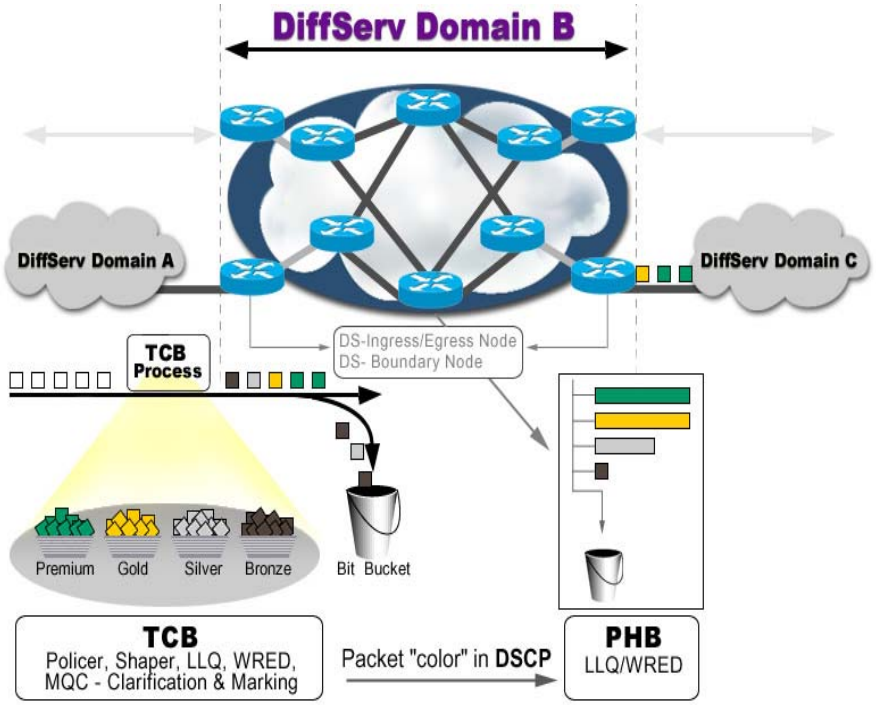
AutoQoS
Technical Presentation

Agenda

- Introduction
- Cisco AutoQoS Framework
- Automation with Cisco AutoQoS
- Cisco AutoQoS for the Enterprise - Deployment Case Study
- Summary

Introduction – IETF DiffServ Architecture (RFC-2475)

- **The idea - different service levels for packets**
- **The service - some significant characteristics of packet transmission in one direction across the network (ie: bandwidth and latency)**



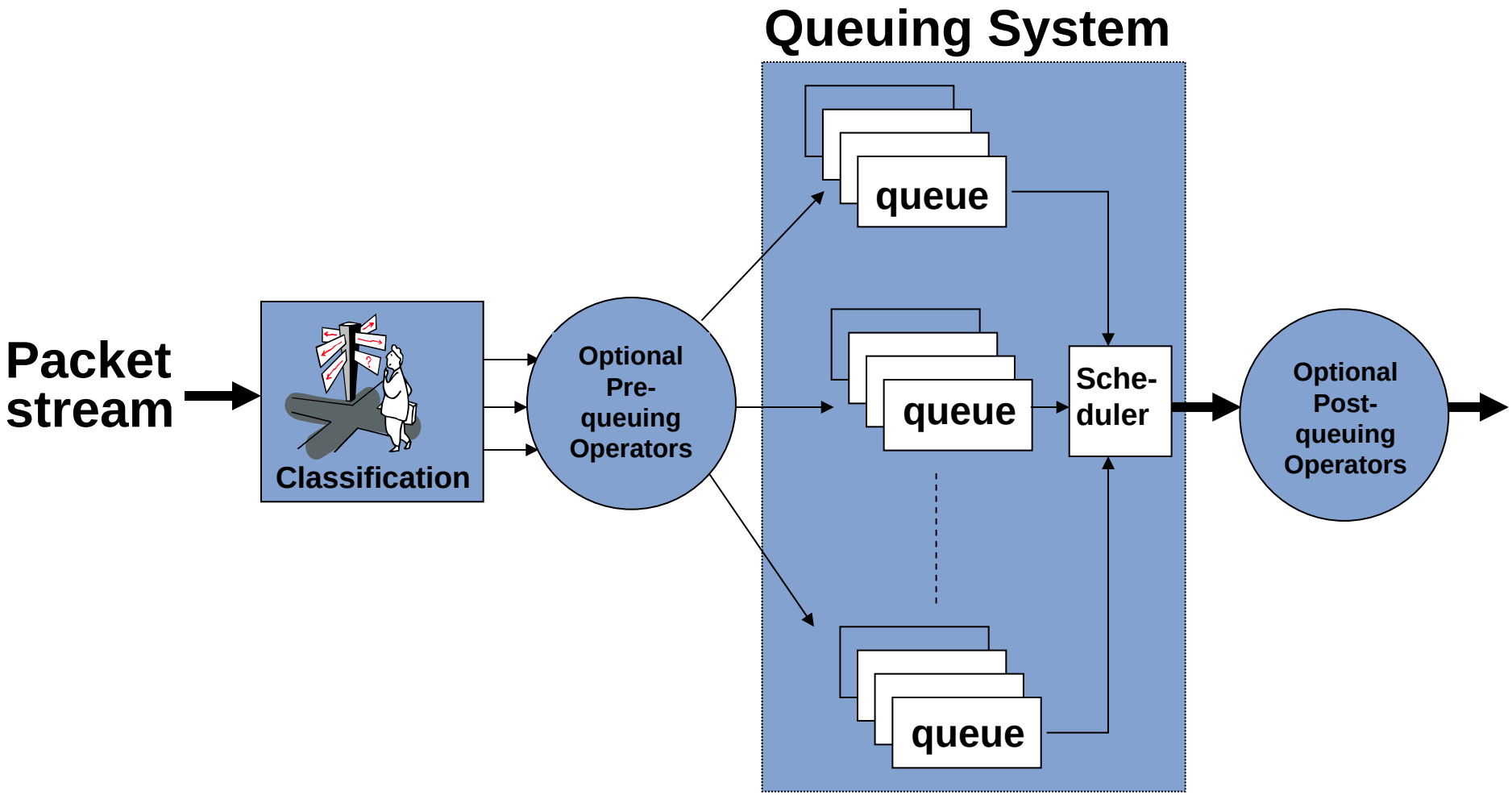
A New Paradigm for Automating the Delivery of Network Quality of Service

- Key takeaways
  - Simpler Quality of Service (QoS) deployments – reduces operator errors
  - Cheaper QoS deployments – up to a 2/3 reduction in cost
  - Faster QoS deployments – up to a 2/3 reduction in deployment time

A New Paradigm for Automating the Delivery of Network Quality of Service

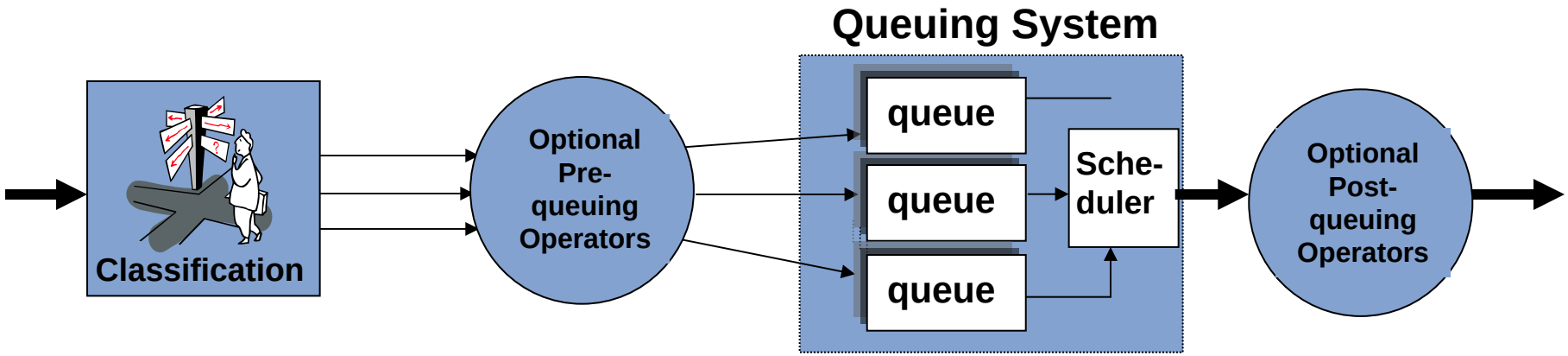
- Cisco AutoQoS: QoS for voice, video, and data
  - Protect business-critical data applications in the Enterprise
  - IP telephony and real-time video require QoS
  - QoS deployment can be challenging
  - Cisco AutoQoS makes QoS deployments simpler, cheaper, and faster
- Cisco AutoQoS allows customers to retain complete control over QoS configuration

