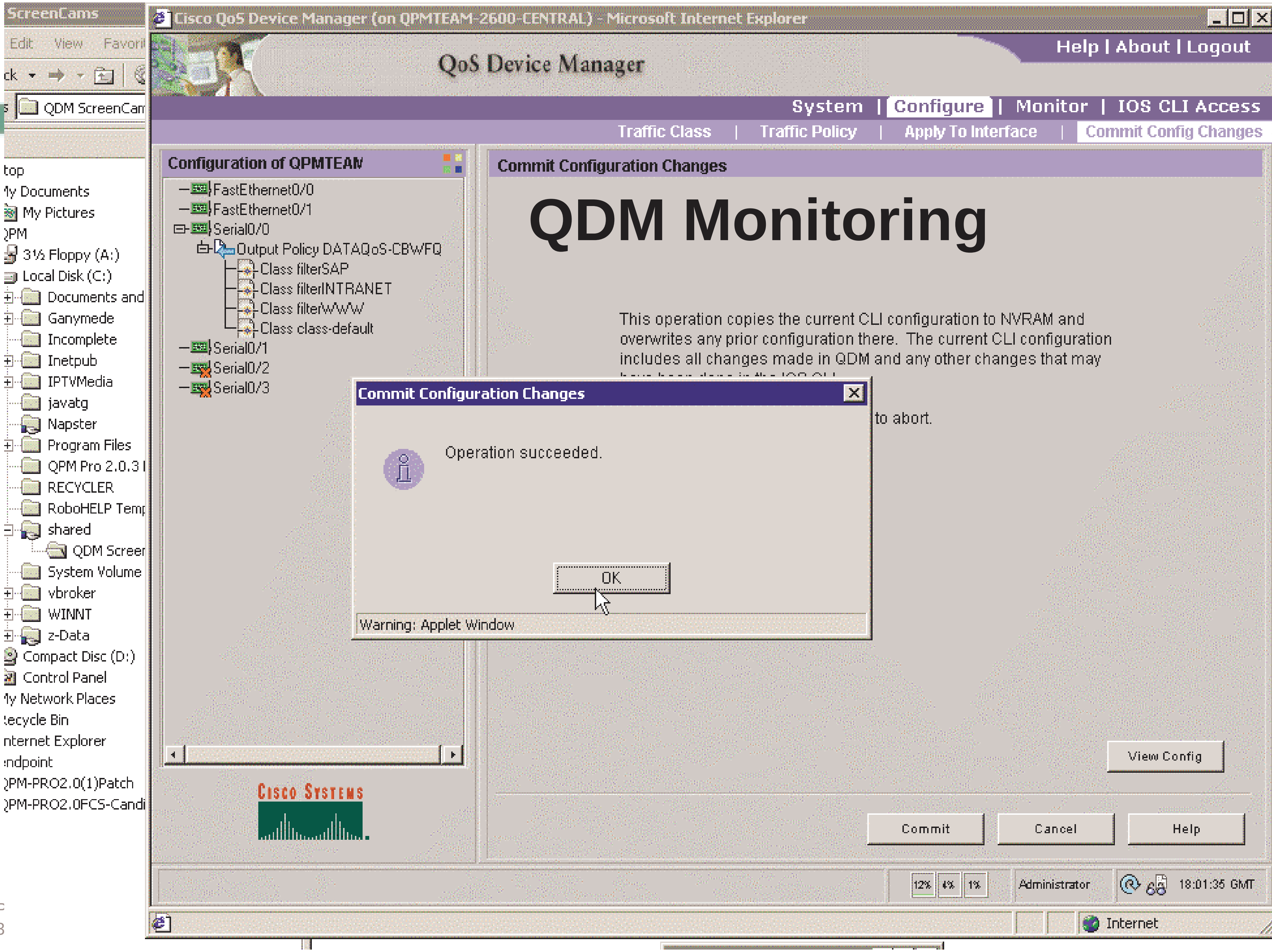


End-User's Point-of-View—After QoS Policy

Cisco.com



QDM Monitoring



F
3

QDM Web Links

- **QDM 2.0 is an IOS add-on (free download):** **http://www.cisco.com/cgi-bin/tablebuild.pl/qdm**
- **CCO (QDM):** **http://www.cisco.com/warp/public/cc/pd/nemnsw/qodvmn/**
- **E-Learning Kit:** **ftp://ftpeng.cisco.com/szigeti/QDM2.0/**

ftp://ftpeng.cisco.com/szigeti/NW2001-PS560/

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Complete QoS Management

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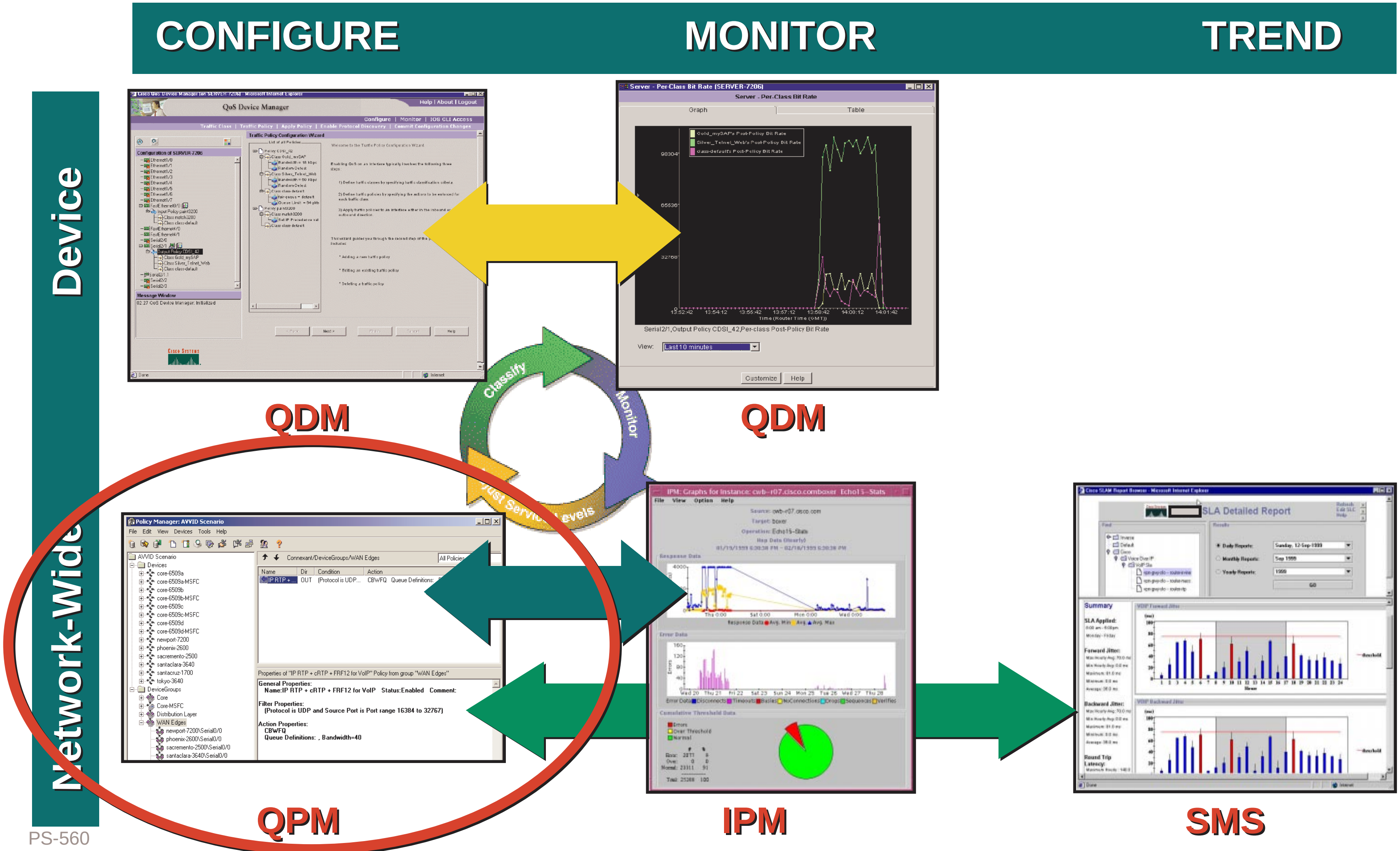
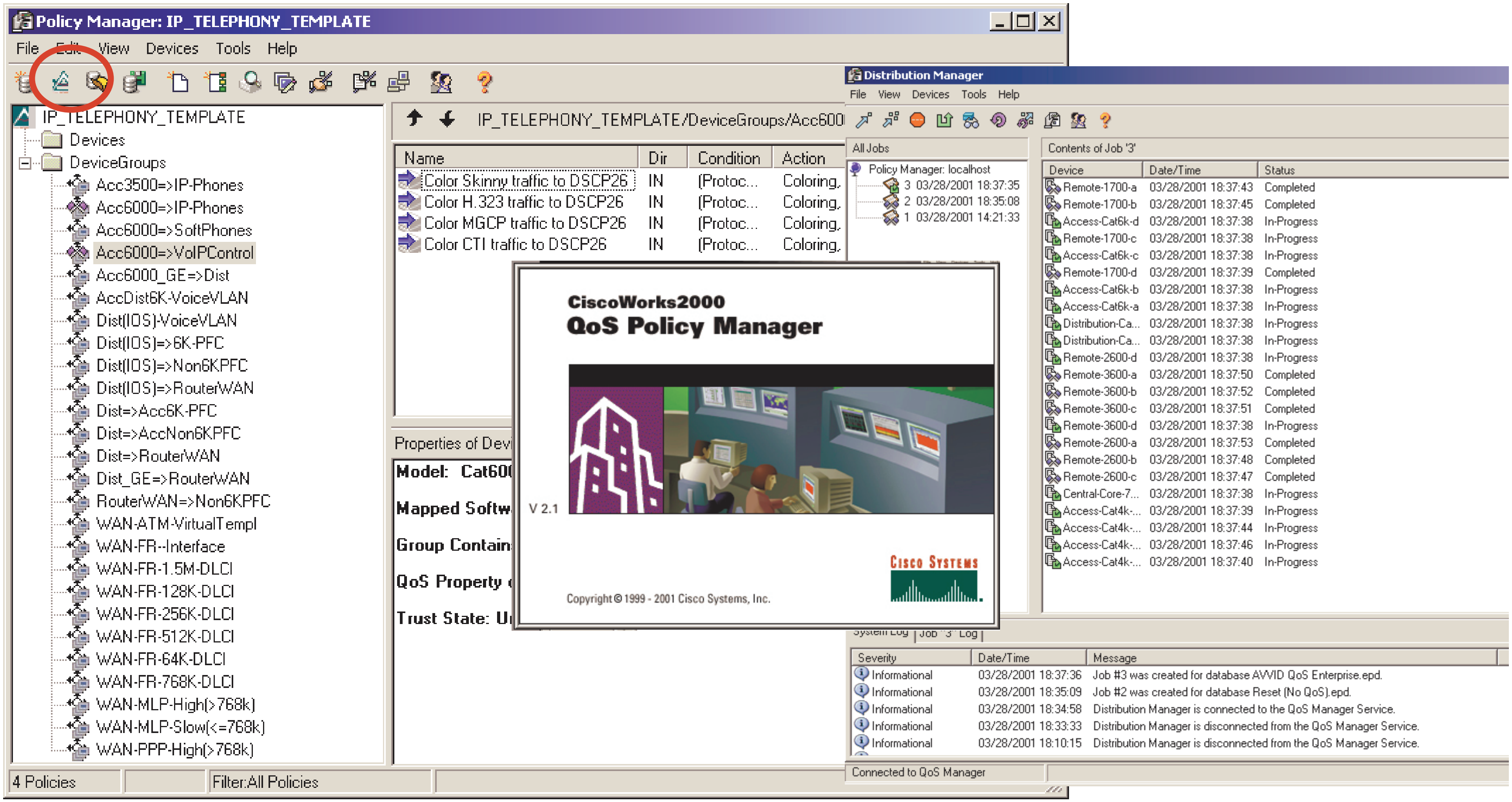
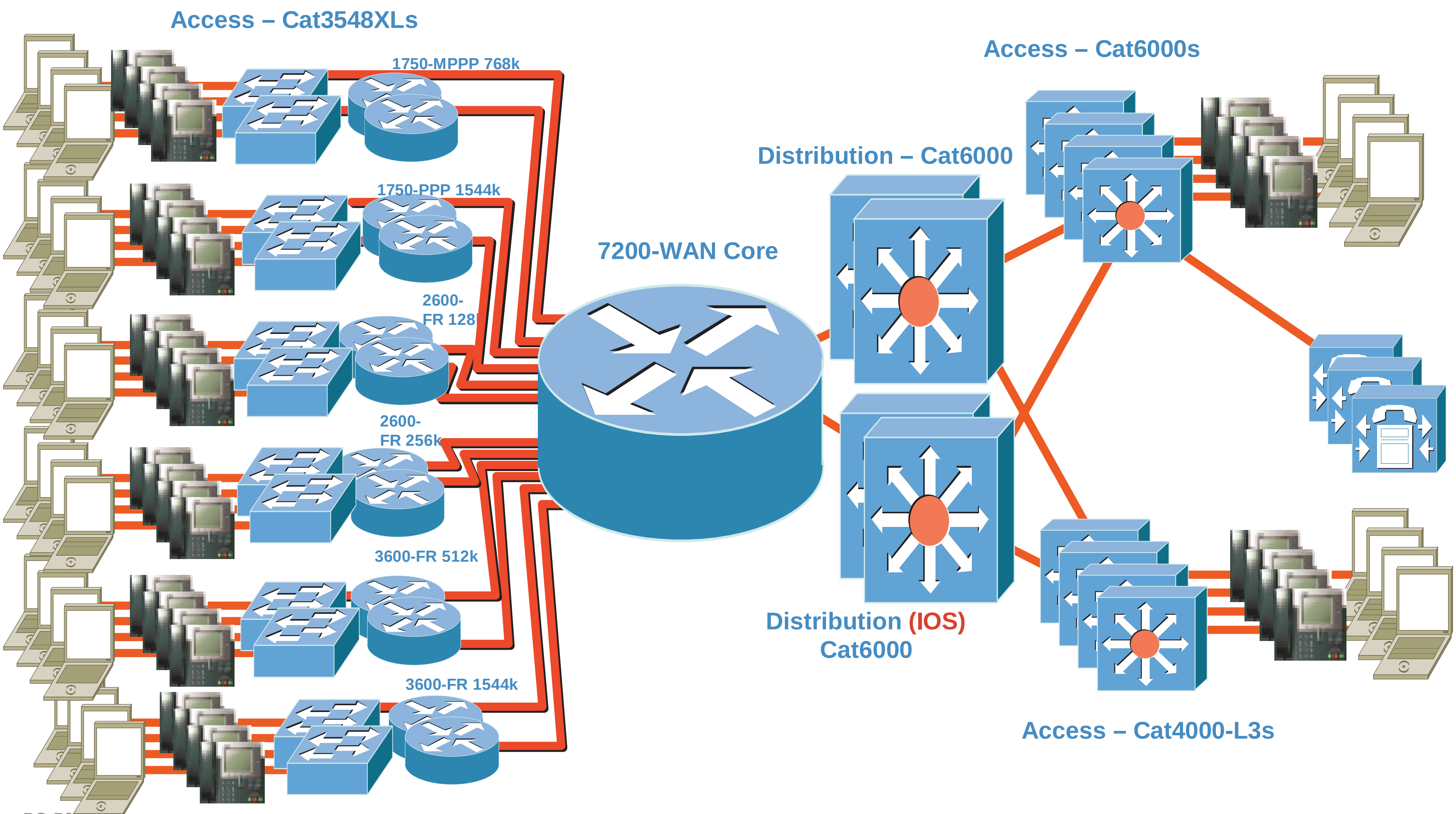


QPM 2.1

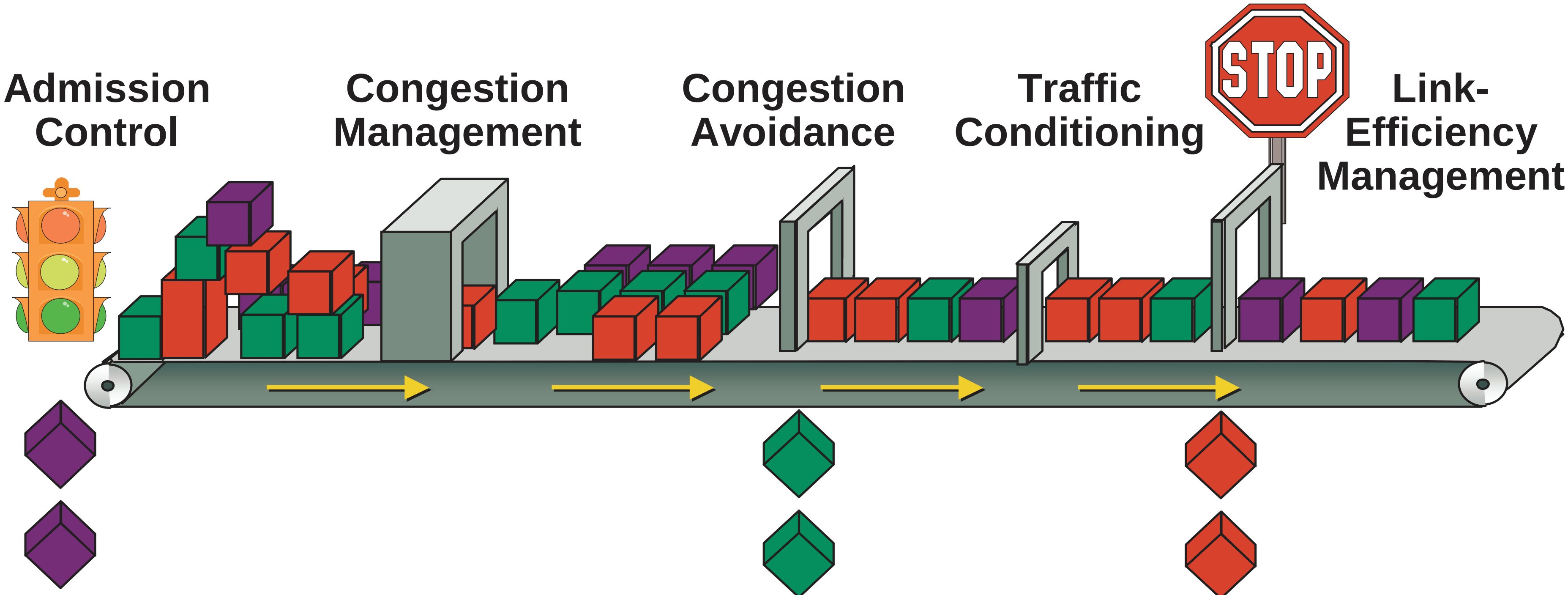


http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/

Enterprise IP Telephony Network (1000 IP Phones)



What QoS Mechanisms Does QPM Support?