Cisco IOS QoS Behavioral Model



Specify Match Conditions and Policy Actions

Match Conditions	Policy Actions



Classification	Pre-queuing	Queuing and Scheduling	Post-queuing
• Classify traffic	• Immediate actions	• Congestion management and avoidance	• Link efficiency mechanisms

Operators for Traffic Classification and QoS Policy Actions

Match Conditions keyword: class-map	Policy Actions keyword: policy-map		
Classification	**Pre-queuing**	**Queuing and Scheduling**	**Post-queuing**
• Classify traffic	• Immediate actions	• Congestion management and avoidance	• Link efficiency mechanisms
Match one or more attributes (partial list): • ACL list • COS • Differentiated Services Code Point (DSCP) • Input-interface • Media Access Control (MAC) address • Packet length • Precedence • Protocol • VLAN	• Mark (Set QoS values) • Police • Drop • Count • Estimate bandwidth	• Queue-limit • Random-detect • Bandwidth • Fair-queue • Priority • Shape	• Compress header • Fragment (Link Fragmentation and Interleaving, Layer 2)

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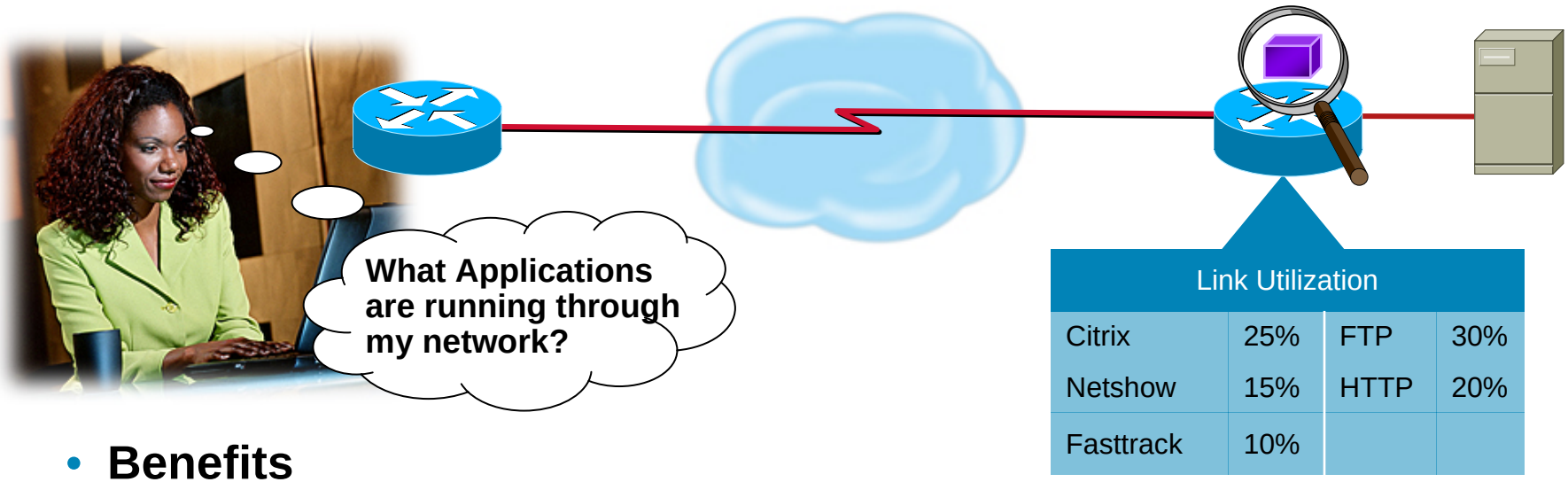
Cisco AutoQoS – Enterprise Framework DiffServ Functions Automated

- **Automation and simplification of the existing user interface to expedite deployment of QoS features for voice, video, and data**
- **Fine-tuning of Cisco AutoQoS generated parameters by user, if desired**

DiffServ Function	Cisco IOS QoS Features	Behavior
Classification	Network Based Application Recognition (NBAR), IP precedence Differentiated Services Code Point (DSCP), port	Classification of voice, video, and data traffic based on packet attributes; up to 10 classes of service
Marking	Class-based marking	Set Layer 2 and Layer 3 attributes to separate packets into classes
Congestion management	Percentage-based Low Latency Queuing (LLQ), Class-Based Weighted Fair Queuing (CBWFQ) Weigted Round Robin (WRR)	Provide EF treatment to voice, AF treatment for video & ERP data and BE treatment to default
Shaping	Class-based Shaping or Frame Relay Traffic Shaping (FRTS)	Shape to Committed Information Rate (CIR) to prevent burst and smooth traffic to configured rate
Congestion avoidance	Weighted Random Early Detection (WRED)	Intelligent packet drop decisions to prevent tail drops across multiple TCP sessions
Link efficiency mechanism	Header compression, link fragmentation and interleaving	Reduce Voice over IP (VoIP) bandwidth requirement and jitter experienced by voice packets

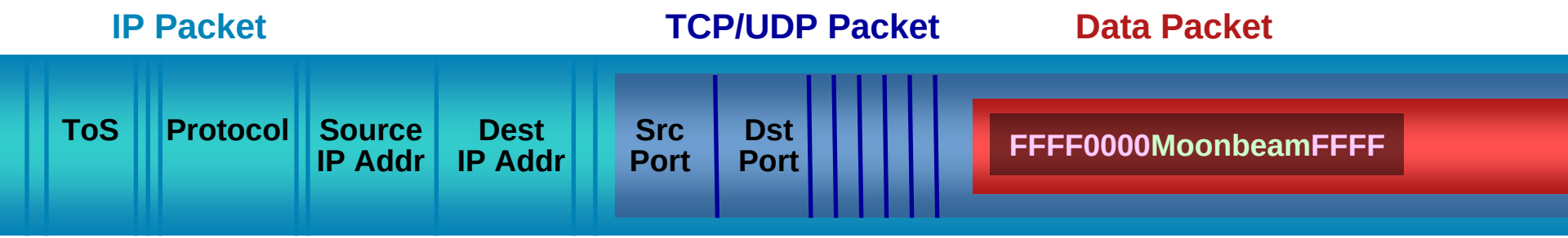
Cisco AutoQoS Framework – Network Based Application Recognition



- **Benefits**
  - **Identifies Layer 4 to Layer 7 applications and protocols**
    - **Stateful and deep packet inspection**
  - **Protocol discovery analyzes application traffic patterns in real time, identifies traffic running on the network and provides statistics**
- **Currently supports more than 98 protocols and applications**

NBAR User-Defined Custom Application Classification

Cisco IOS Software Release 12.3(4)T Nov 2003



- Name – Name the match criteria – up to 24 characters
  - *lunar_light*
- Offset – Specify the beginning byte of string or value to be matched in the data packet, counting from ***zero*** for the first byte
  - *Skip first 8 bytes*
- Format – Define the format of the match criteria
  – ASCII, hex or decimal
  - *ascii*
- Value – The value to match in the packet
  – if ASCII, up to 16 characters
  - *Moonbeam*
- [Source or destination port] – Optionally restrict the direction of packet inspection; defaults to *both* directions if not specified
  - *[source | destination]*
- TCP or UDP – Indicate the protocol encapsulated in the IP packet
  - *tcp*
- Range *or* selected port number(s)
  – "range" with start and end port numbers, up to 1000
  – 1 to 16 individual port numbers
  - *range 2000 2999*

Example

```
ip nbar custom lunar_light
  8 ascii Moonbeam tcp
  range 2000 2999

class-map solar_system

match protocol lunar_light

policy-map astronomy
  class solar_system
  set ip dscp AF21

interface <>

service-policy output
  astronomy
```

Cisco AutoQoS Framework – NBAR RTP Payload Type Classification

- **Eases classification of voice and video traffic**

  VoIP, streaming / real time video, audio / video conferencing, fax over IP

- **Distinguishes between Real-Time Transport Protocol (RTP) packets based on payload type and CODECS**
- **Removes dependencies on UDP port range and DSCP markings**

CODEC	Payload Type
G.711 (Audio)	0 (mu-law) 8 (a-law)
G.721 (Audio)	2
G.722 (Audio)	9
G.723 (Audio)	4
G.728 (Audio)	15
G.729 (Audio)	18
H.261 (Video)	31
MPEG-1 (A/V) MPEG-2 (A/V)	14 (Audio), 32 (Video), 33 (A-V)
Dynamic	96 - 127

Cisco AutoQoS Framework – Percentage Based Policies

- Problems

  Fixed CIR imposes scalability issues

  Service policies differ by interface, with a wide range of interface bandwidths

- Solution

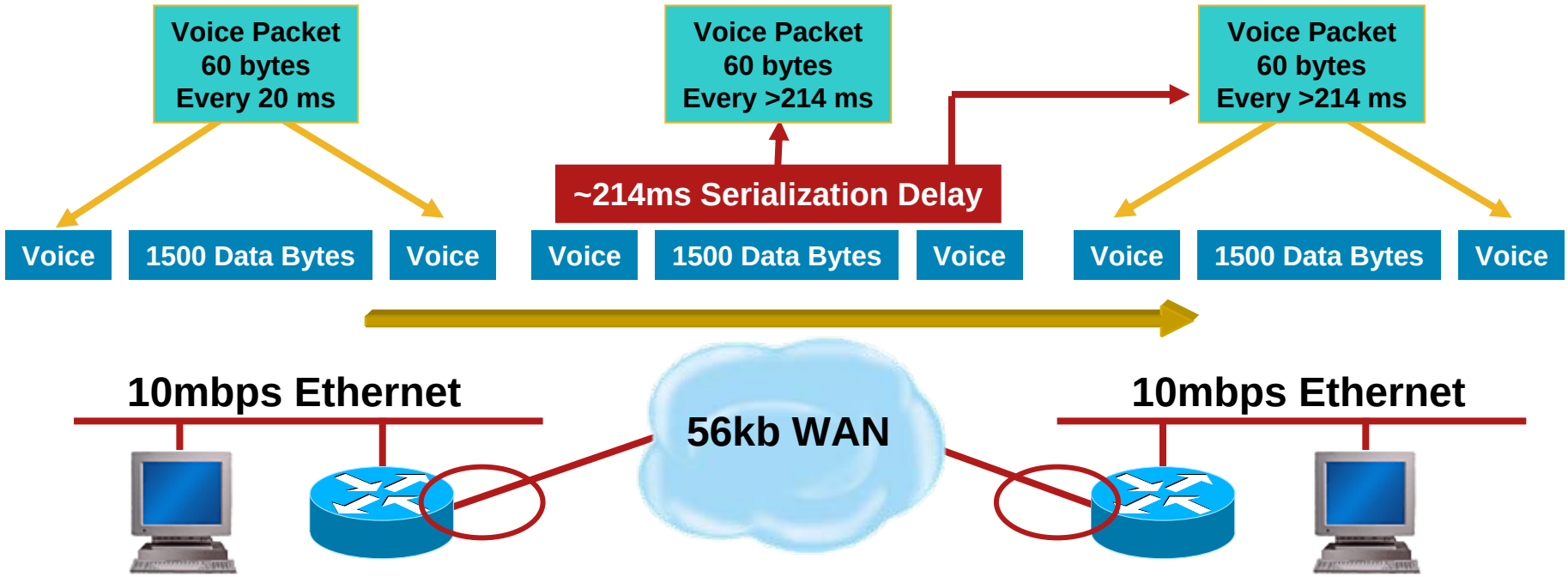
  Configure policies in terms of a percentage of available bandwidth resources

Cisco AutoQoS Framework – Percentage Based Policies

- Advantages
  - Increased scalability and manageability
    - Same policy map can be applied on multiple interfaces and on interfaces with varying bandwidth
  - Build once, apply many policies

Cisco AutoQoS Framework – MLPPP Link Fragmentation & Interleaving

Problem: large packets "freeze out" voice



- Implemented via Multilink Point-to-Point Protocol (MLP) over frame relay, Asynchronous Transfer Mode (ATM), and leased lines
- Fragments are interleaved with the real-time packets, reducing the serialization delay experienced by voice packets

Benefit: reduce the jitter in voice calls

Cisco AutoQoS Framework – RTP Header Compression

PROBLEM: Header = 2 X Payload			
CODEC	PPP 6 Bytes of Header	ATM 53 Bytes Cells with a 48 Byte Payload	Frame-Relay 4 Bytes of Header
G.711 at 50 pps	82.4 kbps	106 Kbps	81.6 kbps
G.711 at 33 pps	75.5 kbps	84 Kbps	75 kbps
G.729A at 50 pps	26.4 kbps	42.4 Kbps	25.6 kbps
G.729A at 33 pps	20 kbps	28 Kbps	19.5 kbps

BENEFIT: Reduction in Voice Bandwidth Requirement			
CODEC	PPP 6 Bytes of Header	ATM 53 Bytes Cells with a 48 Byte Payload	Frame-Relay 4 Bytes of Header
G.711 at 50 pps	68 kbps	N/A	67 kbps
G.711 at 33 pps	66 kbps	N/A	65.5 kbps
G.729A at 50 pps	12 kbps	N/A	11.2 kbps
G.729A at 33 pps	10.5 kbps	N/A	10 kbps

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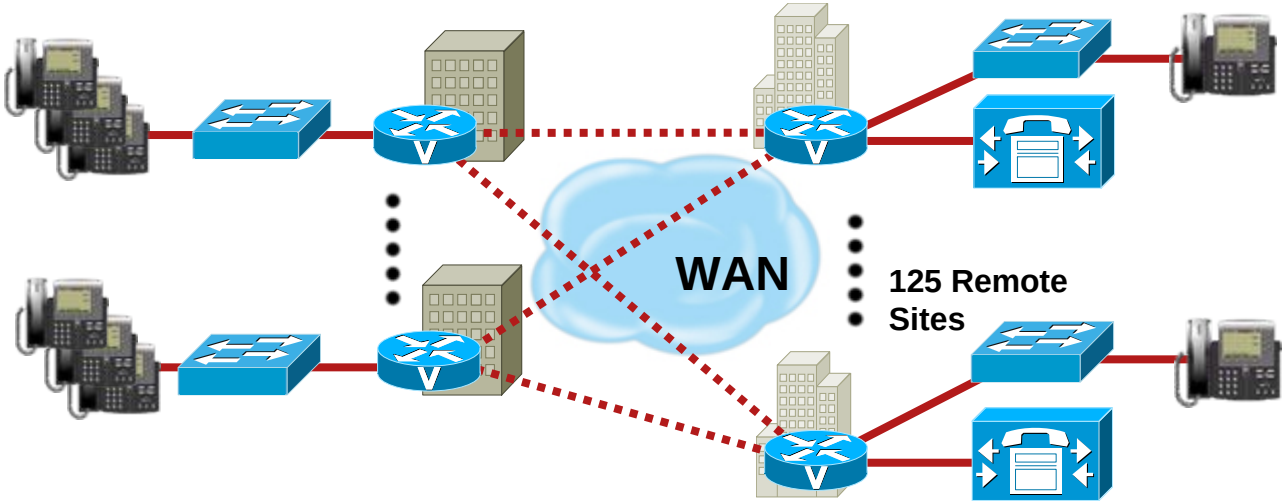
Automation with Cisco AutoQoS – Provisioning the WAN for V/V/D



- **Build Modular QoS Command Line Interface (MQC) policies for voice, video, & data**
  - **Automatic application discovery and intelligent classification (trust / untrust)**
  - **High- and low-speed QoS policies**
- **Automatically enable QoS features specific to underlying transport protocol (FR, ATM, PPP, FR-to-ATM)**
  - **Enable Traffic Shaping where required**
  - **Enable LFI (FRF.12, MLP) where required**
  - **Enable CRTP**
- **Monitoring and SNMP Alerts**

Automation with Cisco AutoQoS - Deploying QoS for the Enterprise WAN

- Simplifies QoS configuration for voice, video, and data into two simple steps
- Automatically discovers statistics for all applications and protocols using NBAR / DSCP
- Automatically provisions up to 10 classes of service

Automation with Cisco AutoQoS - Deploying QoS for the Enterprise WAN

- Generated parameters and configuration can be user-modified
- Intelligent policy generation

  Based on underlying network environment and site specific network traffic profile