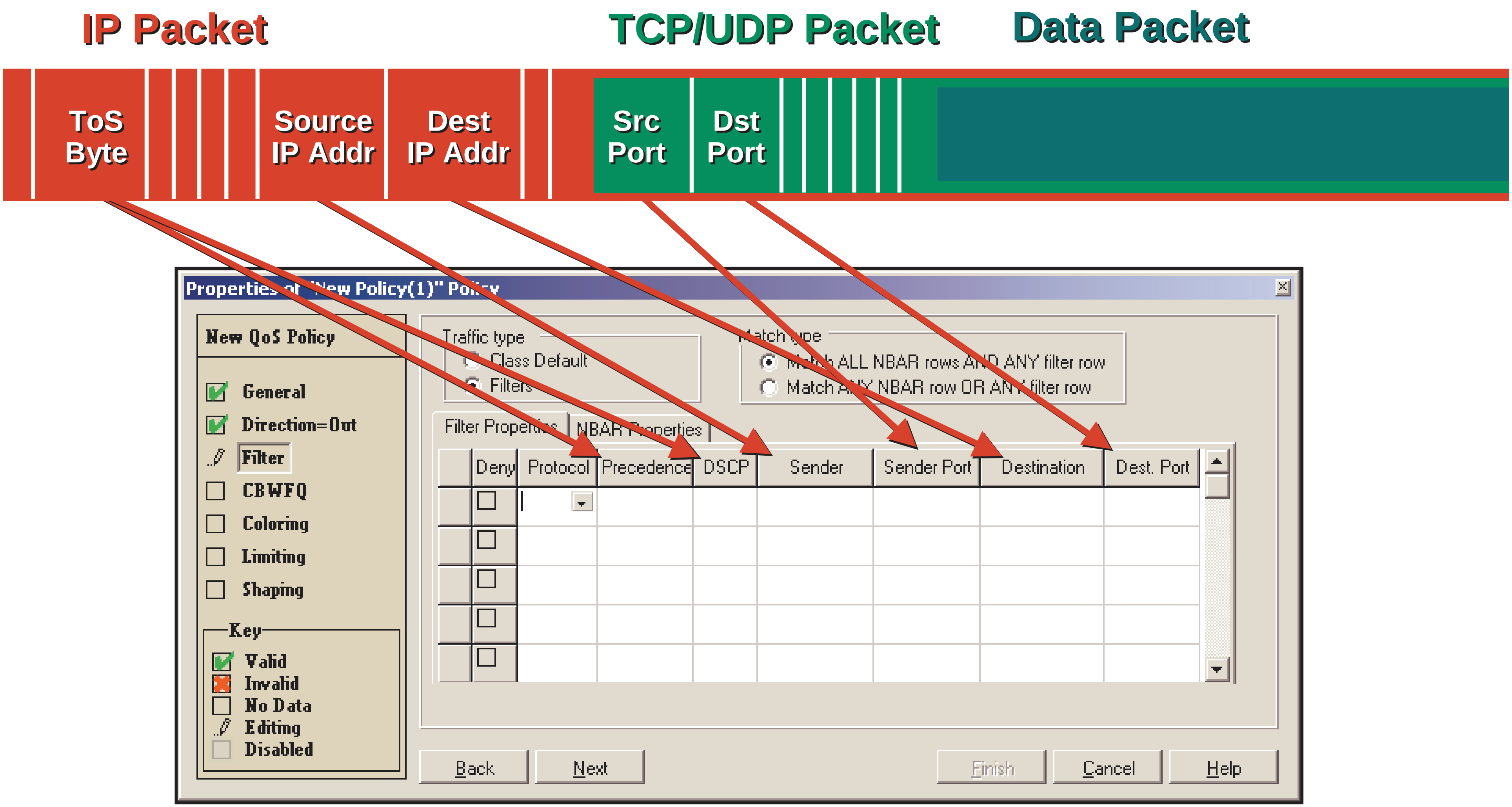


CLASSIFYING	QUEUEING	DROPPING	POLICING	FRAG/COMPR
ACLs	PQ/CQ/WFQ	TAIL	LIMITING	LFI
IPP/DSCP/Trust	IP RTP PRIORITY	WRED	GTS/FRTS	FRF.12
IP RTP	CBWFQ/LLQ		RSVP BW	cRTP
NBAR	2Q2T/1P2Q2T		CAR	
RSVP				

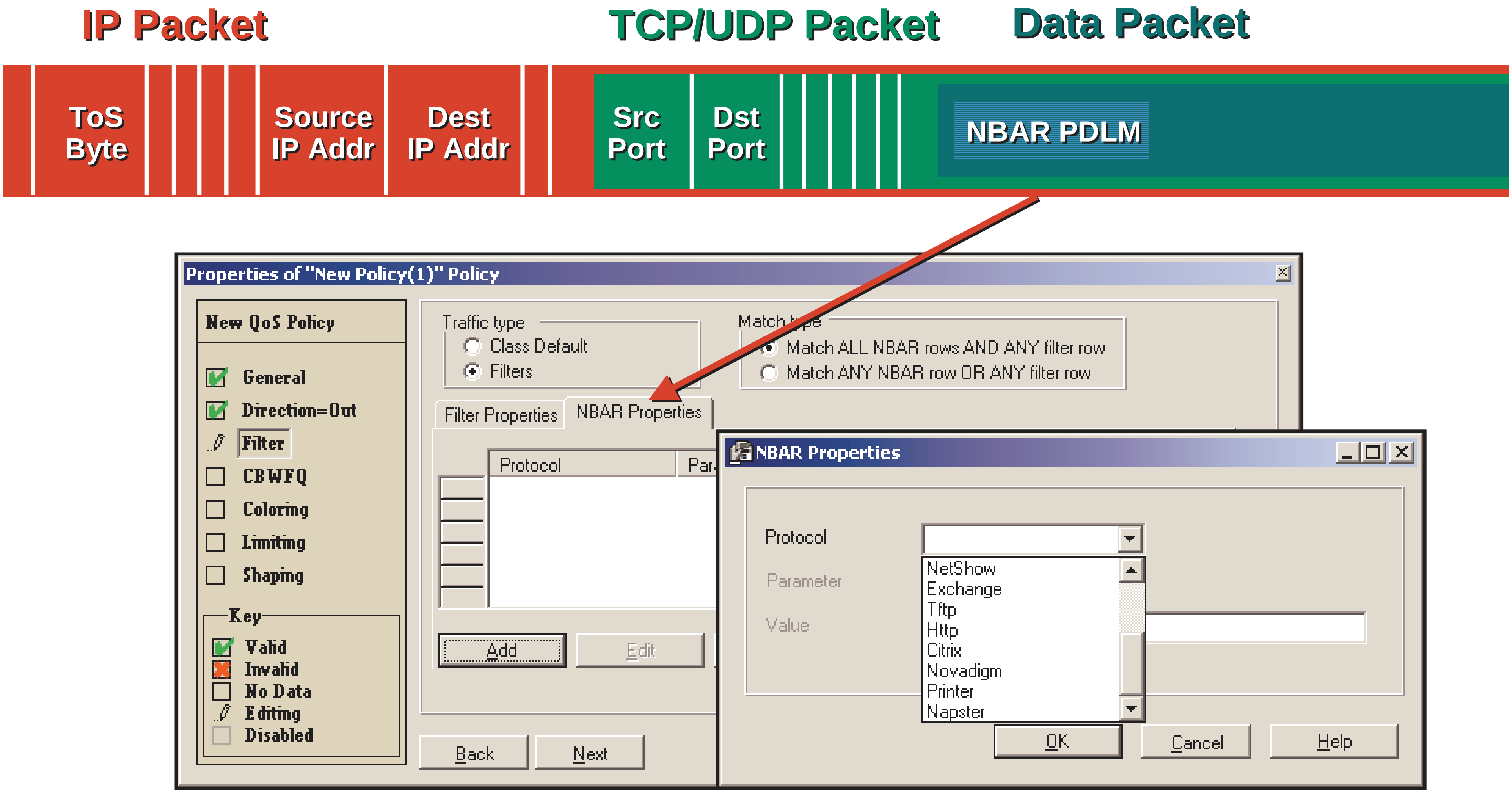
QoS by OSI Layer

LAN		WAN
	Layers 5-7— Application Layer HTTP, FTP, Napster	Classification (NBAR) Classification (RTP)
Classification (TCP/UDP)	Layer 4—Transport Layer TCP, UDP	Classification (TCP/UDP)
Classification (IP/IPP/DSCP)	Layer 3—Network Layer IP	Classification (IP/IPP/DSCP) PQ/CQ/WFQ/CBWFQ/LLQ+WRED Policing/Limiting/Shaping
Trust/Trust-Ext 2Q2T/1P2Q2T Policing/Limiting/Shaping	Layer 2—Data-Link Layer Ethernet, PPP, Frame-Relay	LFI FR Shaping + FRF.12 cRTP
	Layer 1—Physical	

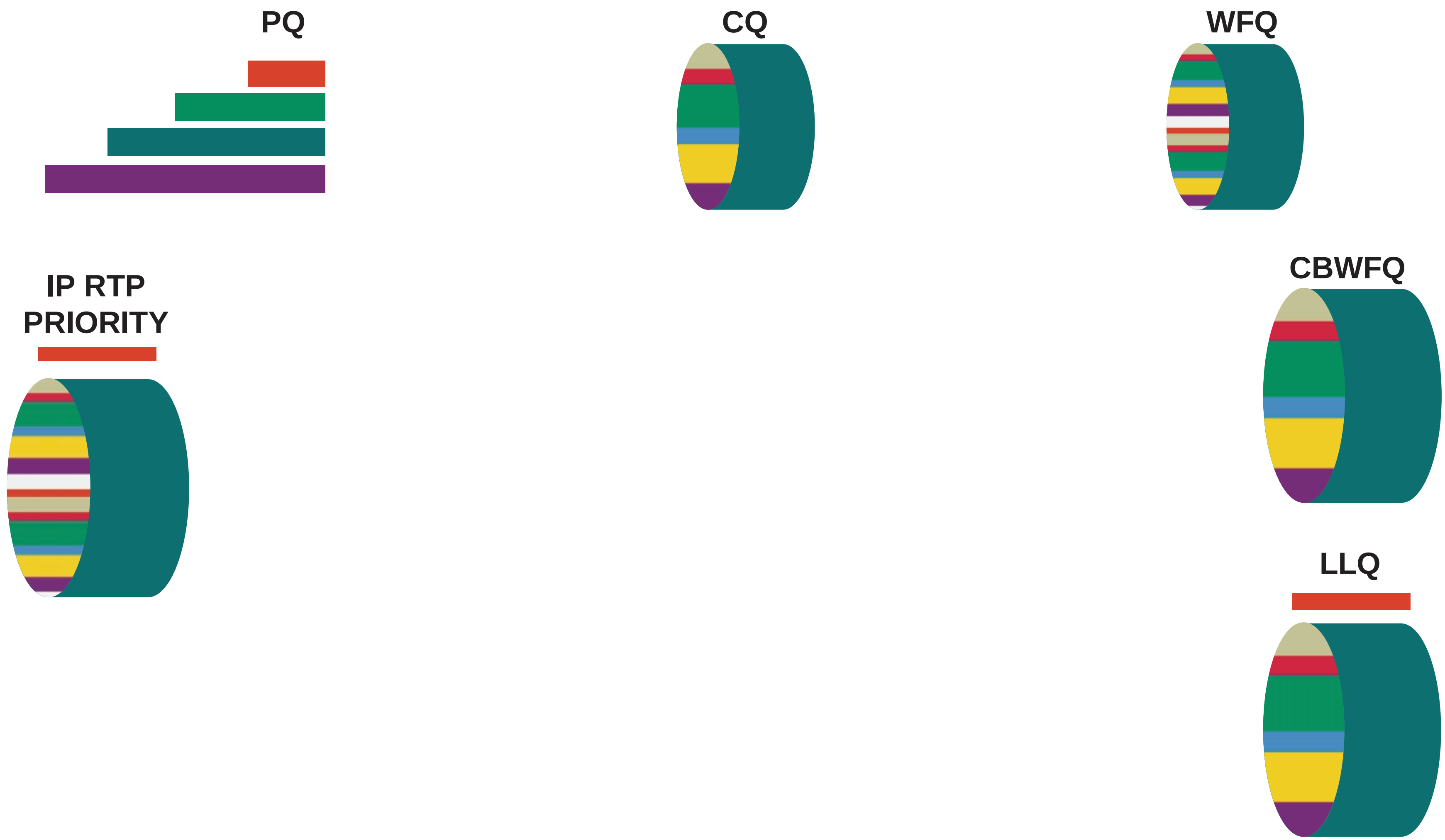
QoS Classification



QoS Classification—NBAR



Congestion Management (Queuing)



Configuring Queuing with QPM 2.0

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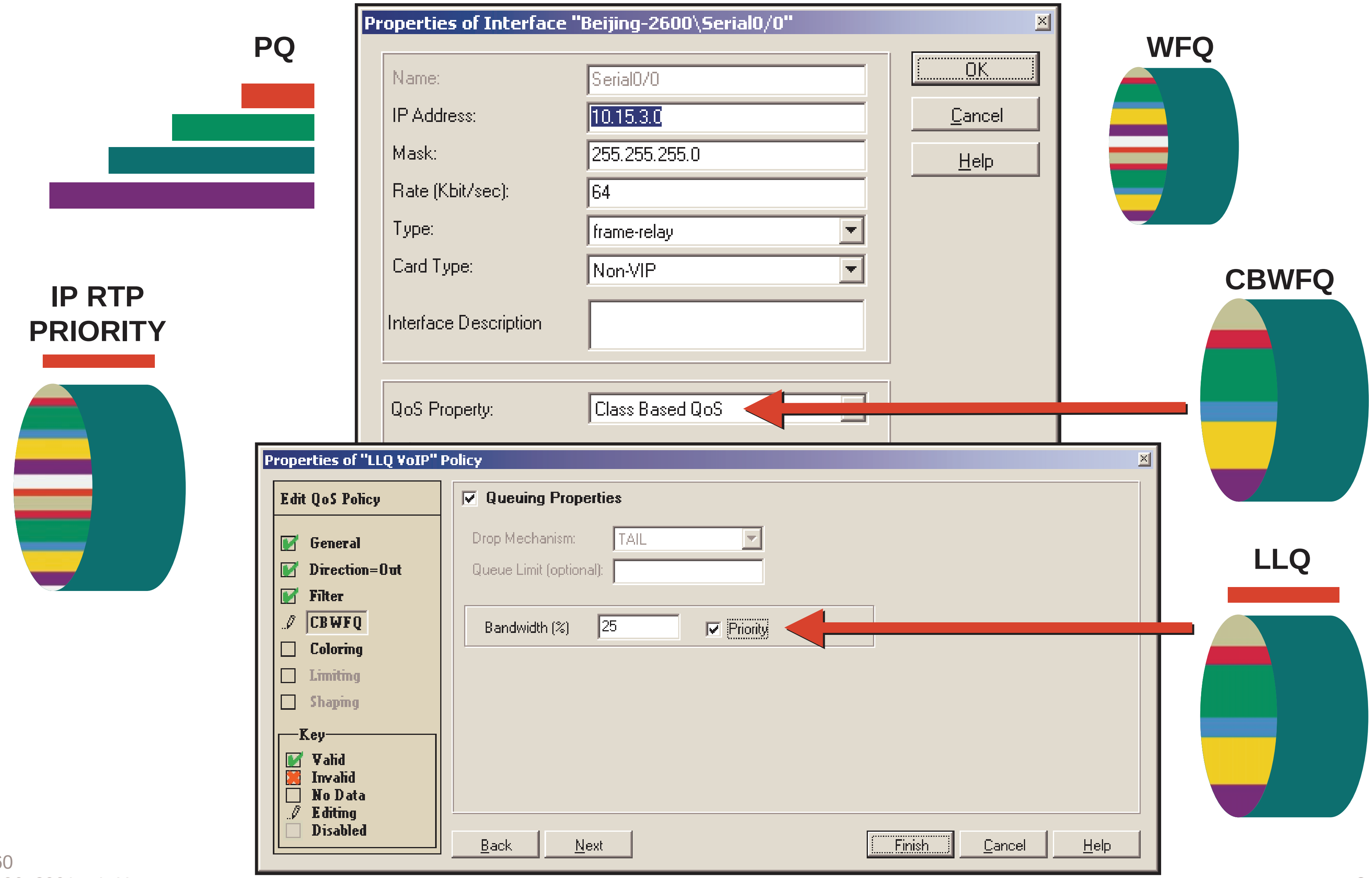
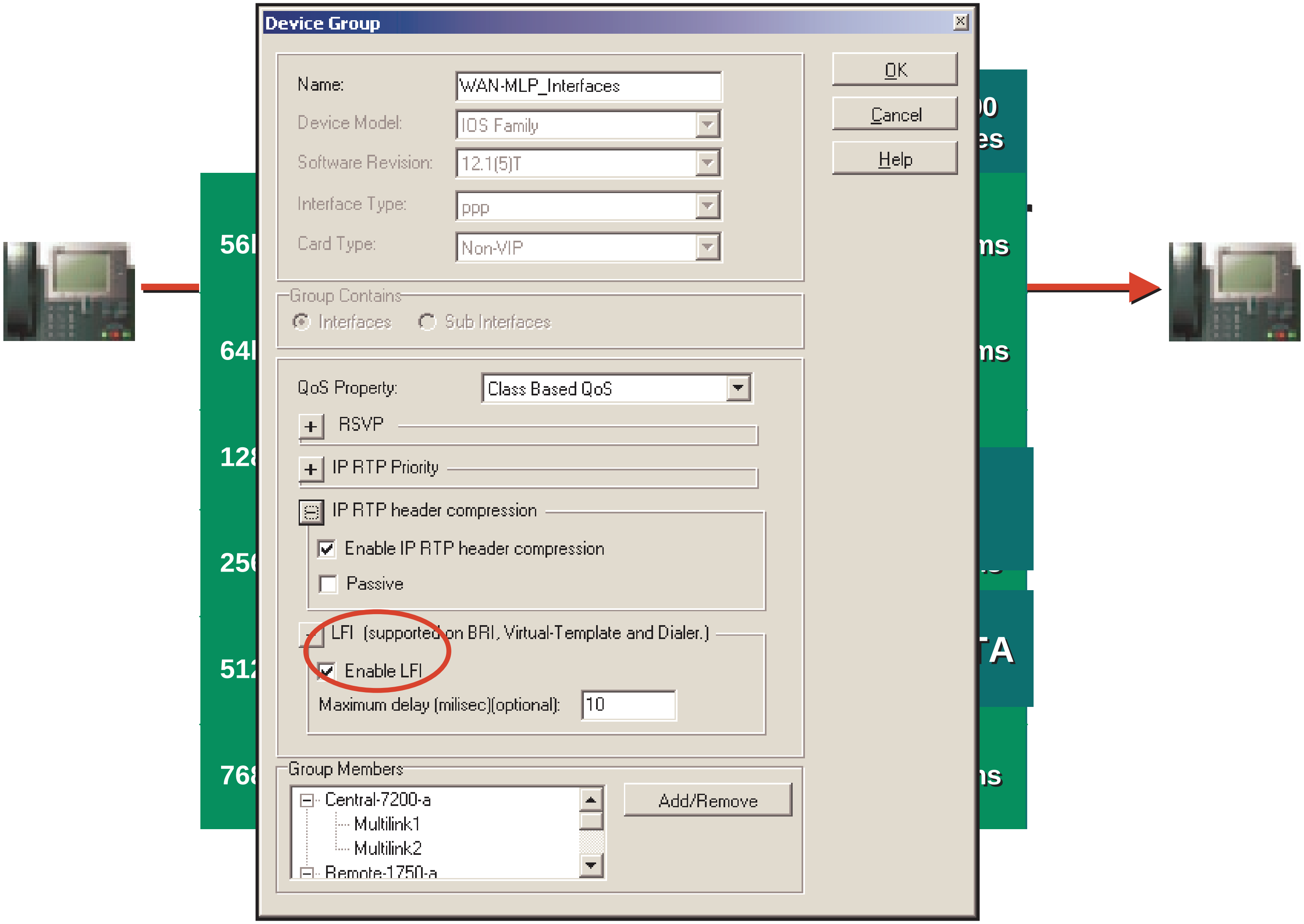