  Automatically enables link-specific QoS settings, if required

Automation with Cisco AutoQoS - Deploying QoS for the Enterprise WAN

- Supported on frame relay, ATM, High-Level Data Link Control (HDLC), PPP and frame relay-to-ATM links
- Provides Remote Monitoring (RMON) alerts, if packets are dropped
- Provisioning and monitoring support added via Security Device Manager (SDM)
- Command Line Interface

`auto discovery qos [trust]` – **Untrusted Mode by default**

`auto qos`

`show auto qos [interface <interface-name>]`

`show auto discovery [interface <interface-name>]`

Deploying Cisco AutoQoS for the Enterprise WAN: A Two-Step Approach

Comprehensive QoS deployment in two steps

- Run AutoDiscovery to profile traffic
  - Collects data from the offered traffic for several days, a week, etc., as desired: default is 3 days
  - Uses NBAR-based protocol discovery
  - Performs statistical analysis
- Generate and deploy MQC-based QoS policies
  - Maps applications to their corresponding DiffServ classes
  - Assigns appropriate values for bandwidth and scheduling parameters

Procedure

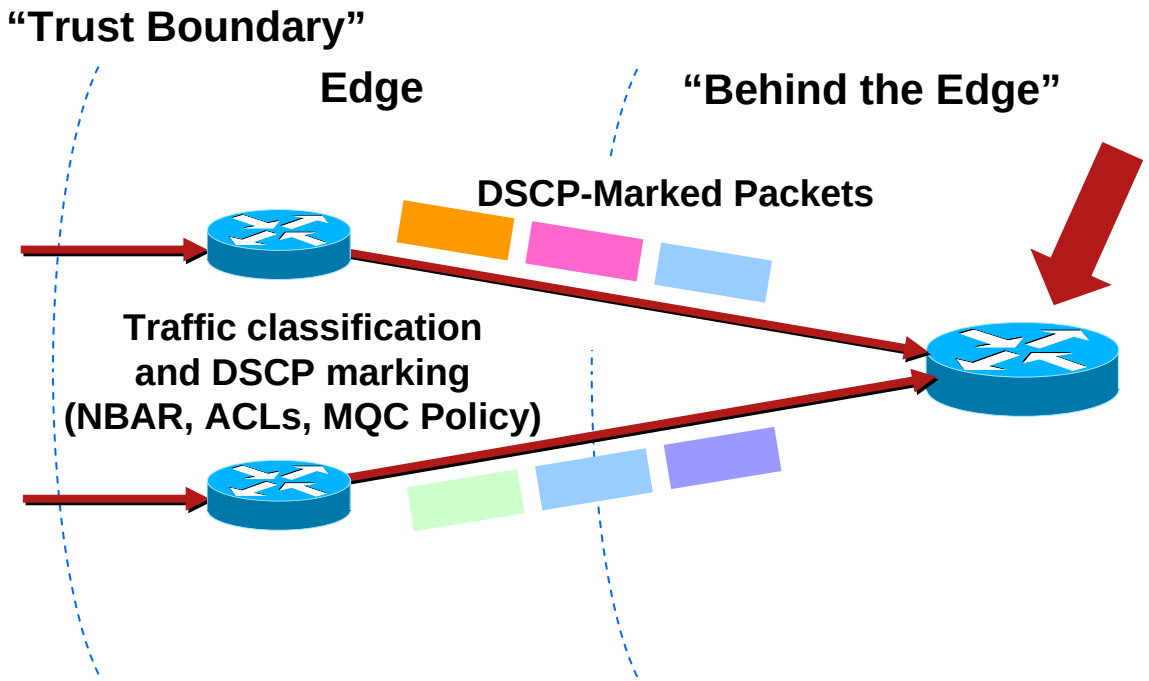
1. **Invoke "`auto discovery qos <trust>`" on the applicable link in "trust" or "untrust" mode**

   Use "`show auto discovery qos`" to view data collection in progress and recommended QoS policy

2. **Automatically configure the link with "`auto qos`" command**

   Use "`show auto qos`" to display the QoS policy settings deployed

Deploying QoS for the Enterprise WAN - "Trust" Option for AutoDiscovery

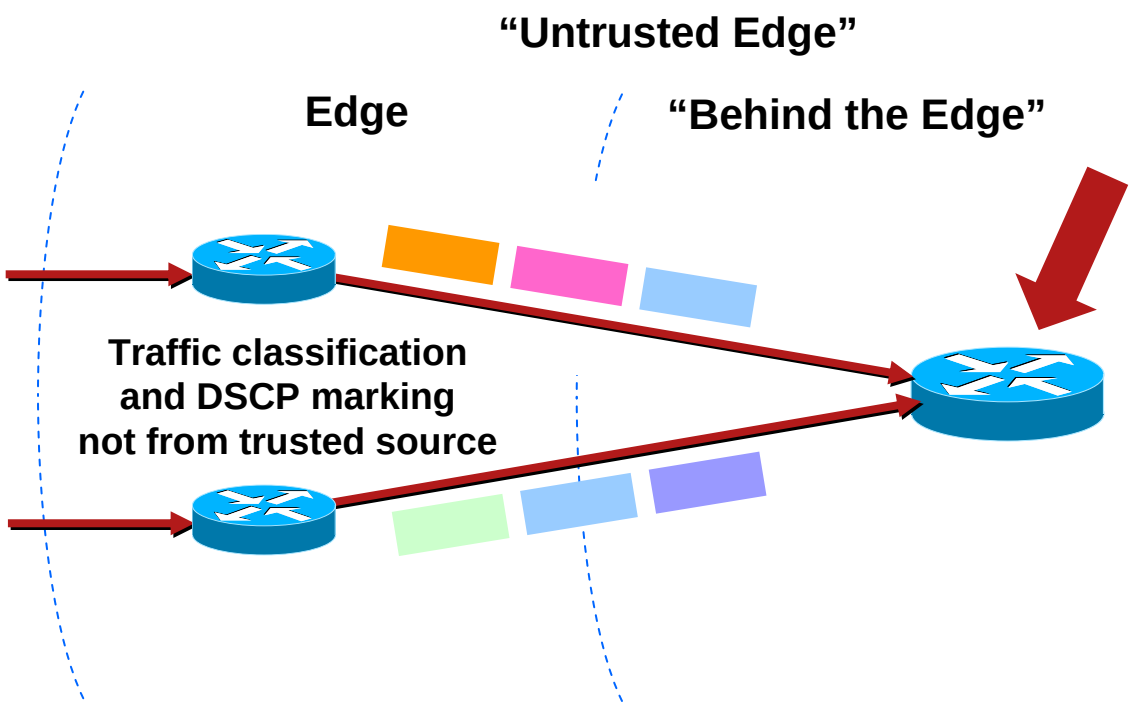


ACL = Access Control List
DSCP = Differentiated Services Code Point
MQC= Modular QoS Command Line Interface
NBAR = Network Based Application Recognition

>auto discovery trust

- Use when DSCP values are already assigned
  - AutoDiscovery does not inspect and reclassify traffic
  - QoS policy based on statistics for DSCP-marked traffic received by router

Deploying QoS for the Enterprise WAN - “Untrust” Option for AutoDiscovery



ACL = Access Control List

DSCP = Differentiated Services Code Point

MQC= Modular QoS Command Line Interface

NBAR = Network Based Application Recognition

>auto discovery

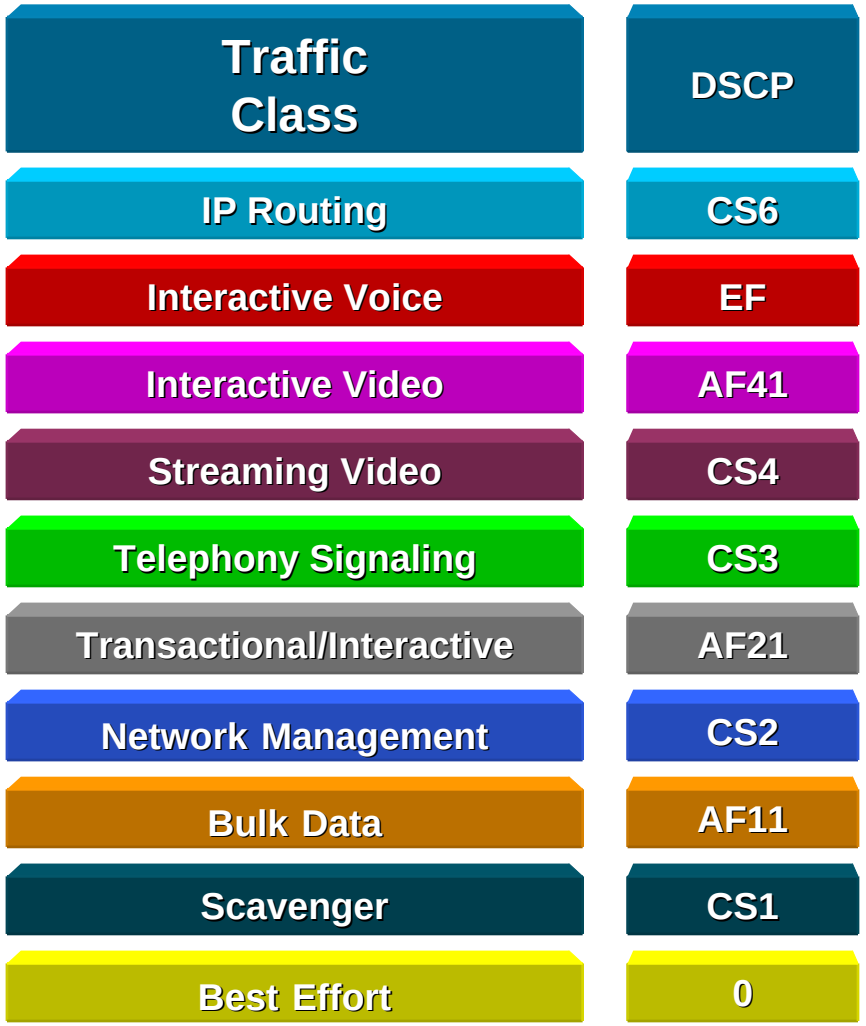
- This is the default mode for enabling AutoDiscovery
- Use when DSCP values and markings are not trusted

  AutoDiscovery inspects the traffic based on application properties using NBAR

  QoS policy based on statistics obtained using NBAR protocol discovery

Deploying QoS for the Enterprise WAN – Cisco AutoQoS DiffServ Class Provisioning

AutoDiscovery	Cisco AutoQoS Policy
Application and protocol-types	Cisco AutoQoS class-maps Match statements
Offered bit rate (average and peak)	Minimum bandwidth to class queues, scheduling and WRED



QoS Configuration *Without* Cisco AutoQoS

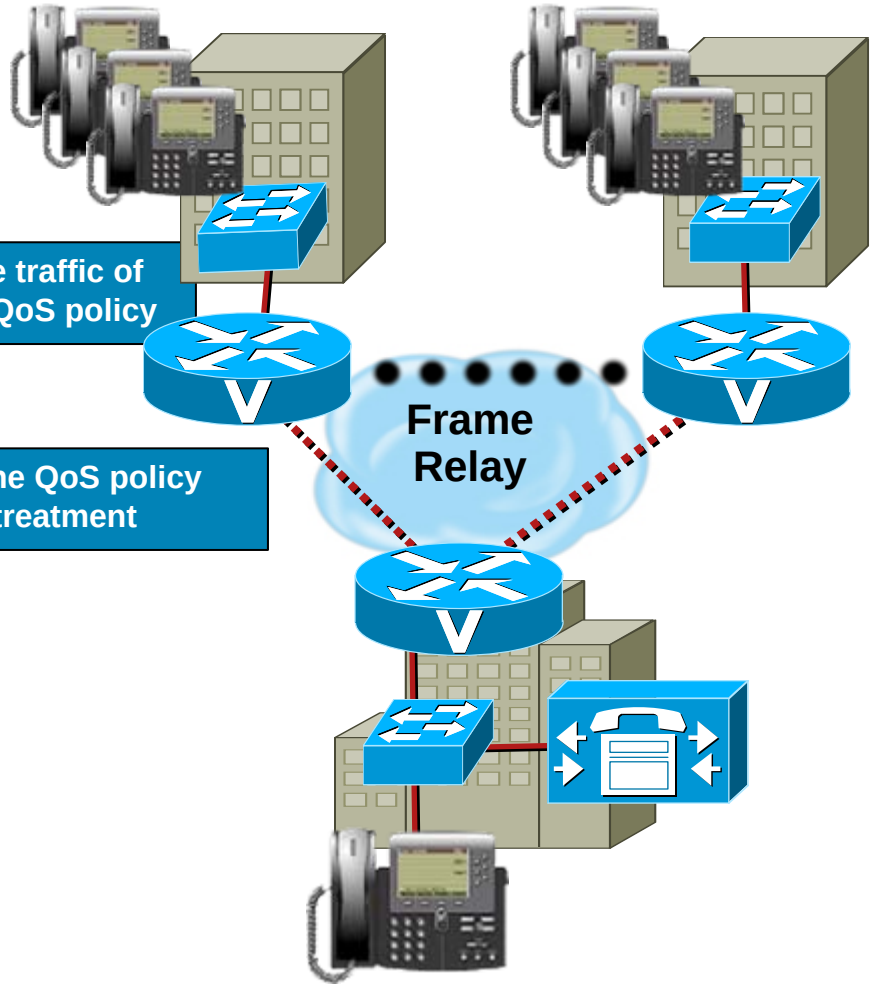
Without Cisco AutoQoS

Configuring QoS for voice, video and data on a low-speed FR WAN link

```
class-map VoIP-Bearer
  match protocol rtp audio
class-map Video
  match protocol rtp video
Class-map Transactional
  match protocol citrix
  match protocol sqlnet
!
policy-map QoS-Policy
 class VoIP-Bearer
   priority percent 25
   compress header ip
   set ip dscp ef
class Video
   bandwidth remaining percent 50
   compress header ip
   set ip dscp af41
Class Transactional
   bandwidth remaining percent 25
   random-detect
   set ip dscp af21
class class-default
   fair-queue
```

Classify the traffic of interest for QoS policy

Define QoS policy treatment



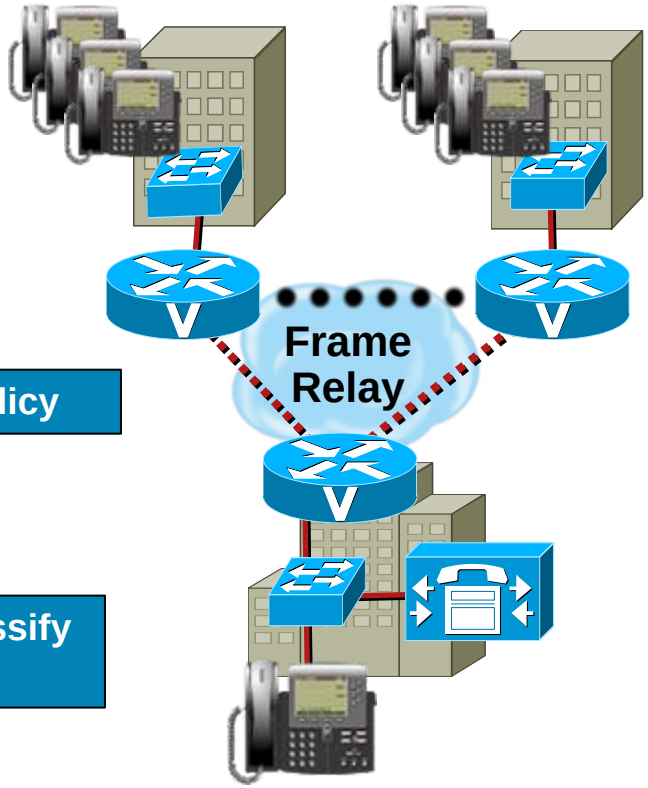
QoS Configuration *Without* Cisco AutoQoS (Cont.)