Link Efficiency Mechanisms: Fragmentation Mechanisms



Link Efficiency Mechanisms:
IP RTP Header Compression

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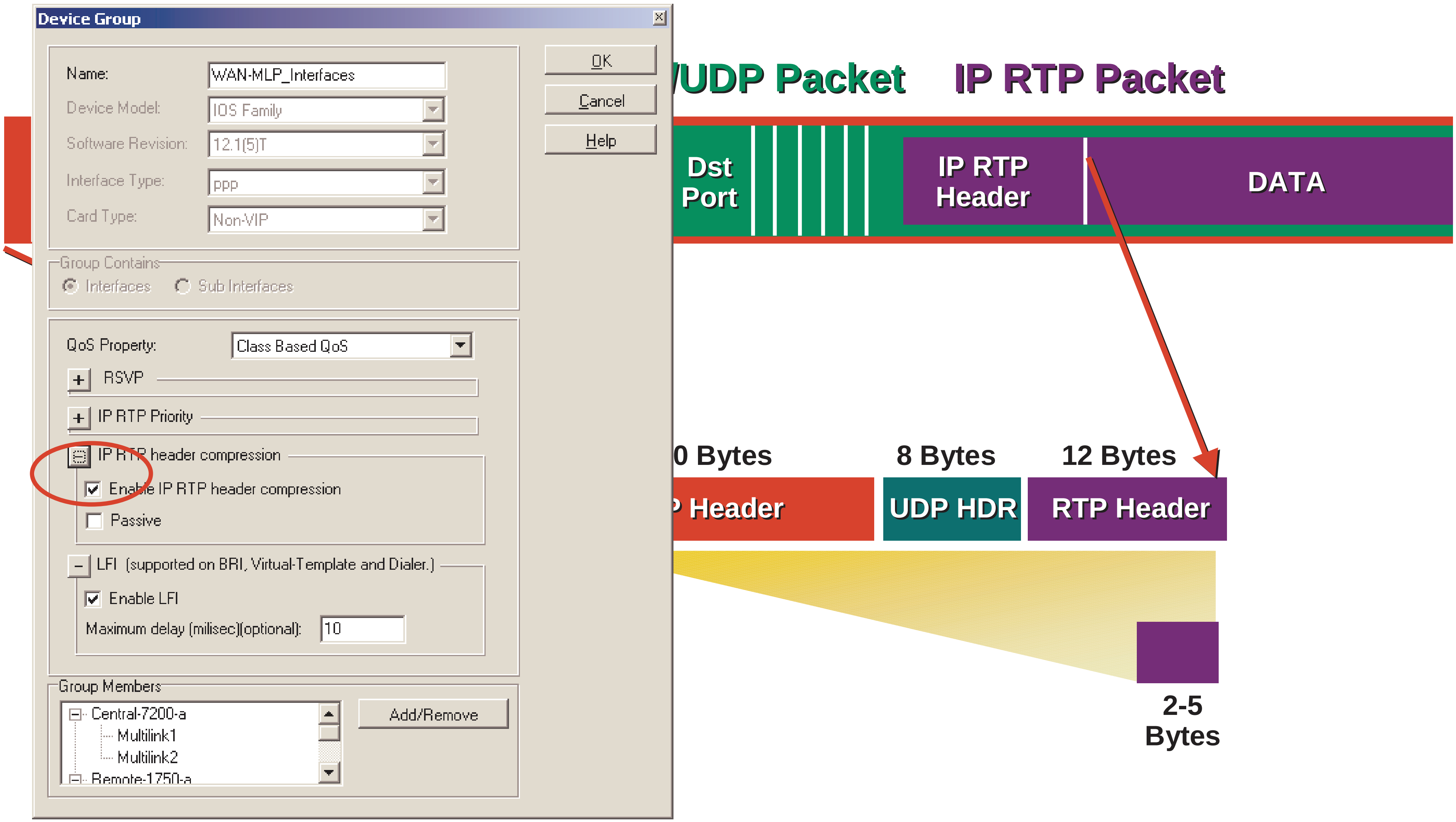
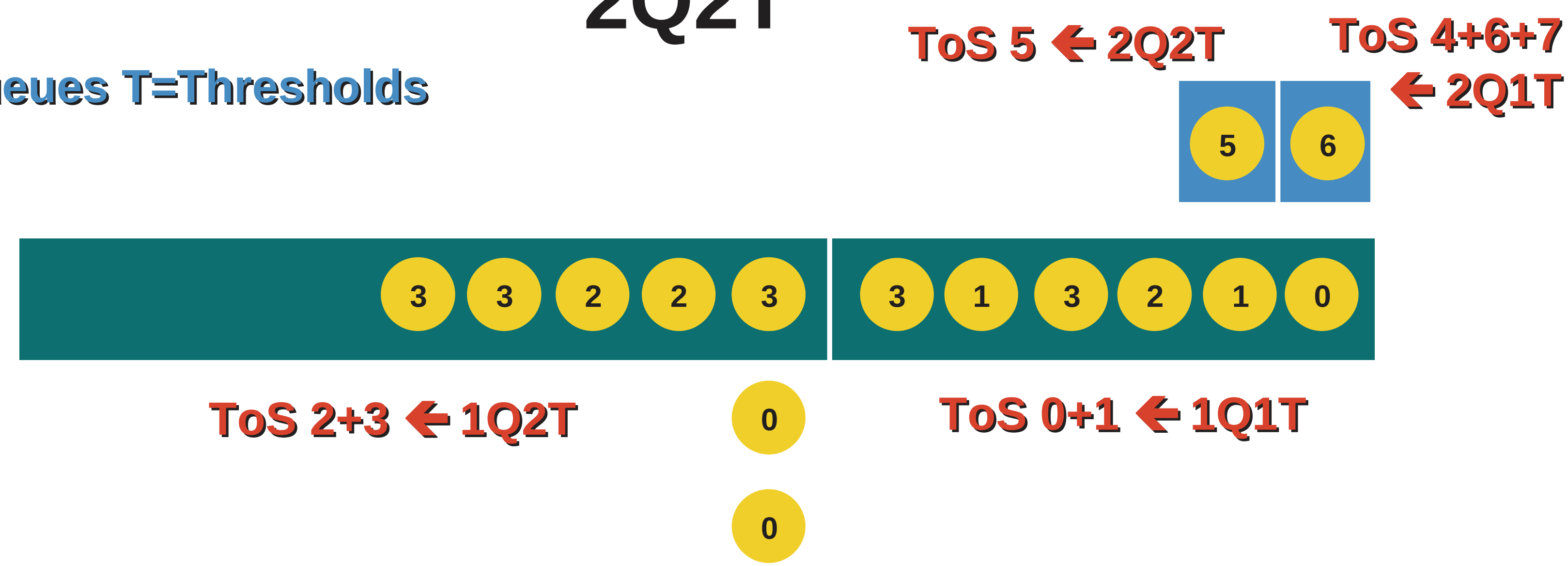


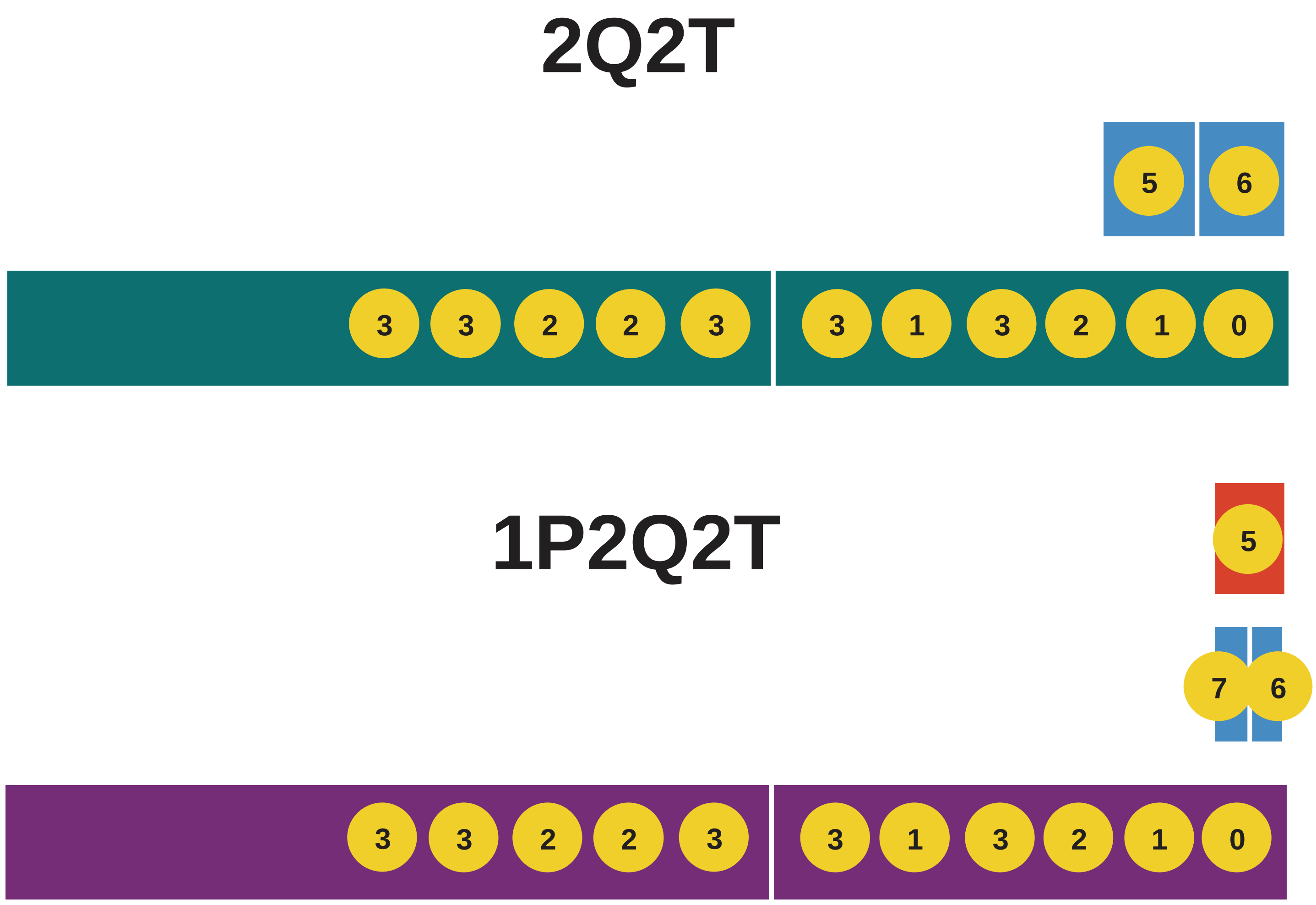
Catalyst Queueing

2Q2T

Q=Queues T=Thresholds



Catalyst Queueing



Catalyst Queueing

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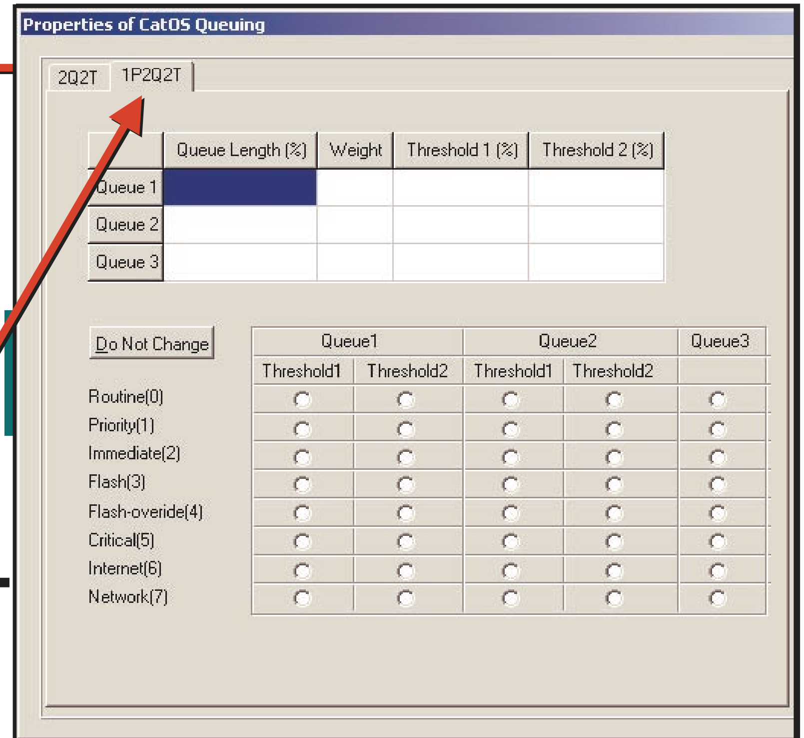
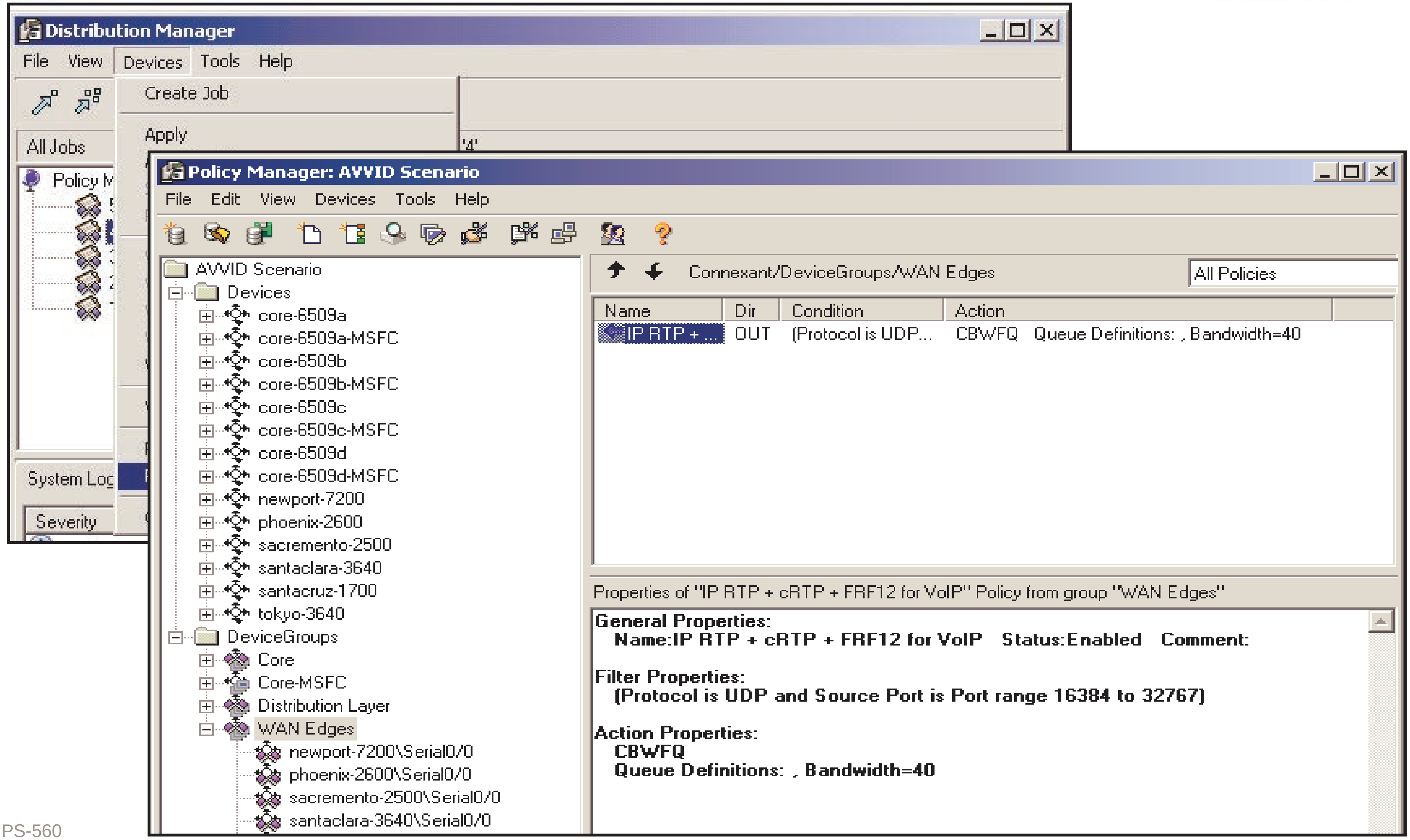
2Q2T



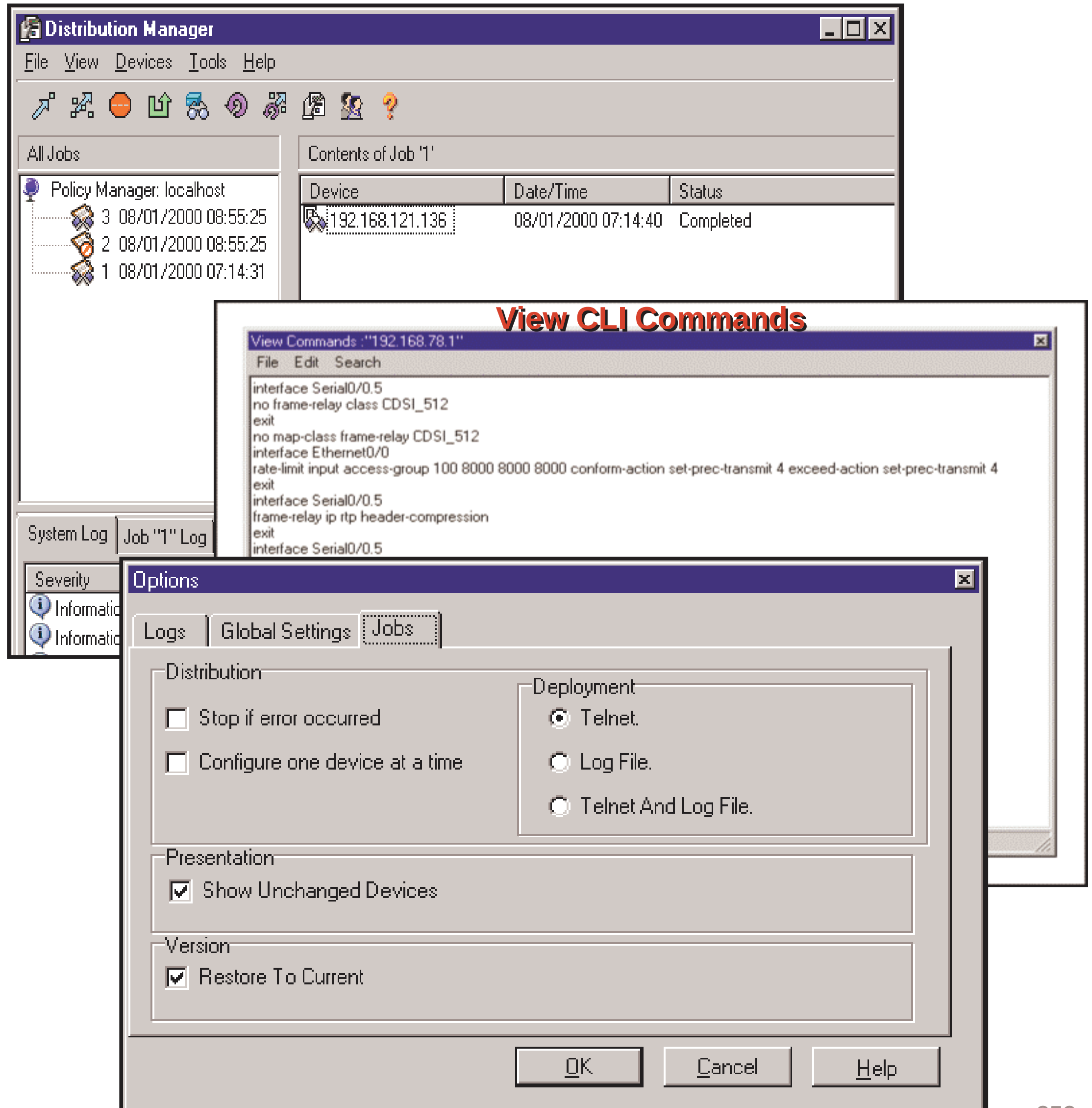
1P2Q2T

Centralized Multi-Device Management



Deployment Control

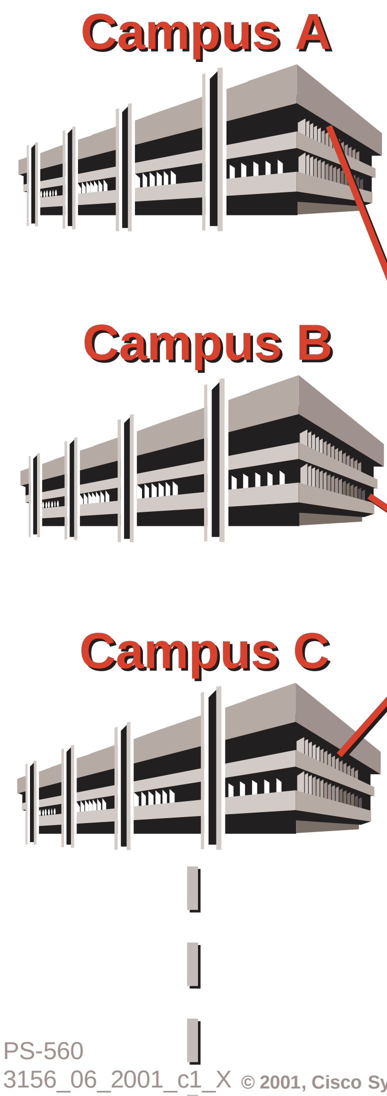
- Detect device information
- Upload existing QoS configs
- Preview CLI
- Log configuration and policy changes
- Event driven policy changes
- Fast rollback to correct unintended results
- Detect and correct unapproved changes