Without Cisco AutoQoS

```
Policy-map Parent
 class class-default
   shape average 256000
   service-policy QoS-Policy
!
interface Serial4/0
  encapsulation frame-relay
!
interface Serial4/0.1 point-to-point
 bandwidth 256
ip address 10.1.71.1 255.255.255.0
 frame-relay interface-dlci 100
  class FR-Policy
!
Map-class frame-relay FR-policy
  frame-relay fragmentation 320
  service-policy output Parent
!
Access-list 101 permit tcp any any eq 1720                    \\H.323
Access-list 101 permit tcp any any range 11000 11999 \\H.323
Access-list 101 permit udp any any eq 2427                   \\MGCP
Access-list 101 permit udp any any eq 2428                   \\MGCP
```

Apply QoS policy

Define ACLs to classify VoIP signaling



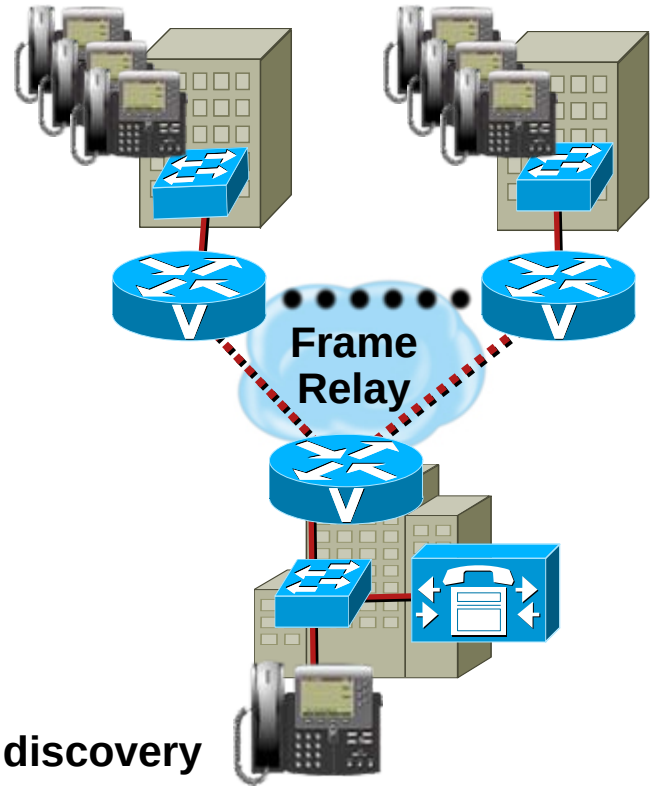
QoS Configuration *With* Cisco AutoQoS

With Cisco AutoQoS

Specify BW, IP address and FR DLCI

```
interface Serial4/0 point-to-point
Encapsulation frame-relay
bandwidth 256
ip address 10.1.71.1 255.255.255.0
frame-relay interface-dlci 100
  auto discovery qos
```

Enable AutoDiscovery



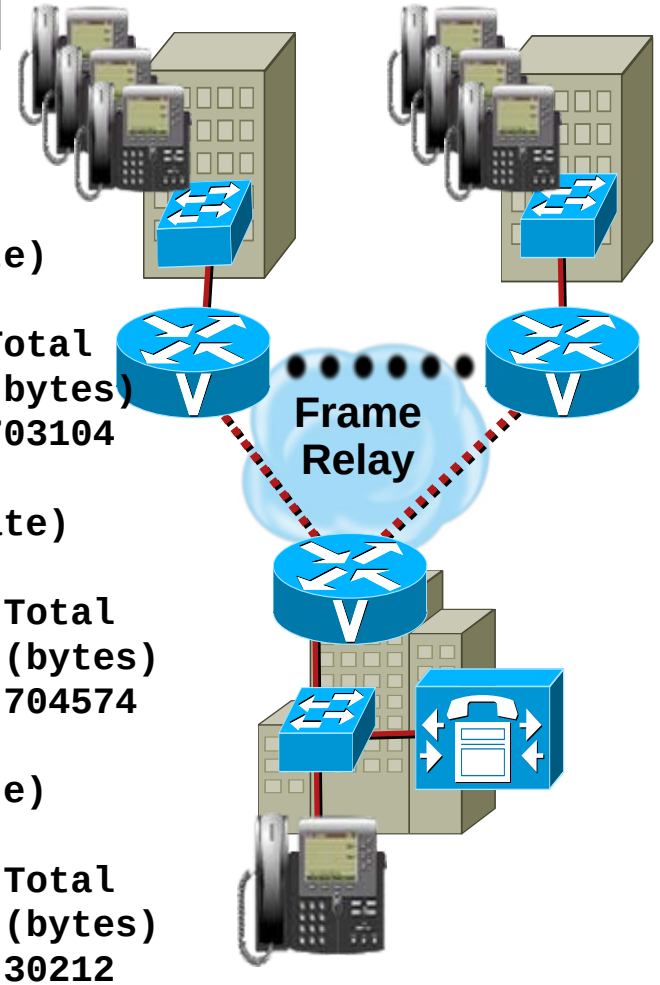
AutoDiscovery notes

- Enable on an interface of interest
- Do not change interface bandwidth when running auto discovery
- Cisco Express Forwarding must be enabled

QoS Configuration *With* Cisco AutoQoS (Cont.)

Review the generated QoS policy/statistics

```
show auto discovery qos
AutoQoS Discovery enabled for applications
 Discovery up time: 2 days, 55 minutes
 AutoQoS Class information:
 Class VoIP:
  Recommended Minimum Bandwidth: 517 Kbps/50% (PeakRate)
  Detected applications and data:
  Application/          AverageRate          PeakRate      Total
  Protocol              (kbps/%)             (kbps/%)      (bytes)
  rtp audio             76/7                 517/50        703104
 Class Interactive Video:
  Recommended Minimum Bandwidth: 24 Kbps/2% (AverageRate)
  Detected applications and data:
  Application/          AverageRate          PeakRate      Total
  Protocol              (kbps/%)             (kbps/%)      (bytes)
  rtp video             24/2                 5337/52       704574
 Class Transactional:
  Recommended Minimum Bandwidth: 0 Kbps/0% (AverageRate)
  Detected applications and data:
  Application/          AverageRate          PeakRate      Total
  Protocol              (kbps/%)             (kbps/%)      (bytes)
  citrix                  36/3                 74/7        30212
  sqlnet                  12/1                 7/<1        1540
```



Cisco AutoQoS Discovery – Suggested Policy

With Cisco AutoQoS

```
Suggested AutoQoS Policy for the current uptime:
 !
 class-map match-any AutoQoS-Voice-Et3/1
  match protocol rtp audio
 !
 class-map match-any AutoQoS-Inter-Video-Et3/1
  match protocol rtp video
 !
 class-map match-any AutoQoS-Signaling-Et3/1
  match protocol sip
  match protocol rtcp
 !
 class-map match-any AutoQoS-Transactional-Et3/1
  match protocol citrix
 !
 class-map match-any AutoQoS-Bulk-Et3/1
  match protocol exchange

policy-map AutoQoS-Policy-Et3/1
 class AutoQoS-Voice-Et3/1
  priority percent 1
  set dscp ef
 class AutoQoS-Inter-Video-Et3/1
  bandwidth remaining percent 1
  set dscp af41
 class AutoQoS-Signaling-Et3/1
  bandwidth remaining percent 1
  set dscp cs3
. . .
 class AutoQoS-Transactional-Et3/1
  bandwidth remaining percent 1
  random-detect dscp-based
  set dscp af21
 class AutoQoS-Bulk-Et3/1
  bandwidth remaining percent 1
  random-detect dscp-based
  set dscp af11
 class class-default
  fair-queue
```

Suggested policy is based on AutoDiscovery statistics

Options

- Continue AutoDiscovery (policy may change)
- Copy and change the policy (offline)

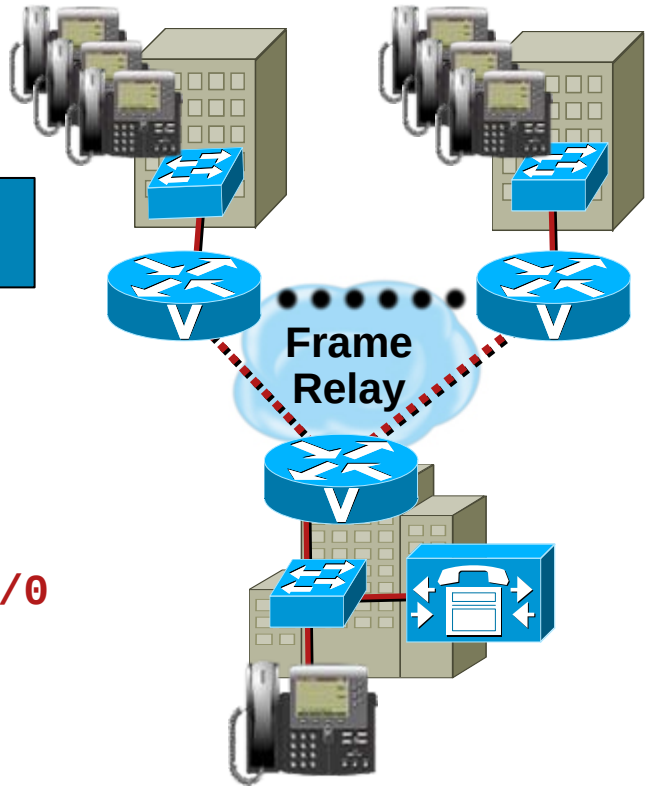
QoS Configuration *With* Cisco AutoQoS (Cont.)

With Cisco AutoQoS

```
interface Serial4/0 point-to-point
 bandwidth 256
 ip address 10.1.71.1 255.255.255.0
frame-relay interface-dlci 100
  auto qos
```

Apply generated Cisco AutoQoS policy

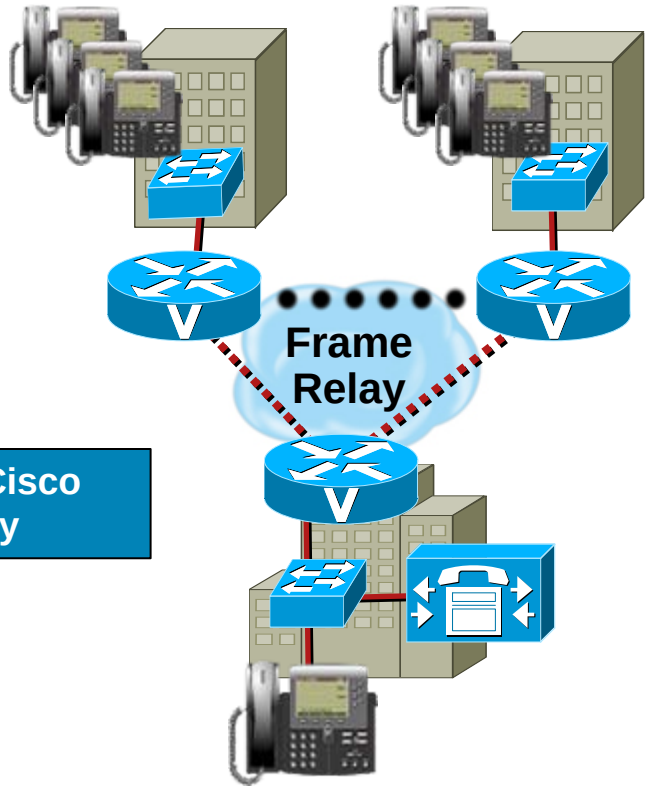
```
 policy-map AutoQoS-Policy-Se4/0-Parent
    class class-default
    shape average 256000
     service-policy AutoQoS-Policy-Se4/0
 !
  class-map match-any AutoQoS-Transactional-Se4/0
   match protocol sqlnet
   match protocol citrix
  class-map match-any AutoQoS-Voice-Se4/0
   match protocol rtp audio
  class-map match-any AutoQoS-Inter-Video-Se4/0
   match protocol rtp video
```



QoS Configuration *With* Cisco AutoQoS (Cont.)


```
policy-map AutoQoS-Policy-Se4/0
   class AutoQoS-Voice-Se4/0
    priority percent 70
    set dscp ef
   class AutoQoS-Inter-Video-Se4/0
    bandwidth remaining percent 10
    set dscp af41
   class AutoQoS-Transactional-Se4/0
  bandwidth remaining percent 1
    set dscp af21
   class class-default
    fair-queue
!
interface Serial4/0 point-to-point
  frame-relay interface-dlci 100
   class AutoQoS-FR-Serial4/0-100
!
map-class frame-relay AutoQoS-FR-Serial4/0-100
frame-relay cir 256000
frame-relay mincir 256000
frame-relay fragment 320
service-policy output AutoQoS-Policy-Se4/0-Parent
```

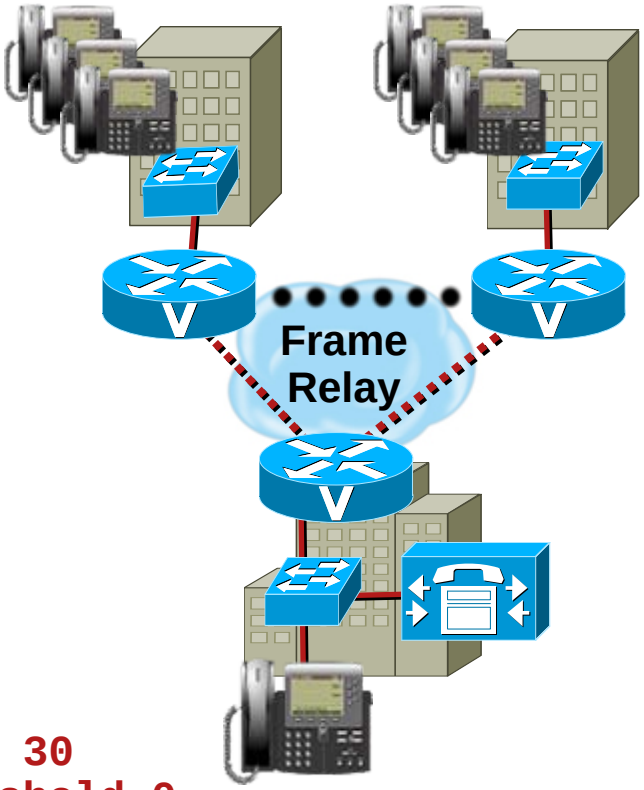
Apply generated Cisco AutoQoS policy



QoS Configuration *With* Cisco AutoQoS (Cont.)

Monitoring drops in LLQ

- Thresholds are activated in RMON alarm table to monitor drops in voice class
- Default drop threshold is 1bps




```
rmon event 33333 log trap AutoQoS description
“AutoQoS
SNMP traps for Voice Drops” owner AutoQoS

rmon alarm 33350 cbQoSCMDDropBitRate.2881.2991 30
Absolute rising-threshold 1 33333 falling-threshold 0
Owner AutoQoS
```

RMON event configured and generated by Cisco AutoQoS

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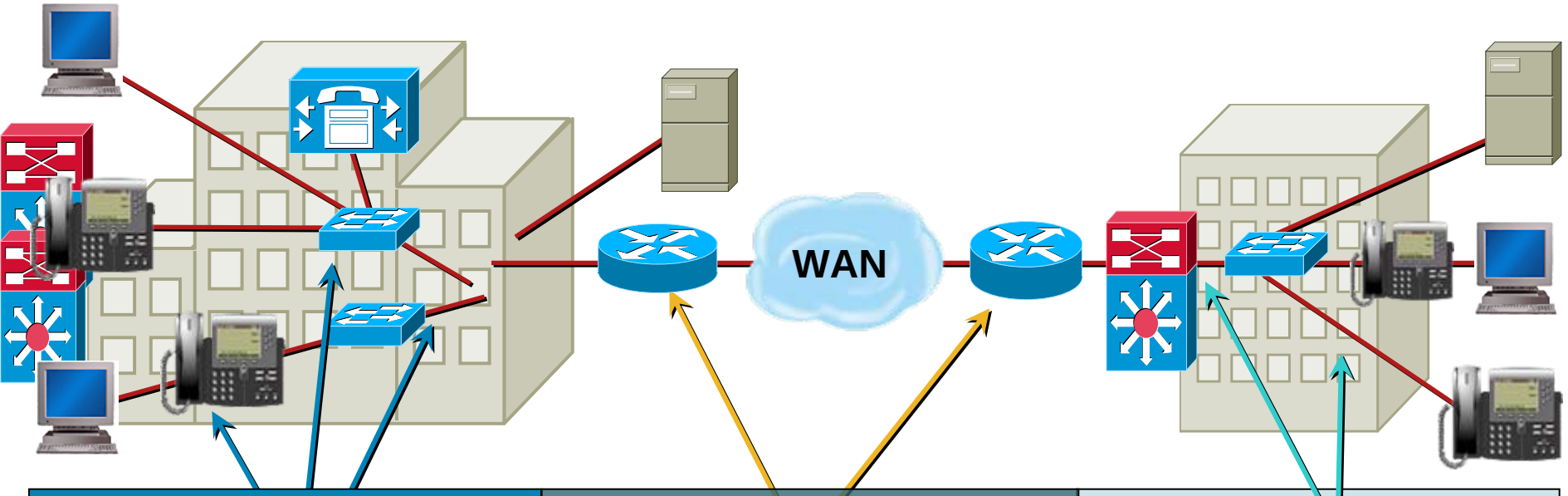
QoS Deployment for Converged Networks

Goal: deploy consistent, end-to-end QoS for voice, video, and data



Access Layer	WAN	Distribution Layer
• Classification and trust boundary • Marking / remarking • Egress queue scheduling • Buffer management	• Intelligent classification • Bandwidth provisioning • Admission control • shaping • Link fragmentation and interleaving • Header compression	• Layer 3 policing • Egress scheduling (multiple queues with WRR) • Priority queuing for VOIP • Buffer management