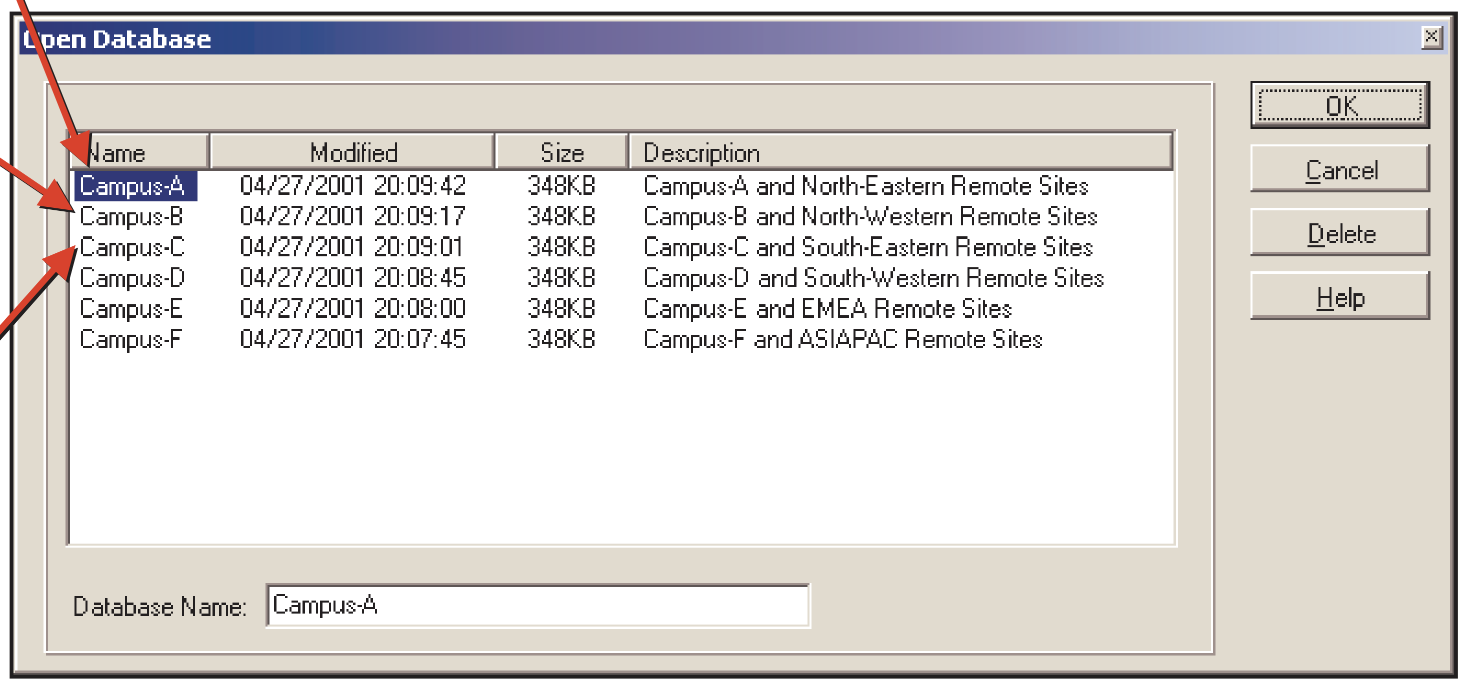


Large Scale QPM Deployments

Cisco.com

- Suitable for large deployments such as VoIP
- No design limitations
- Hundreds or thousands of devices can be managed
- Built-in telnet deployment or config file output can be utilized
- Recommend partitioning coverage into sub groups
- Detailed deployment scenarios to be delivered





QPM Web Links

- **CCO (QPM):**
  http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/
- **Patches (CCO):**
  http://www.cisco.com/cgi-bin/tablebuild.pl/qos-patches
- **QPM-VLab/Demo Download:**

  ftp://ftpeng.cisco.com/szigeti/QPM2.1/

ftp://ftpeng.cisco.com/szigeti/NW2001-PS560/

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Complete QoS Management

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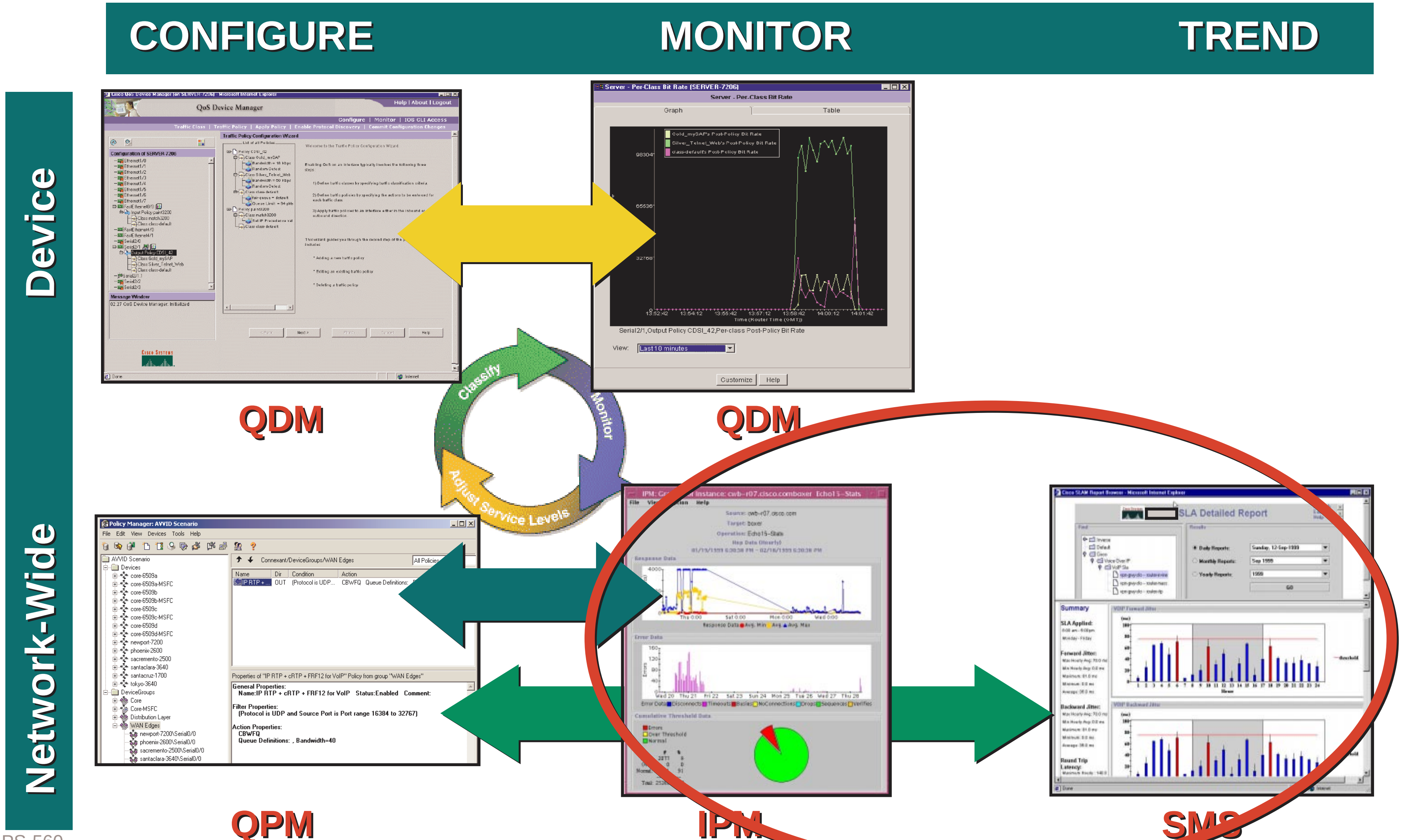
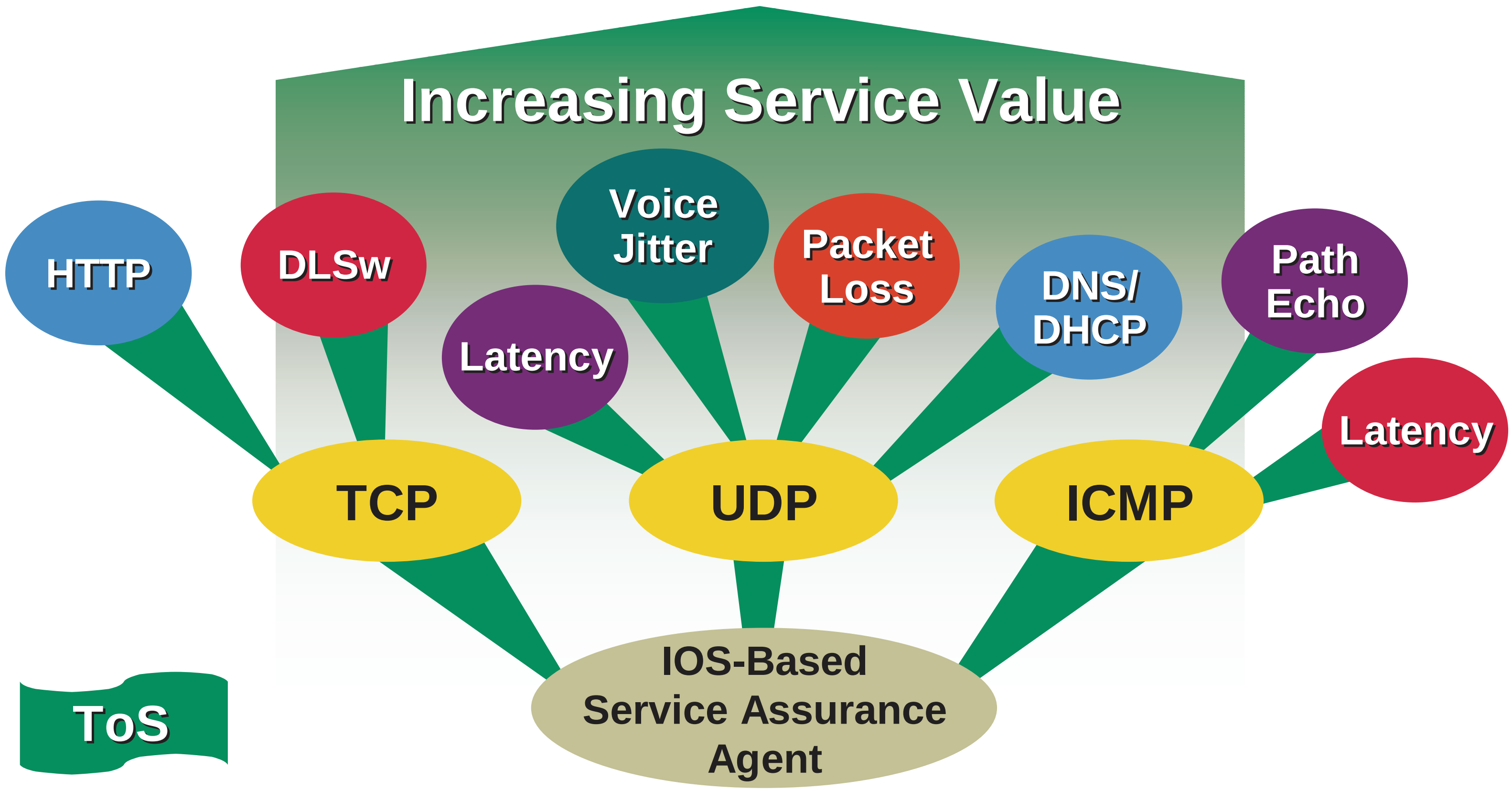
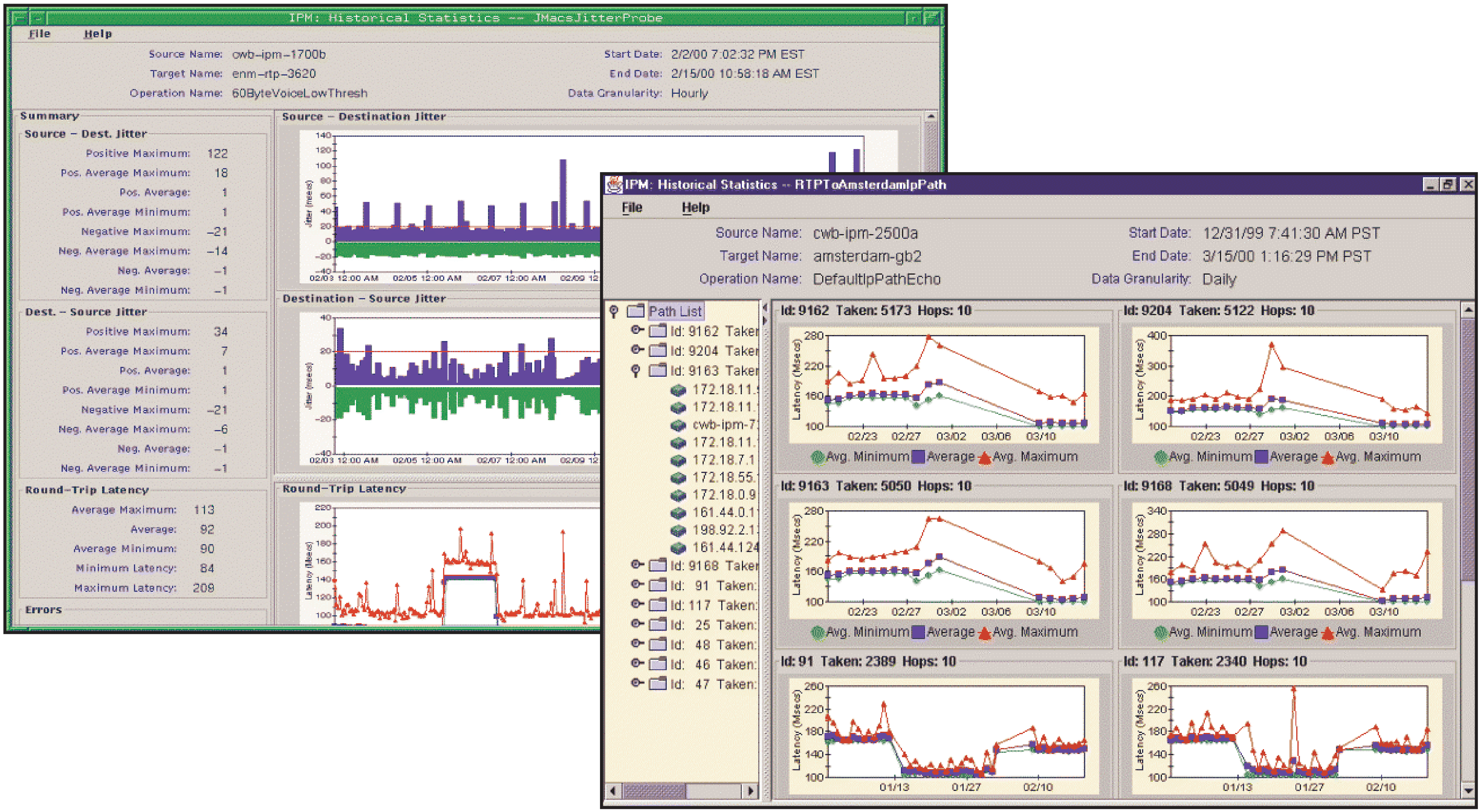


Service Assurance Agent—SA Agent



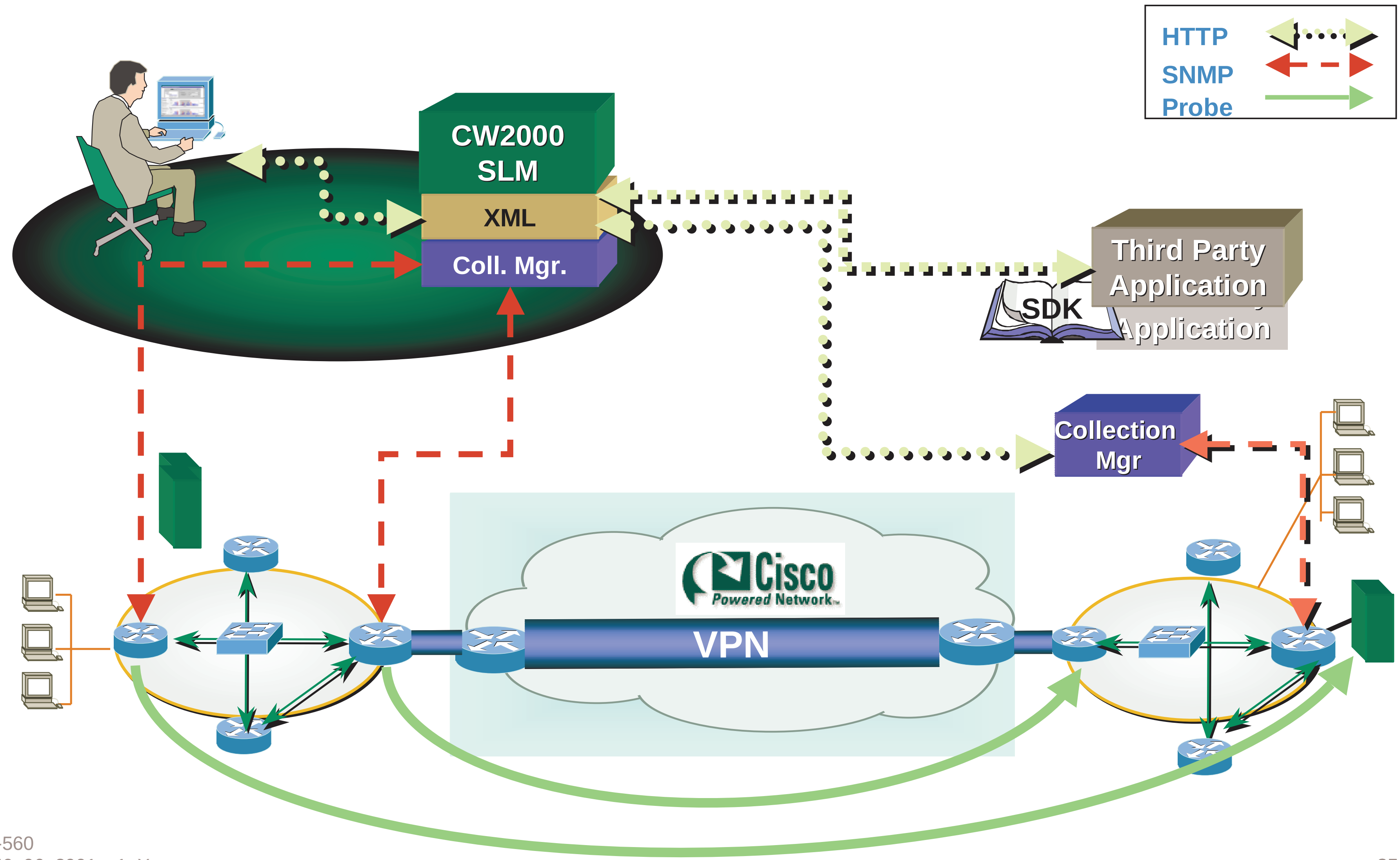
http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/fun_c/fcprt3/fcd301d.pdf

Internet Performance Monitor—IPM

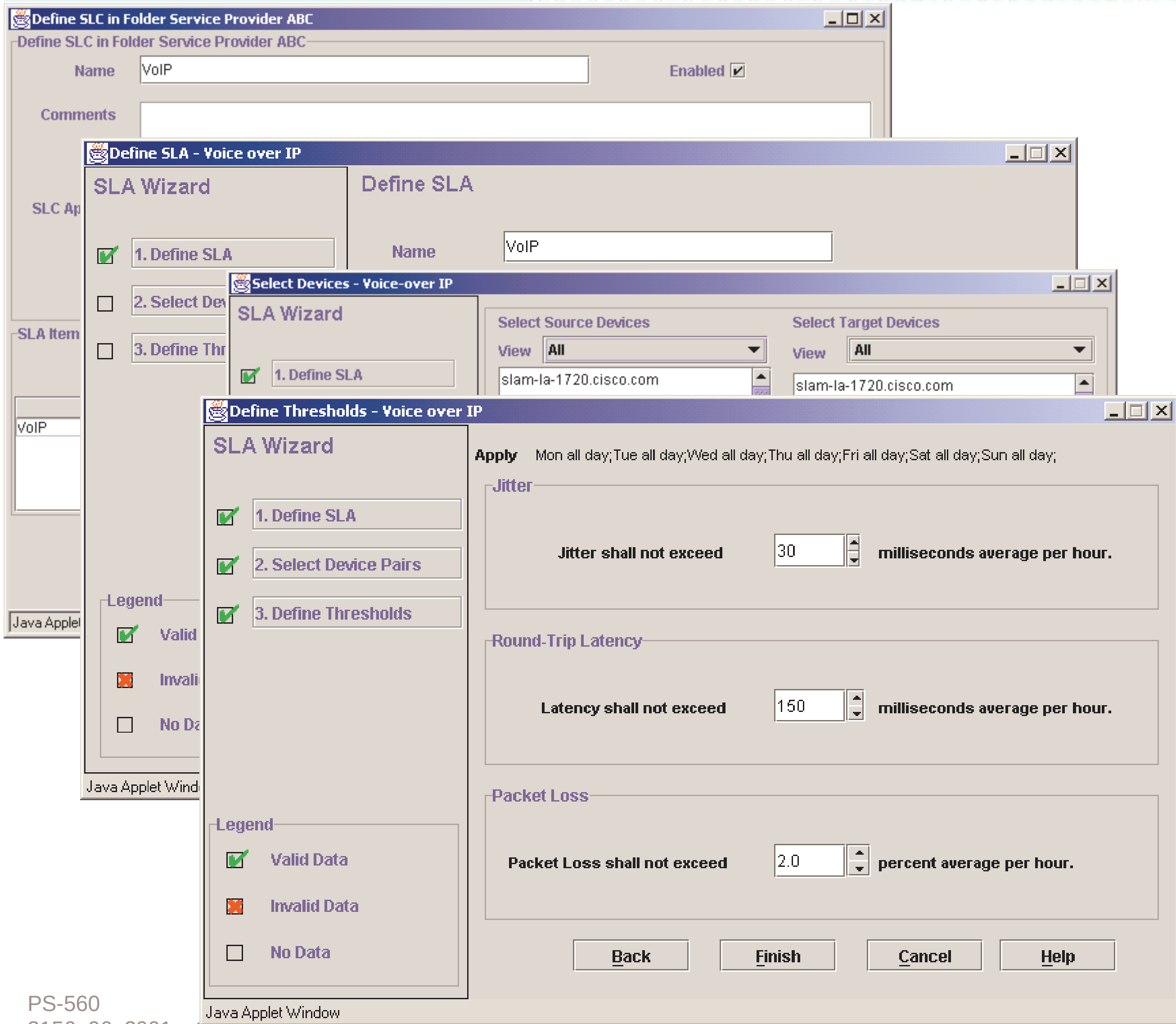


http://www.cisco.com/univercd/cc/td/doc/product/rtrmgmt/ipmcw2k/ipm20/index.htm

Service Management Solution (SMS)

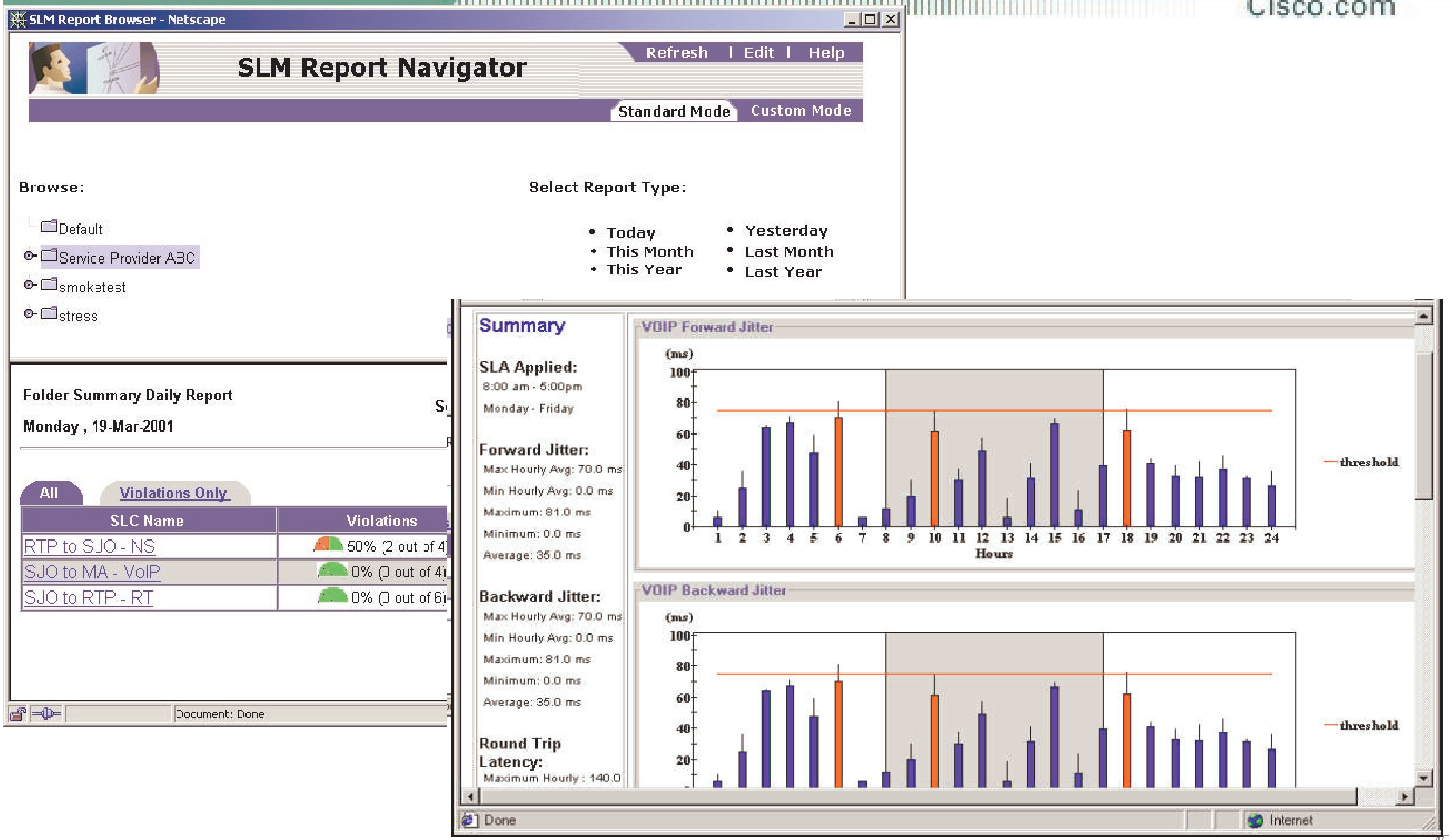


Create SLAs



- **Wizard-driven creation**
- **User sees terms of SLA -- not MIB**
- **Multiple jobs created in single step**
- **System provisions / manages jobs**

SLA Reports


SLM Report Browser - Netscape
SLM Report Navigator
Refresh | Edit | Help
Standard Mode
Custom Mode
Browse:
Default
Service Provider ABC
smoketest
stress
Select Report Type:
Today
This Month
This Year
Yesterday
Last Month
Last Year
Folder Summary Daily Report
Monday , 19-Mar-2001
All
Violations Only
SLC Name
Violations
RTP to SJO - NS
50% (2 out of 4
SJO to MA - VoIP
0% (0 out of 4)
SJO to RTP - RT
0% (0 out of 6)
Document: Done
Summary
SLA Applied:
8:00 am - 5:00pm
Monday - Friday
Forward Jitter:
Max Hourly Avg: 70.0 ms
Min Hourly Avg: 0.0 ms
Maximum: 81.0 ms
Minimum: 0.0 ms
Average: 35.0 ms
Backward Jitter:
Max Hourly Avg: 70.0 ms
Min Hourly Avg: 0.0 ms
Maximum: 81.0 ms
Minimum: 0.0 ms
Average: 35.0 ms
Round Trip Latency:
Maximum Hourly : 140.0
VOIP Forward Jitter
(ms)
threshold
Hours
VOIP Backward Jitter
(ms)
threshold
Done
Internet

Outline

Cisco.com

- QoS Management—Need + Overview
- QoS Device Manager (QDM) Overview
- QoS Policy Manager (QPM) Overview
- Monitoring and Trending Overview
- White Papers + Case Studies
- Methodology + Best Practices

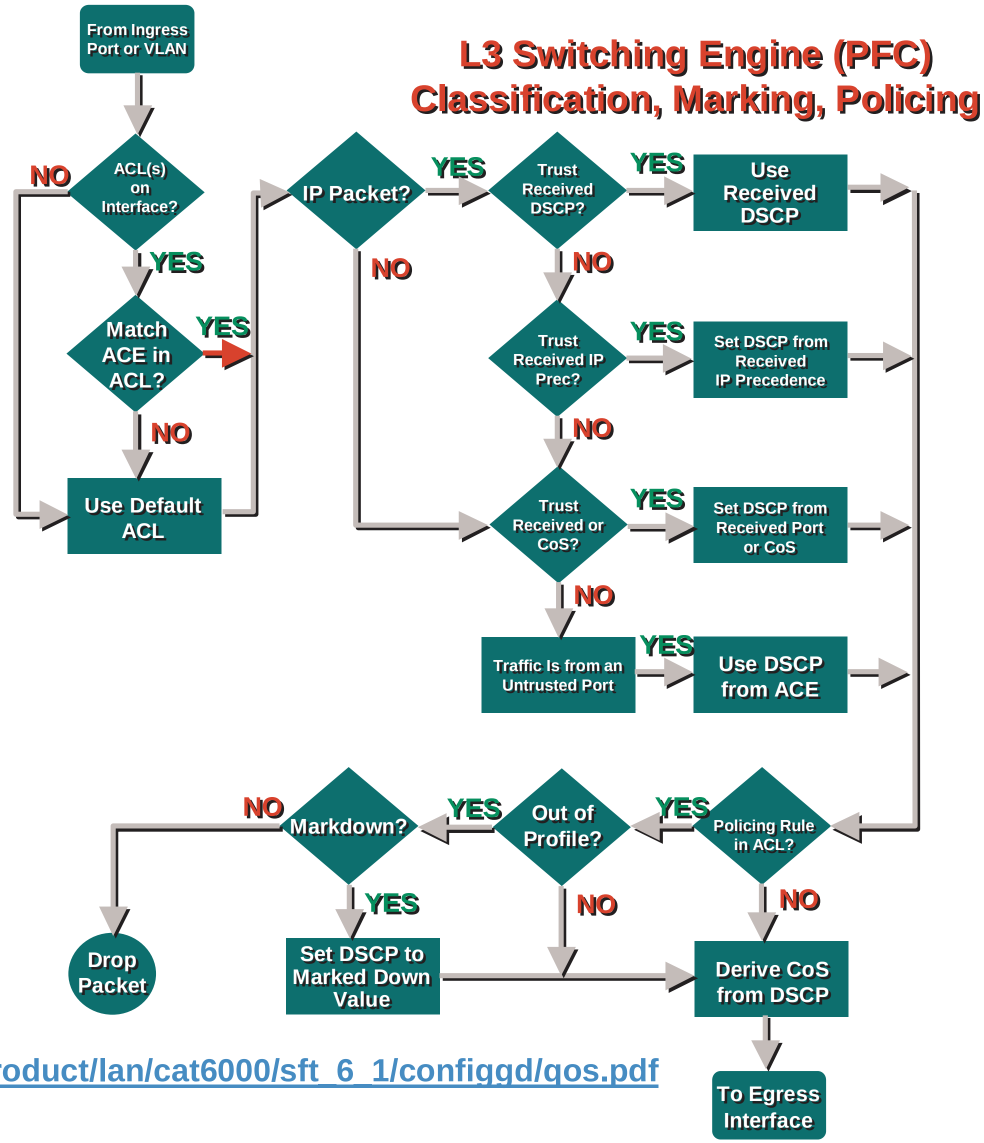
IOS (12.1) QoS Functionality and CLI

Cisco.com

- **Overview**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcdintro.pdf
- **Classification**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt1/qcdclass.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt1/qcdpbr.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt1/qcdprop.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt1/qcdcar.pdf
- **Congestion Management**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt2/qcdconmg.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt2/qcdconmg.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt2/qcdcq.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt2/qcdpq.pdf
- **Congestion Avoidance**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt3/qcdconav.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt3/qcdwred.pdf
- **Traffic Conditioning**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt4/qcdpolsh.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt4/qcdgts.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt4/qcdfrts.pdf
- **Link-Efficiency Mechanisms**
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt6/qcdlem.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt6/qcdlfi.pdf
  - http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt6/qcdcrtp.pdf

Catalyst 6000 QoS

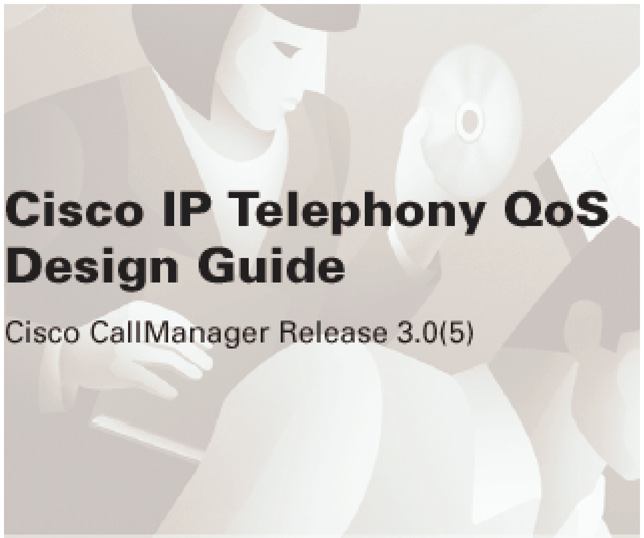
Cisco.com



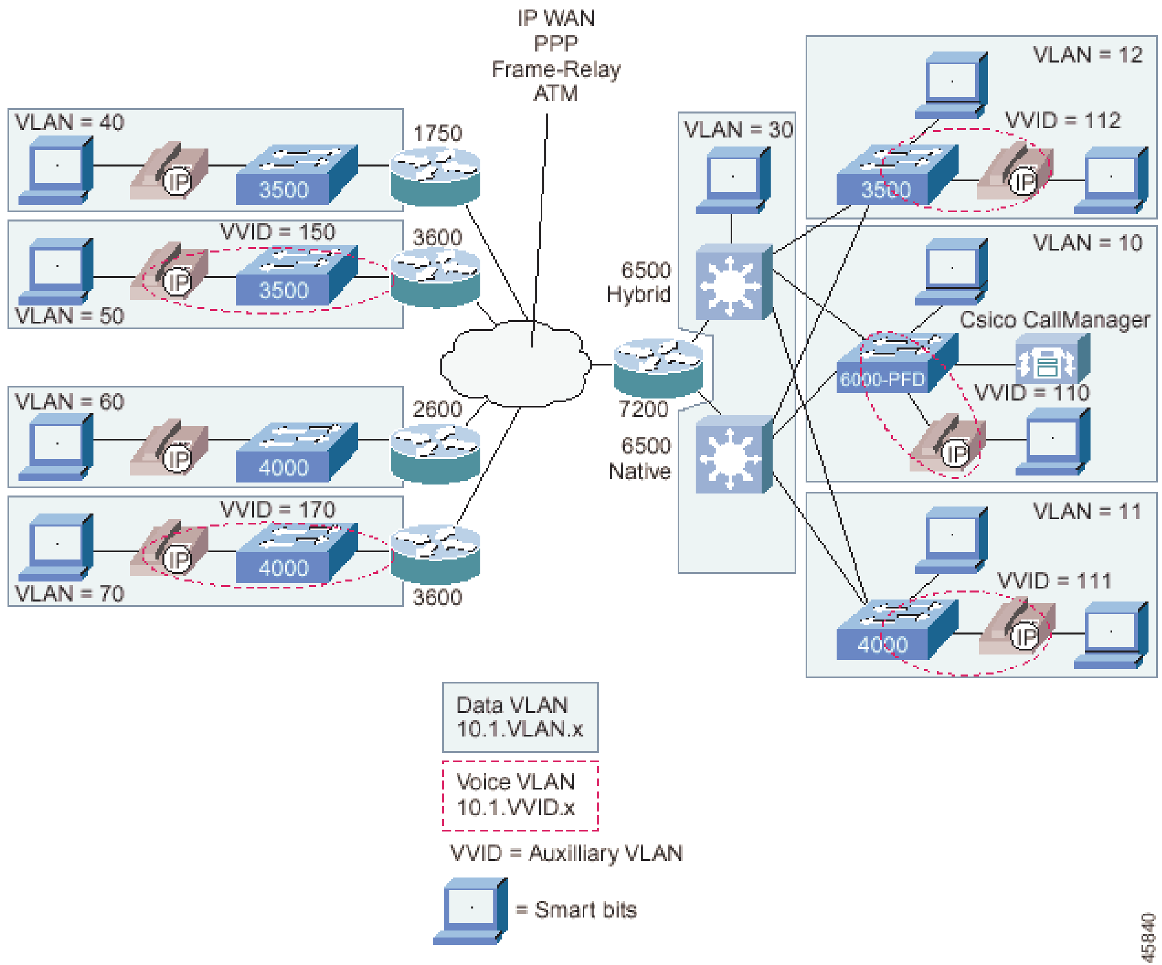
http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/sft_6_1/configgd/qos.pdf

IP Telephony QoS Design Guide

Cisco.com

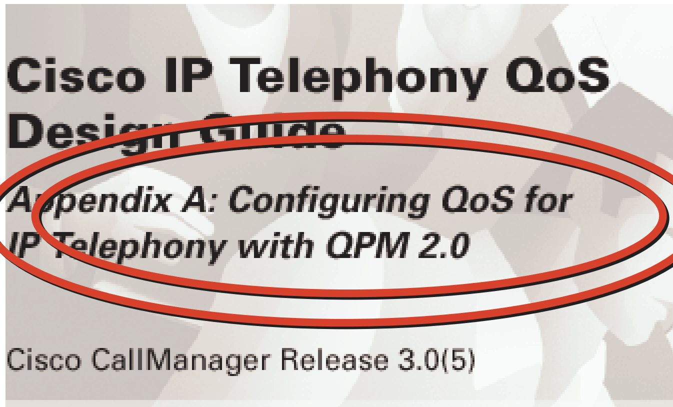


Cisco AVVID

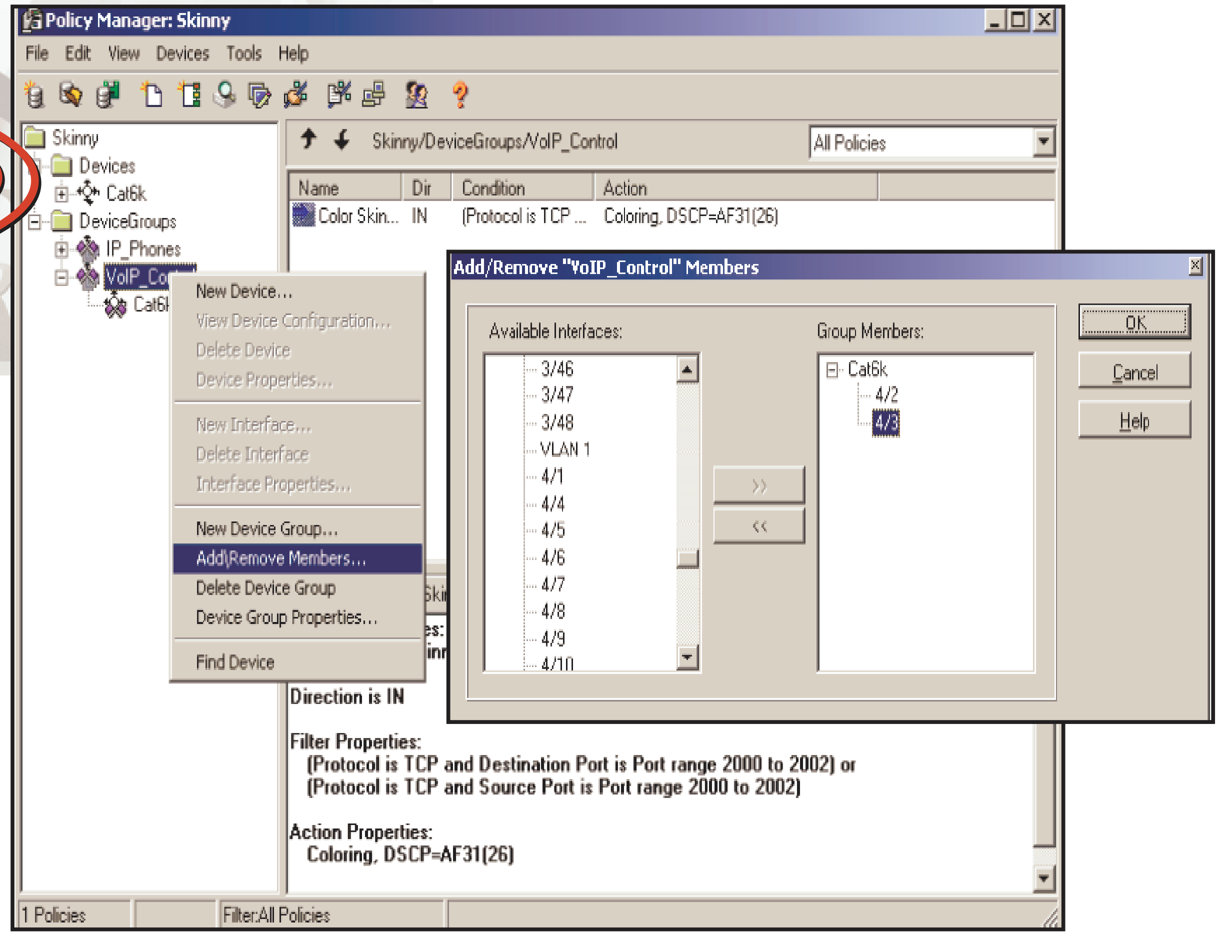


http://www.cisco.com/univercd/cc/td/doc/product/voice/ip_tele/avvidqos/qosguide.pdf

IP Telephony QoS Design Guide: QPM Appendix

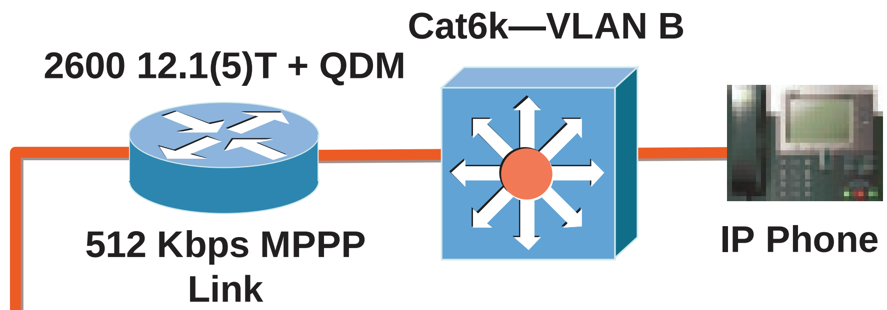


Cisco AVVID

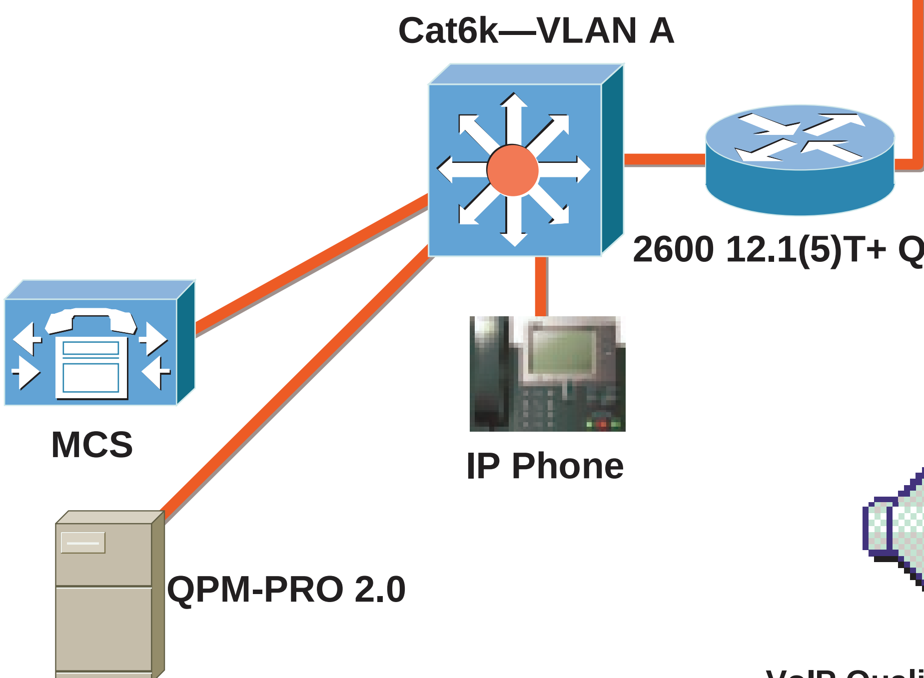


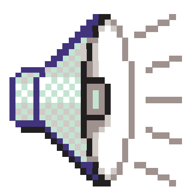
http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/index.shtml

VoIP QoS Demos

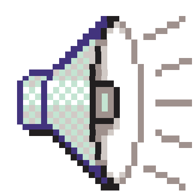


- OBJECTIVE: Voice QoS on WAN
- VoIP traffic is placed in strict-priority (LLQ) queue
- IP RTP header is compressed from 40 bytes to 5 bytes
- Link-Fragmentation and Interleaving is enabled to prevent serialization delay over the slow WAN link



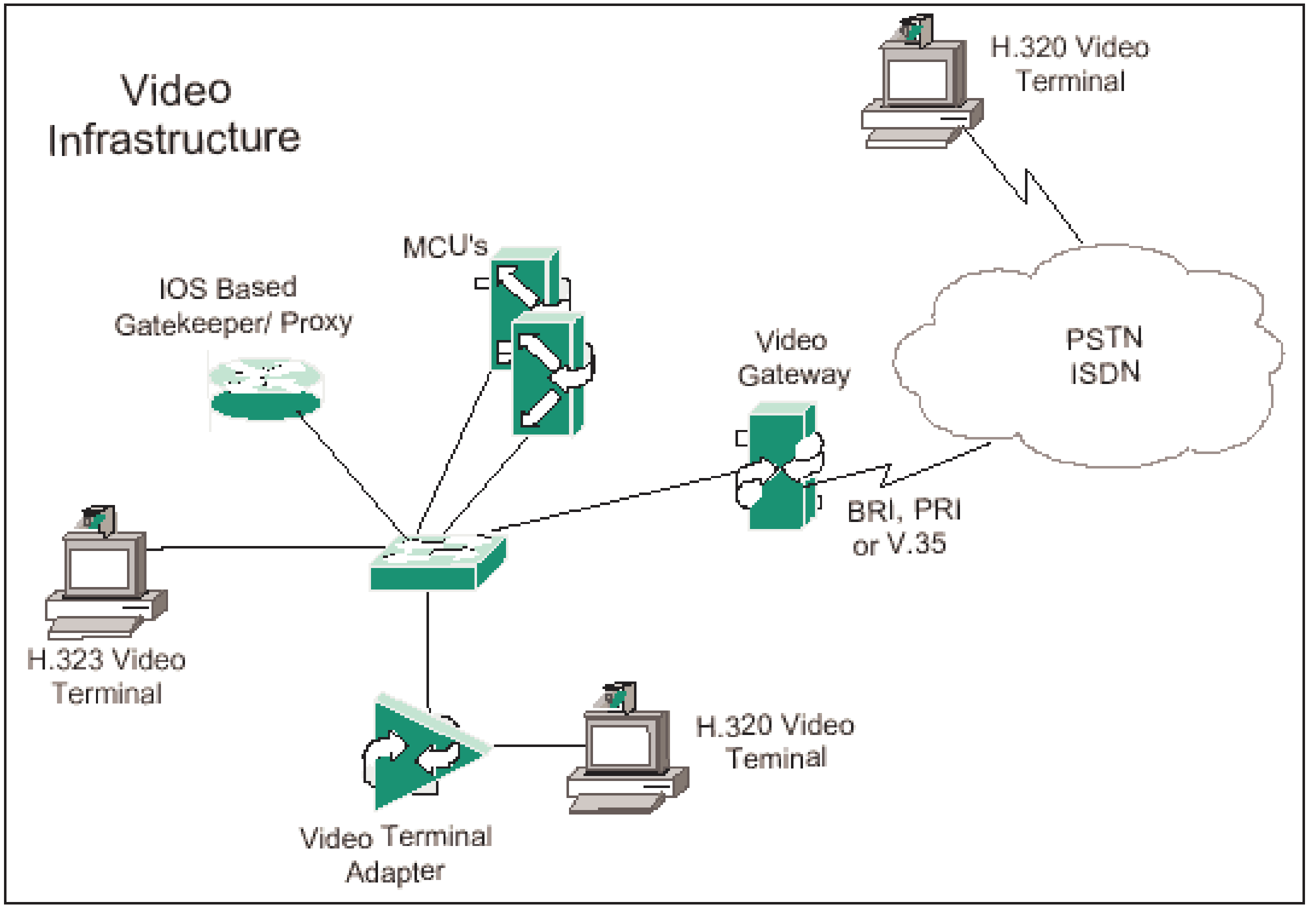


VoIP Quality Before QoS



VoIP Quality After QoS

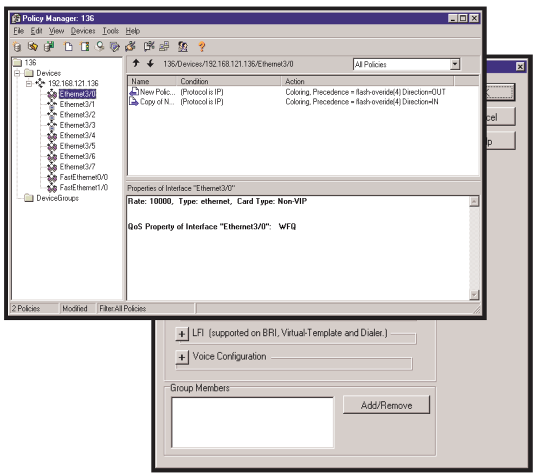
IP/VC Design Guide



QPM + SMS

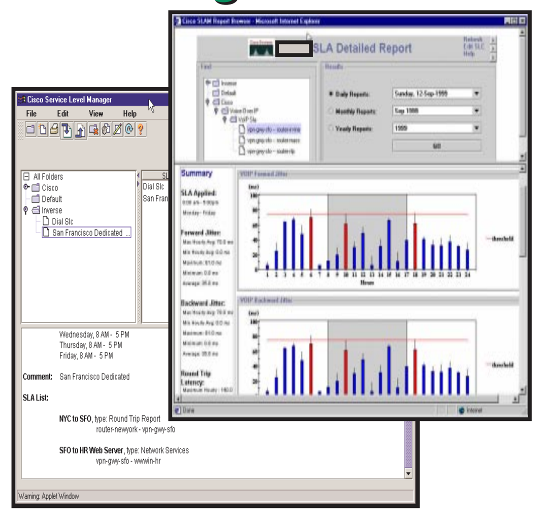
QPM-PRO

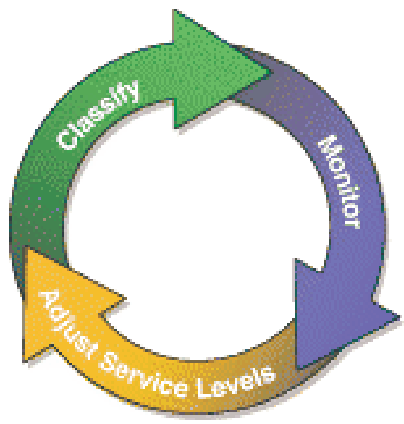
QoS Policy Manager



SMS

Service Management Solution





1. QPM classifies traffic flows and provisions services across network infrastructure

2. SMS monitors and reports on QoS policies

3. Service levels are adjusted as necessary based on threshold alarms reported by SMS

http://www.cisco.com/warp/public/cc/pd/wr2k/svmnso/tech/inte_wp.pdf

Oracle

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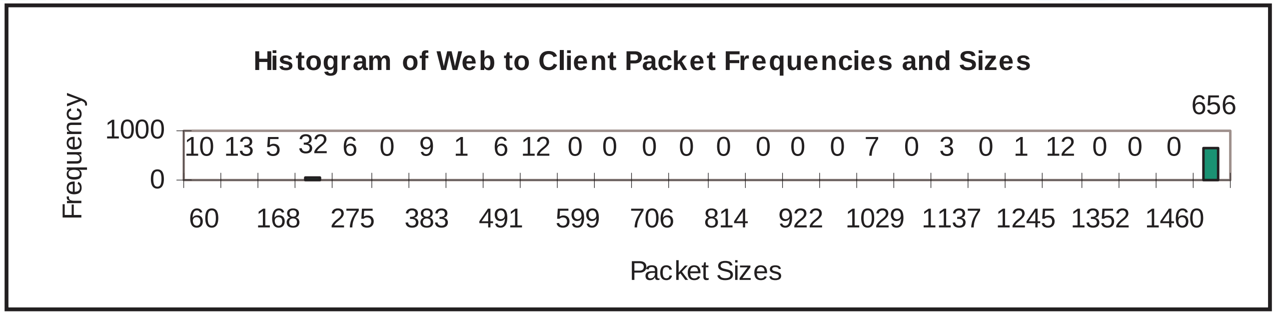
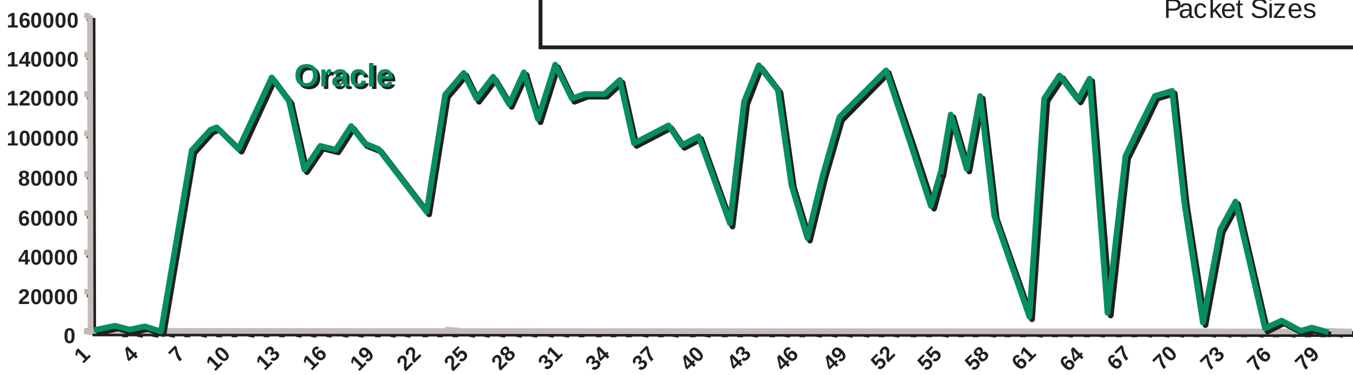
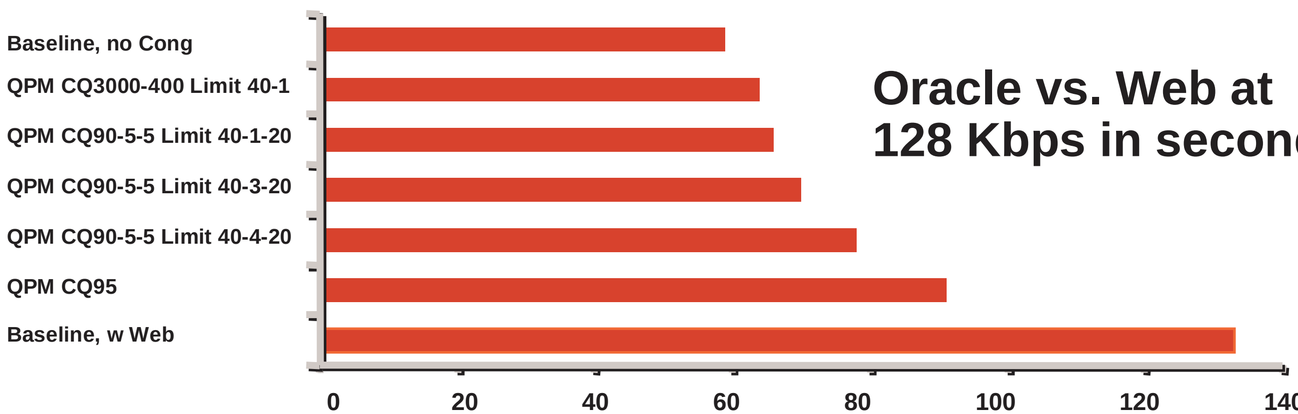
Oracle Traffic Characteristics





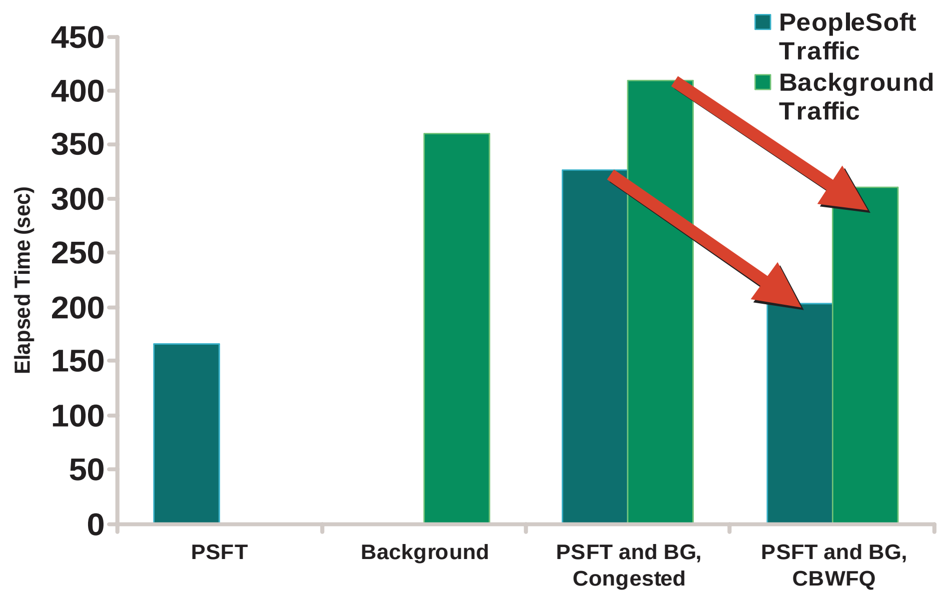


Oracle vs. Web at 128 Kbps in seconds

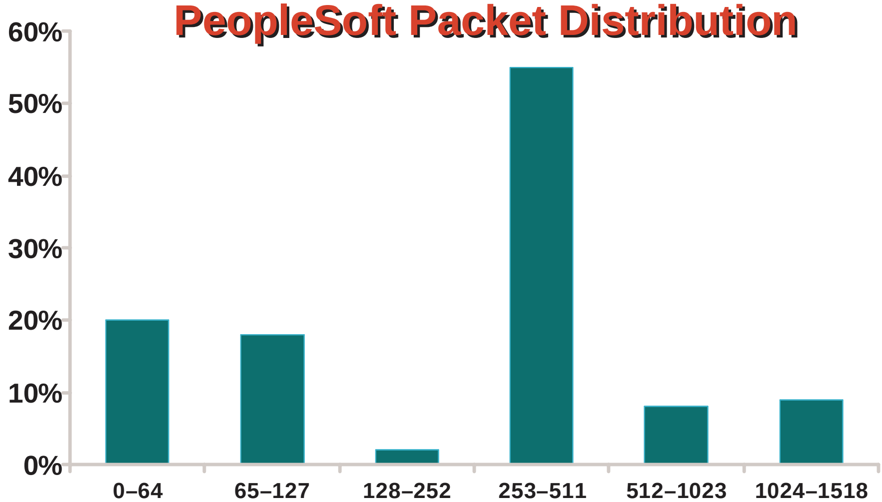
http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/qpm_br.pdf

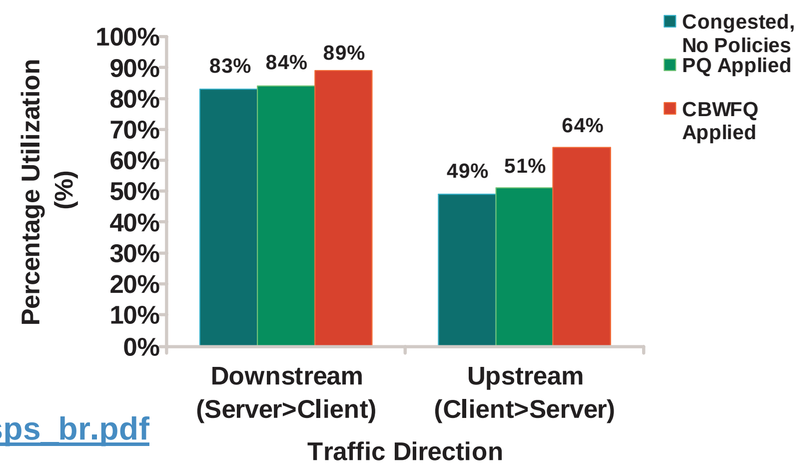
PeopleSoft

- CBWFQ used to improve PeopleSoft response time by 40%
- CBWFQ increases effective BW Utilization, and also (in this case) increases the response time of background traffic



PeopleSoft Packet Distribution





http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/ensps_br.pdf

SAP

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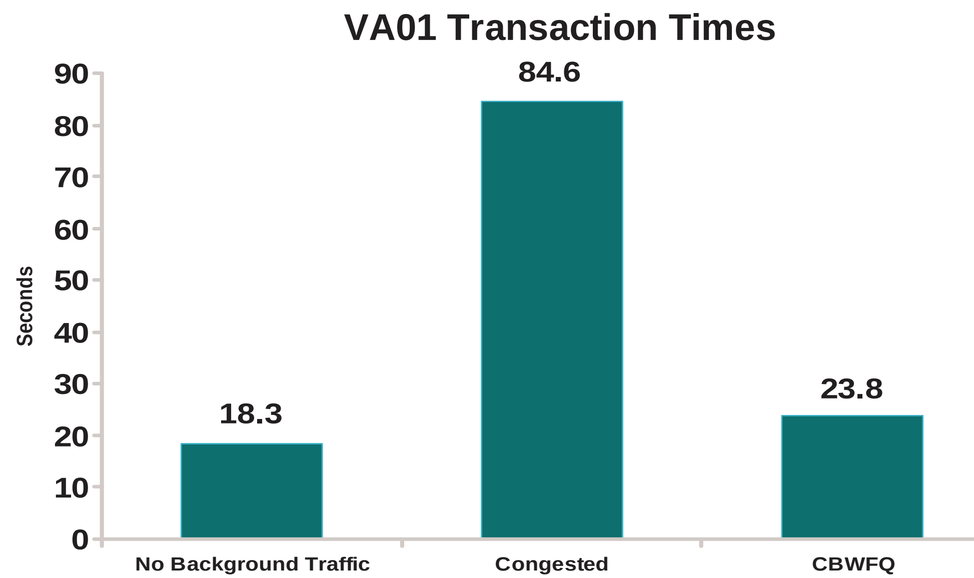
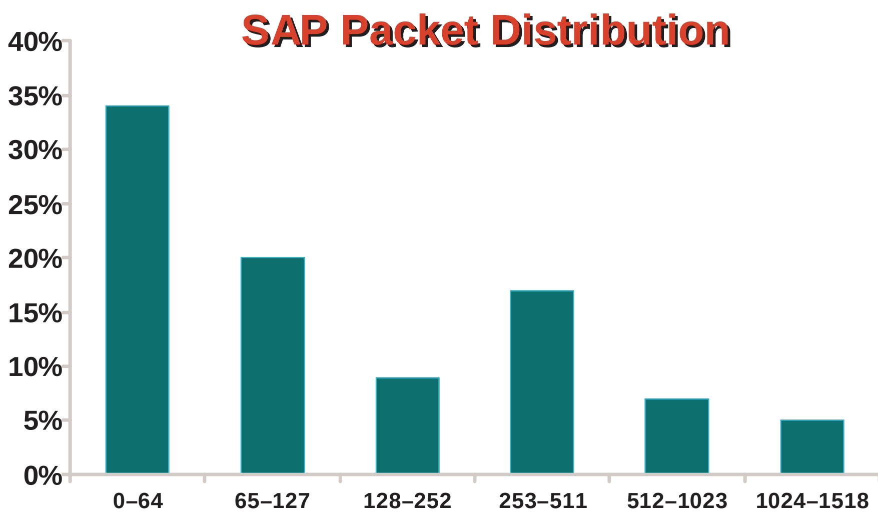
- CBWFQ used to improve SAP response times by 70%
- Latest version of SAP (4.x) is web-based and much more network intensive and will need stricter policies (similar to Oracle)



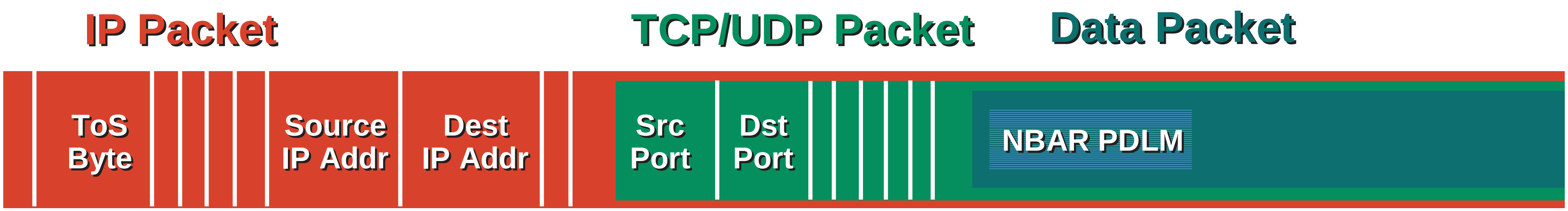


Client Version	VA01 # of Bytes
SAP GUI Release 3.0 F	14,000
SAP GUI Release 4.6C, No Cache	57,000
SAP GUI Release 4.6C, with Cache	33,000
SAP GUI for HTML, Release 4.6C	490,000

ftp://ftpeng.cisco.com/szigeti/WhitePapers/

NBAR

Cisco.com

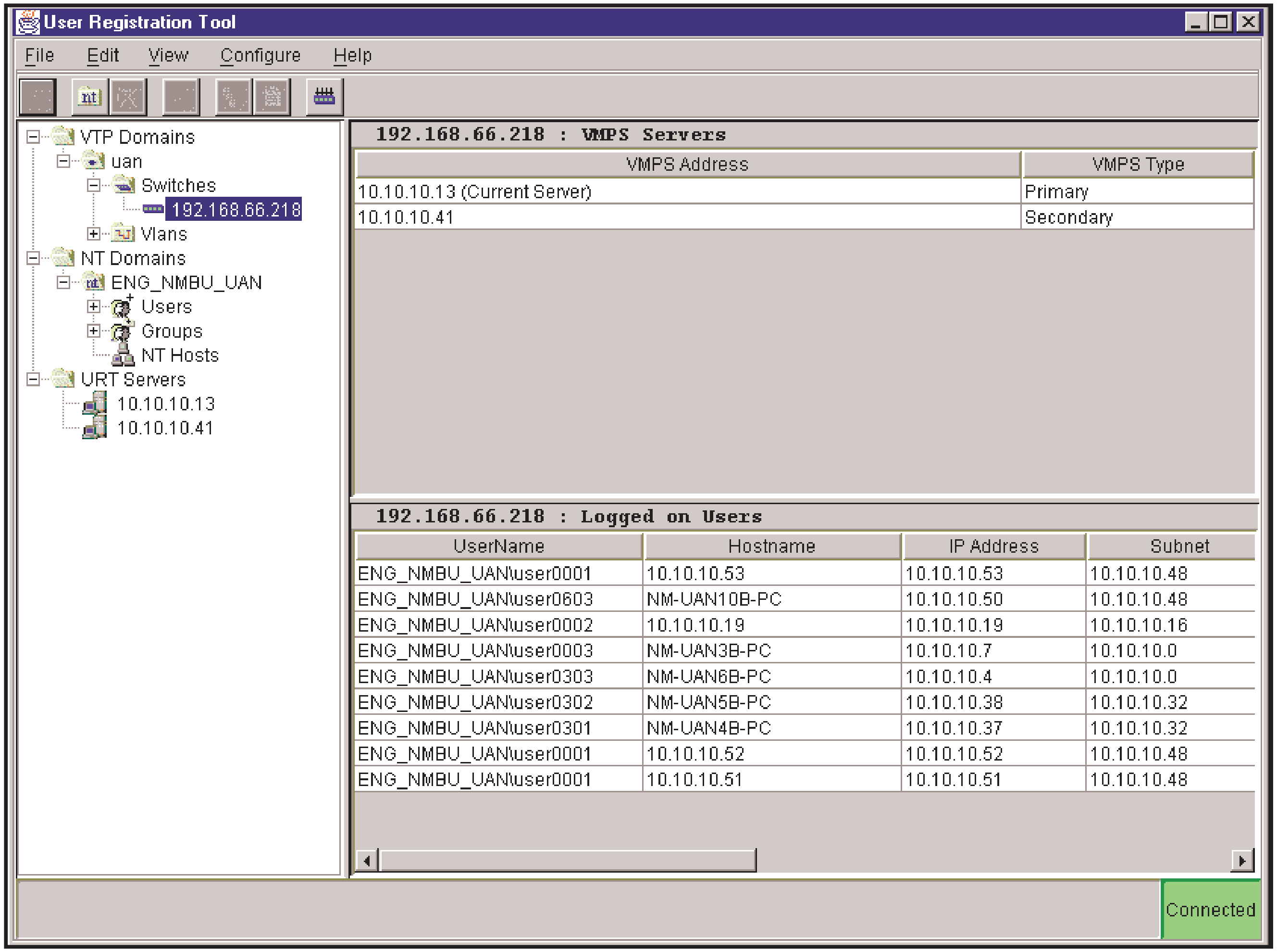


egp	exchange	kerberos	secure-nntp	smtp
gre	finger	l2tp	notes	snmp
icmp	ftp	ldap	novadigm	socks
ipinip	secure-ftp	secure-ldap	ntp	sqlnet
ipsec	gopher	netshow	pcanywhere	ssh
eigrp	http	pptp	pop3	streamwork
bgp	secure-http	sqlserver	secure-pop3	syslog
cuseeme	imap	netbios	printer	telnet
dhcp	irc	nfs	realaudio	secure-telent
dns	secure-irc	nntp	rcmd	tftp
				vdolive
				xwindows

http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121newft/121t/121t5/dtnbar.pdf

URT 2.0

Cisco.com



http://www.cisco.com/univercd/cc/td/doc/product/rtrmgmt/cw2000/fam_prod/user_reg/2_0/urt20/useguide/index.htm

User-Based QoS Solution

USER ← VLAN ← QoS Policy

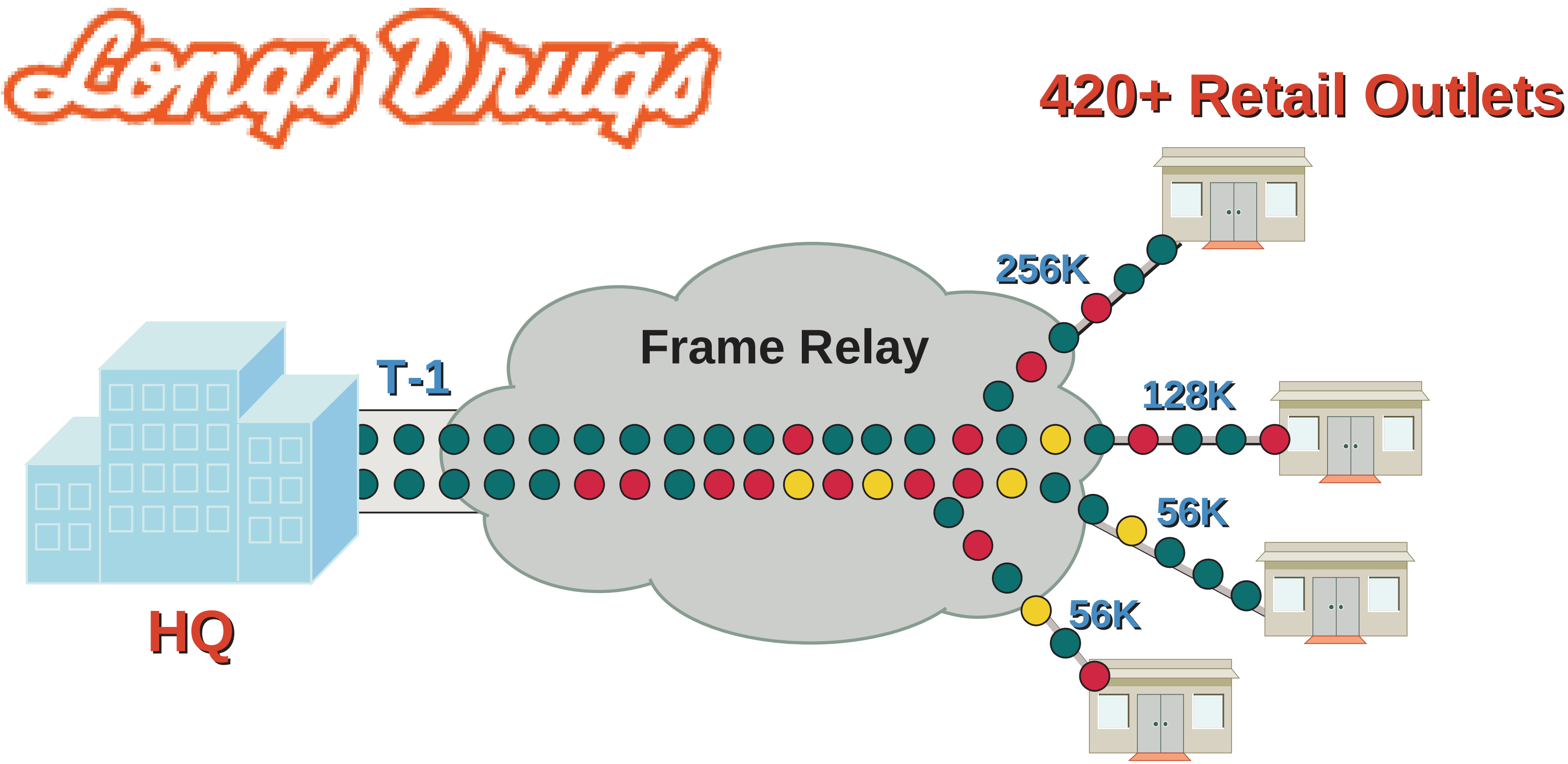
URT **QPM**

http://www.cisco.com/warp/public/146/pressroom/pdf/ent_021700.pdf

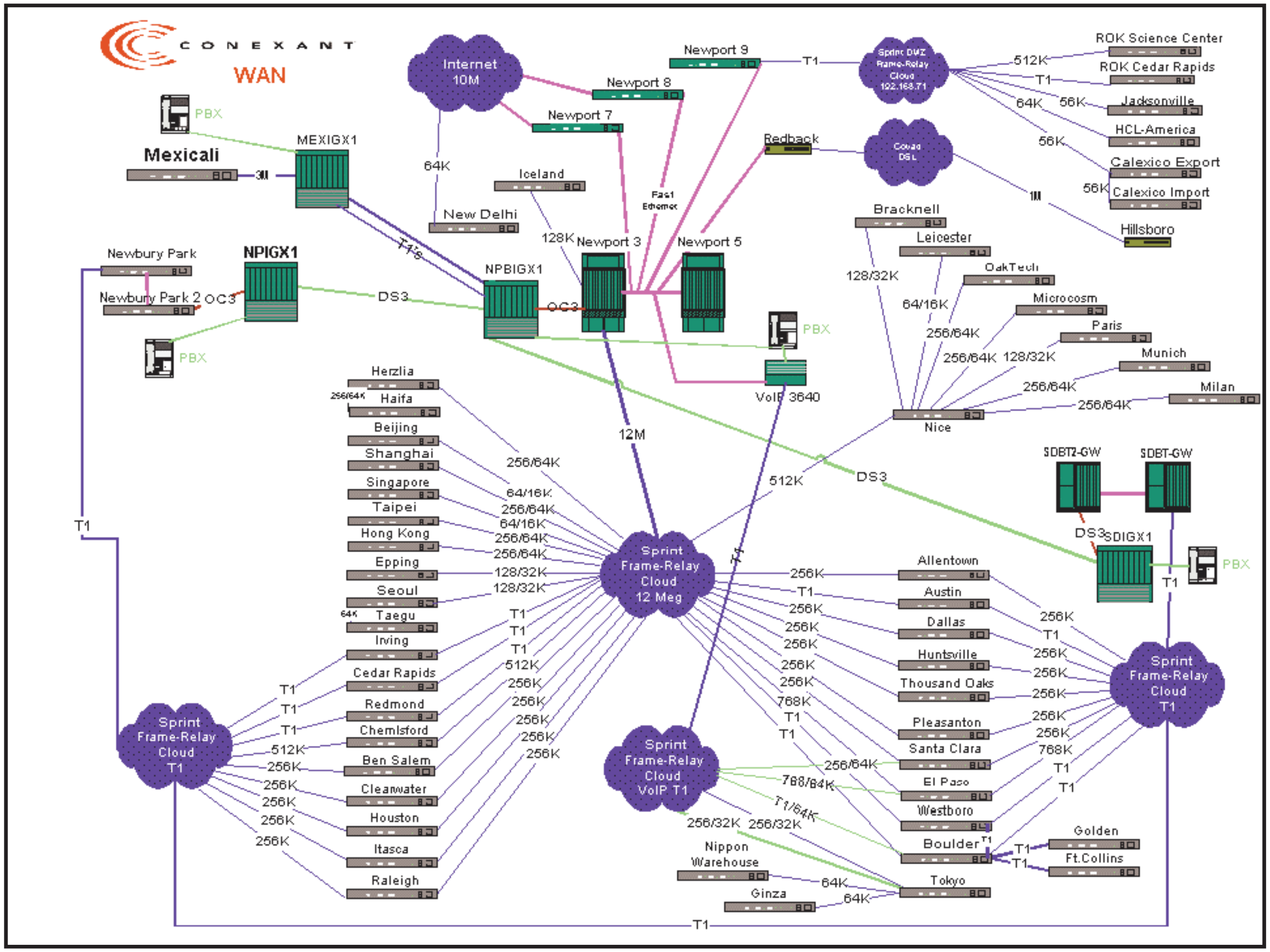
Maxim for Case Studies

“In theory, theory and practice are the same.”

Longs Drugs QDM: Mission-Critical Data



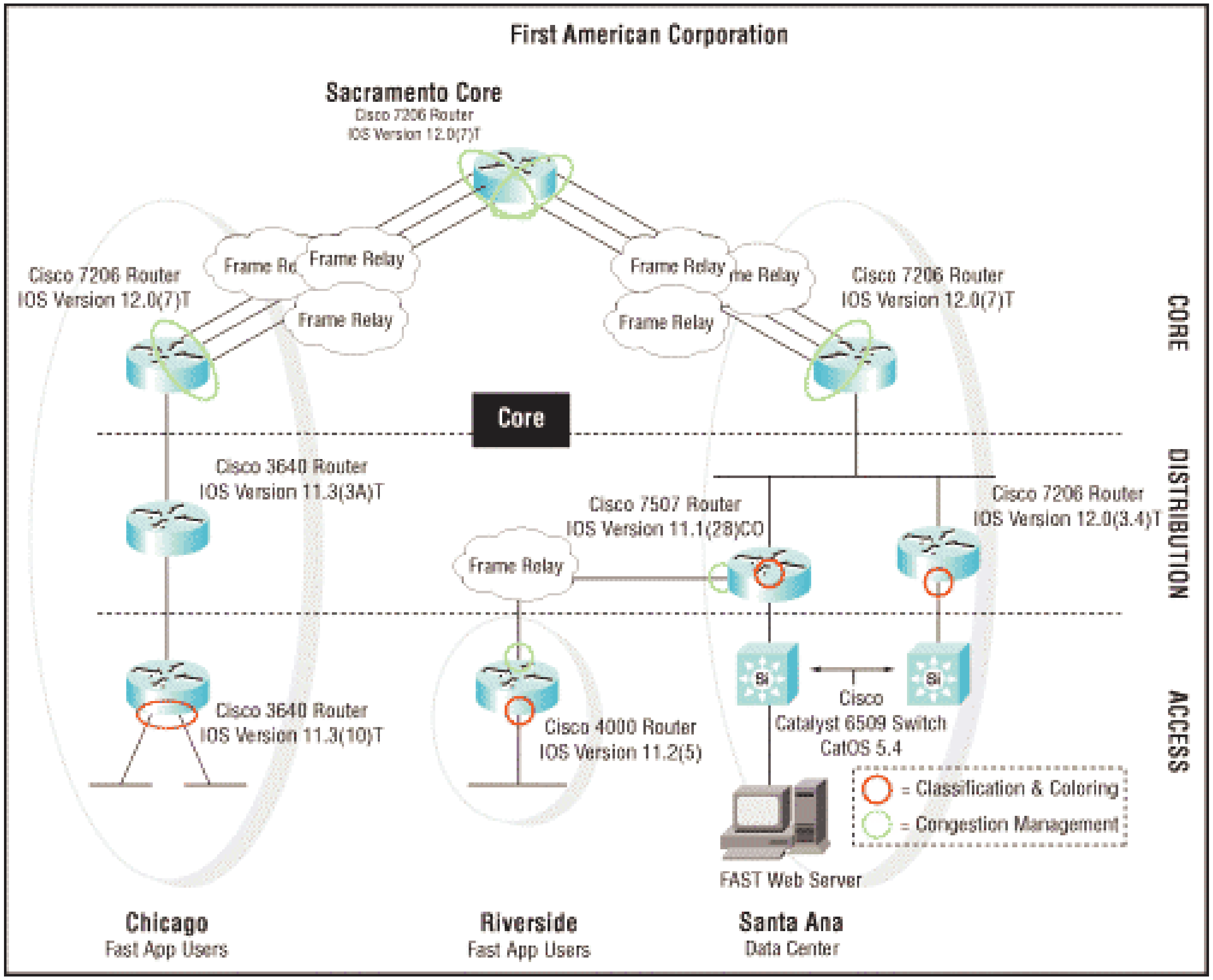
Conexant
QPM: VoIP and Mission-Critical Data



http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/cone_sc.pdf

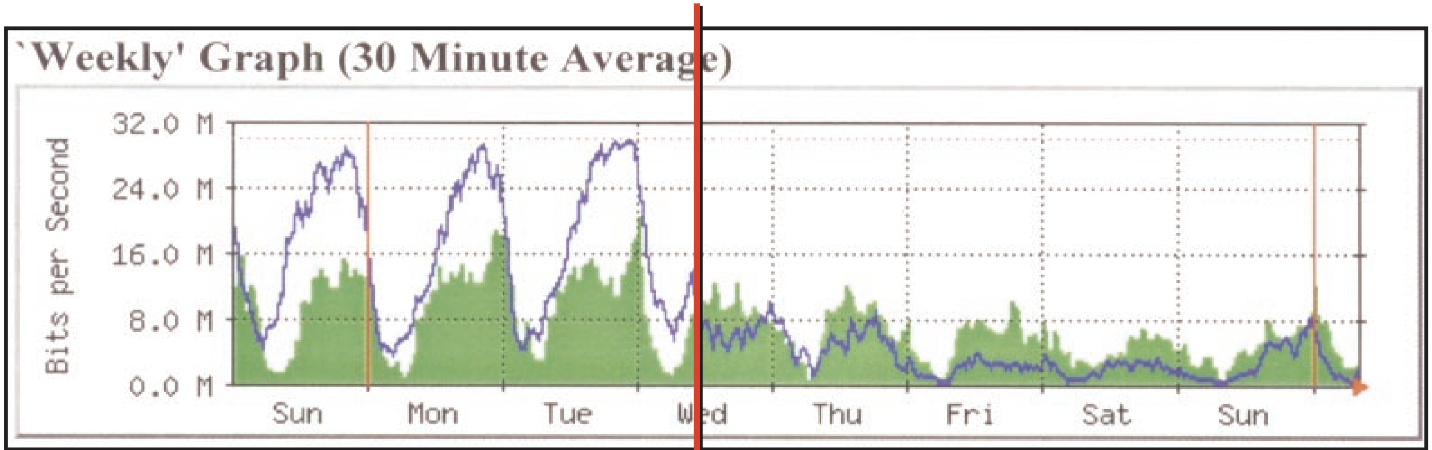
First American Financial
QPM: Custom-Designed Mission-Critical Data

Cisco.com



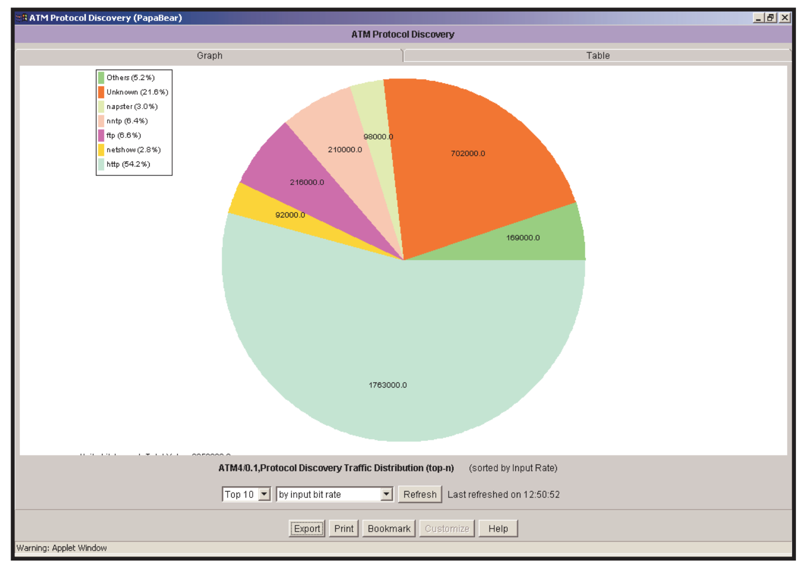
http://www.cisco.com/warp/customer/cc/pd/wr2k/qoppmn/prodlit/1amer_sc.pdf

A Northern California University NBAR + QDM: Rogue Data (Napster)

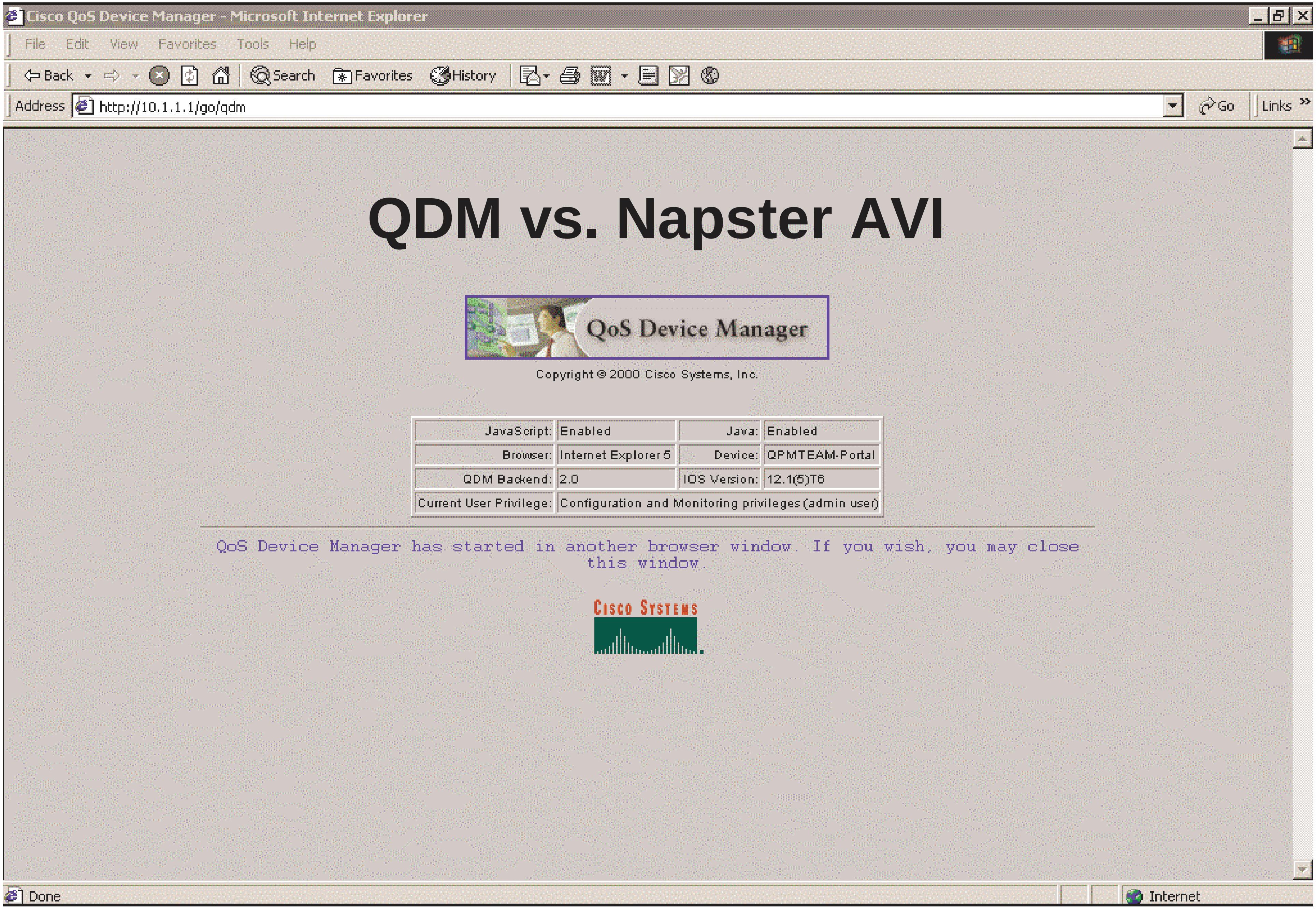


Green: Inbound
Blue: Outbound

- Northern California University:
  - Limiting Napster via NBAR on 30MB ATM PVC to ISP
  - Monitoring QoS with QDM
    - Protocol discovery
    - Dynamic line graphs of Napster traffic
  - Cost savings of $6000+ per month with QoS
  - Additional cost savings ($10,000+) of Cisco solution vs. Competitors
    - Free downloads vs. expensive box-based competitors (i.e. Packeteer, Sitara, etc.)



ftp://ftpeng.cisco.com/szigeti/WhitePapers/

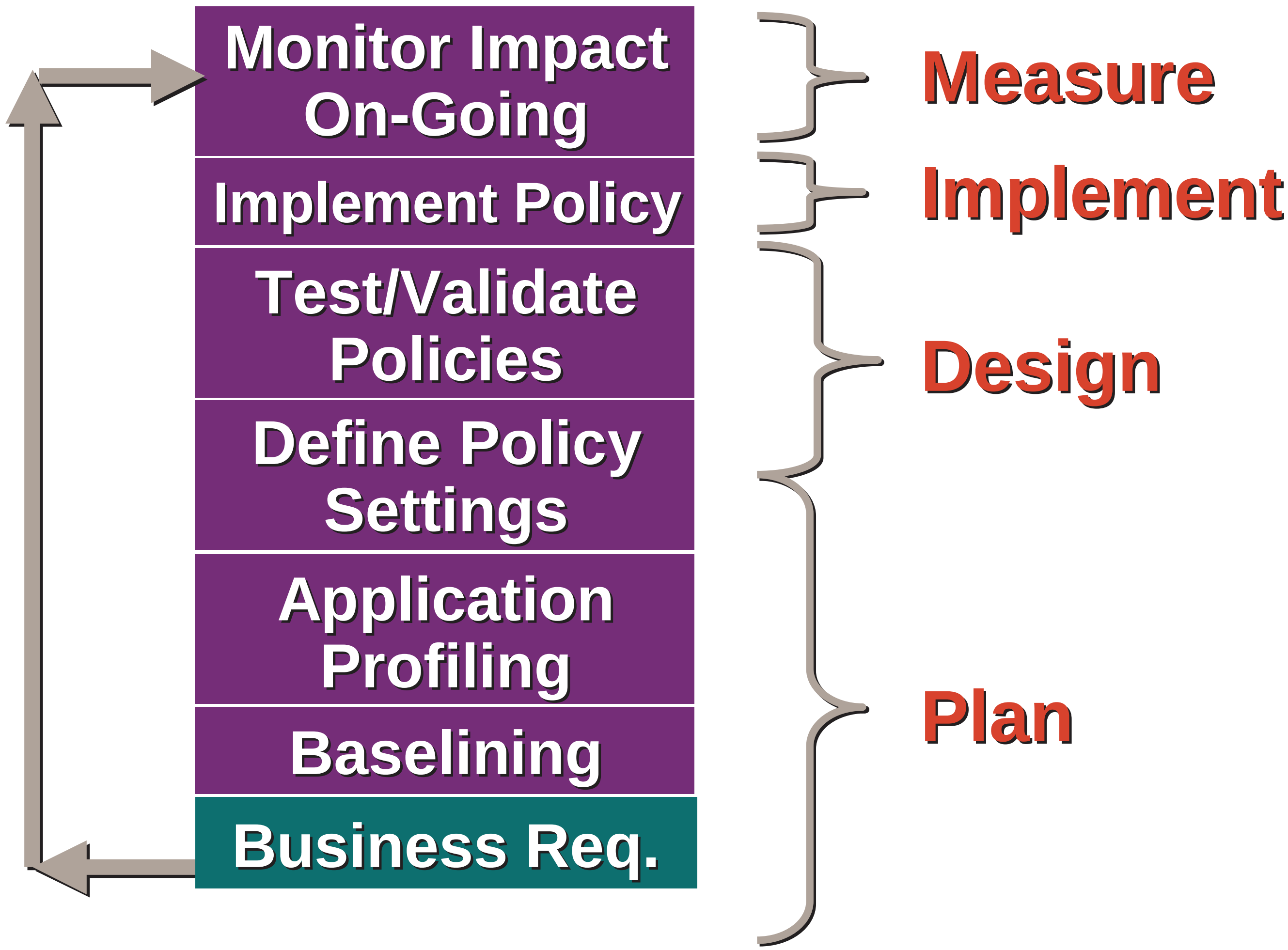

Cisco QoS Device Manager - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://10.1.1.1/go/qdm
Go Links
QDM vs. Napster AVI
QoS Device Manager
Copyright © 2000 Cisco Systems, Inc.
JavaScript: Enabled
Java: Enabled
Browser: Internet Explorer 5
Device: QPMTEAM-Portal
QDM Backend: 2.0
IOS Version: 12.1(5)T6
Current User Privilege: Configuration and Monitoring privileges (admin user)
QoS Device Manager has started in another browser window. If you wish, you may close this window.
Cisco Systems
Done
Internet

Outline

Cisco.com

- QoS Management—Need + Overview
- QoS Device Manager (QDM) Overview
- QoS Policy Manager (QPM) Overview
- Monitoring and Trending Overview
- White Papers + Case Studies
- Methodology + Best Practices

Implementation Methodology



Best Practices: VoIP

- LAN
  - Extend trust boundaries to IP Phones
  - Enable queueing on Catalyst switches
  - IP Phones will color VoIP to ToS 5 (DSCP 46)
  - Color Voice Control traffic to ToS 3 (DSCP 26)
  - Configure CoS to ToS/DSCP Mappings
- WAN
  - Use LLQ (if unavailable, use IP RTP Priority)
  - Use IP RTP Header Compression
  - Use LFI or FRF.12 on link speeds of 768kbps or less

http://www.cisco.com/univercd/cc/td/doc/product/voice/ip_tele/avvidqos/qosguide.pdf

Best Practices: Video Conferencing (VC)

Cisco.com

- LAN

  Extend trust boundaries to video conferencing devices (or nearest wiring-closet switch to VC Devices)

  Enable queueing on Catalyst switches

  Color Video traffic traffic to ToS 4 (DSCP 32)

- WAN

  Use RSVP for H.323 VC (+ set all ports to full-duplex)

  Use LLQ and provision priority queue for maximum data rate of video stream + 20%

  (CBWFQ is not recommended for video conferencing)

  Do not provision more than 50% of link to VC

Best Practices: Mission-Critical Data

- LAN

  Enable queueing on Catalyst switches

  Color Mission-Critical Data as close to source as possible to ensure end-to-end QoS

- WAN

  Use CBWFQ and allocate bandwidth percentage based on packet-size, frequency, and background traffic requirements

  Use WRED for congestion avoidance

Best Practices: Entertainment Applications

- **LAN**

  Shape rogue application data as close to source as possible if source or destination IP addresses are known or if the app is bound to well-known ports

  (i.e. have polices on wiring-closet switches to shape gaming or entertainment traffic)

- **WAN**

  Use NBAR's protocol discovery features to detect network activity of popular rogue applications

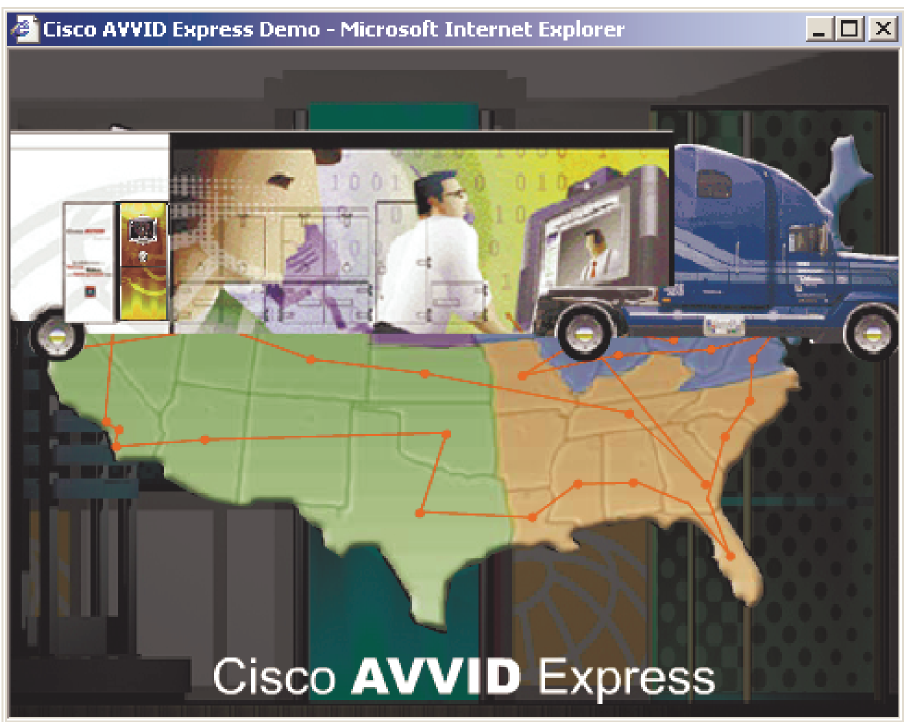
  Use NBAR to identify/classify rogue apps that are not bound to well-known ports

  (NBAR is currently only available on WAN devices)

QPM+QDM in New AVVID QoS Demo

NETWORKERS

World of Solutions



AVVID Express

2001 Network Computing
WELL-CONNECTED AWARDS

Quality of Service (QoS) Essentials

Session PS-560

ftp://ftpeng.cisco.com/szigeti/NW2001-PS560/

Please Complete Your Evaluation Form

Session PS-560

CISCO SYSTEMS

EMPOWERING THE INTERNET GENERATION℠