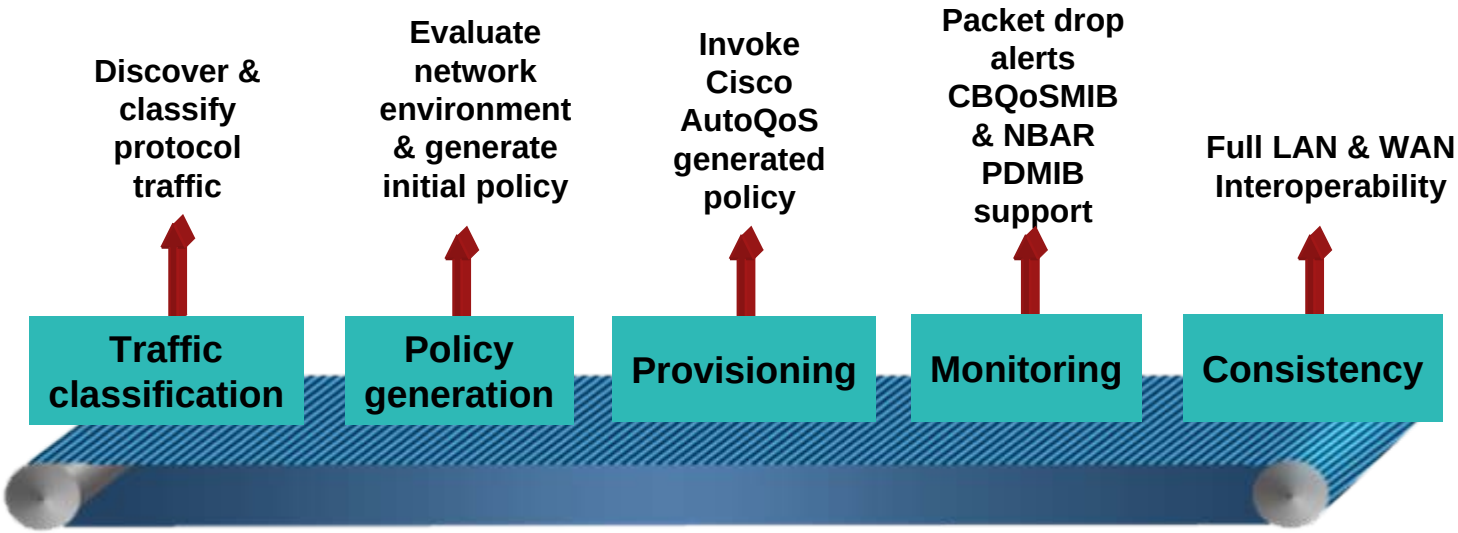
QoS Deployment for Converged Networks – Manual Approach without Cisco AutoQoS

- In the WAN
  - Identify applications and protocols of interest
  - Untrusted edge versus trusted edge
  - Remark traffic based on classification
  - Determine application to class of service mappings, and what queuing should be enabled
  - Determine class bandwidth requirements

QoS Deployment for Converged Networks – Manual Approach without Cisco AutoQoS

- In the WAN
  - Configure transport specific features
  - Traffic shaping, MLPPP and TX-ring settings
  - Enable bandwidth specific QoS features
  - Header compression and fragmentation settings (MLP/LFI or FRF.12)
  - Configure alarm and event settings for monitoring purposes

QoS Deployment for Converged Networks– Automation with Cisco AutoQoS



Accomplish all of the above in five steps

1. **Configure interface / sub-interface bandwidth**
2. **Configure IP address**
3. **Enable AutoDiscovery (trust, untrust)**
4. **Review and invoke Cisco AutoQoS generated policy**
5. **Fine-tune parameters, if required**

QoS Deployment for Converged Networks – Monitoring & Reporting with QPM 3.0

CLI

interface Serial0

–bandwidth 256

–Ip address 10.1.61.1 255.255.255.0

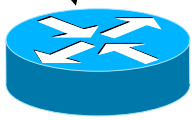
–auto qos

ppp multilink

ppp multilink fragment-delay 10

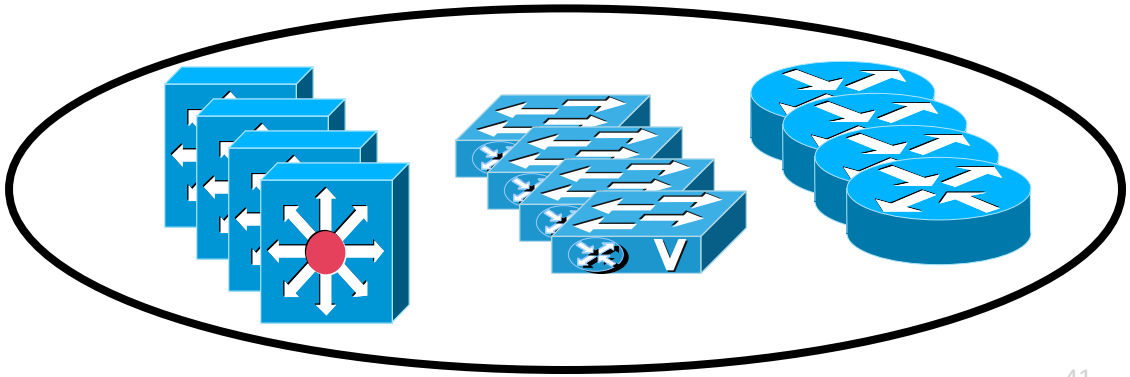
ppp multilink interleave

- **Device-based**
- **Single command**
- **Intelligent classification**
- **Reporting via syslog & traps**

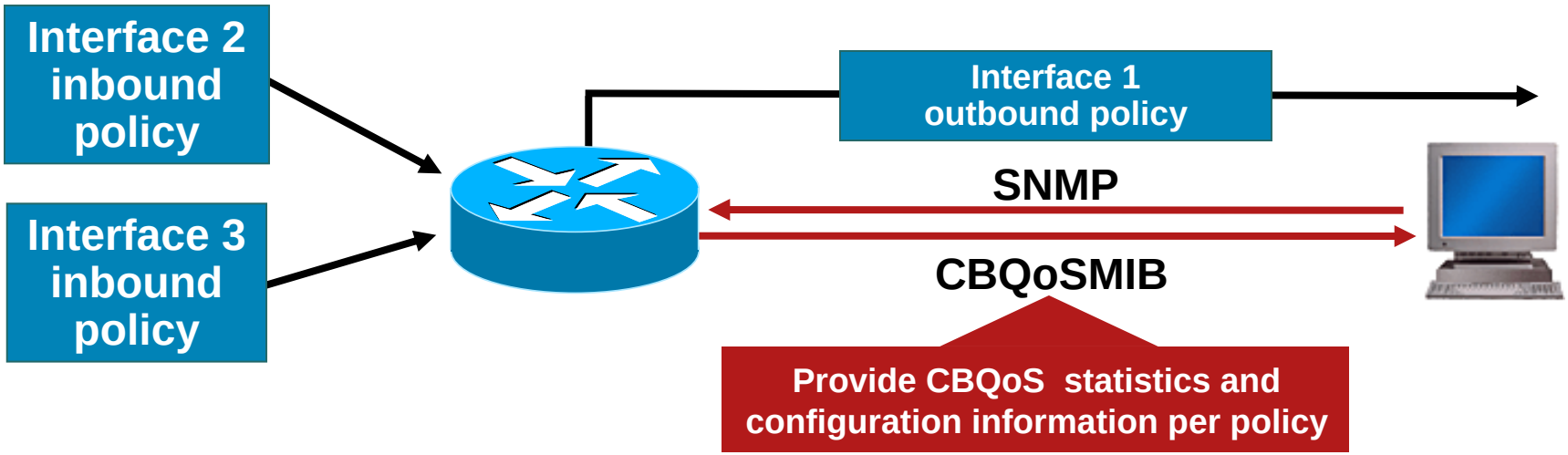


- **Central web-based tool**
- **QoS config guidance**
- **Templates, customize**
- **Deployment control**
- **File export**

- **Monitoring**
- **Reports**
- **Troubleshooting**
- **Multi-device, global**



QoS Deployment for Converged Networks – Class-Based QoS MIB (CBQoSMIB)



- Primary accounting mechanism for MQC-based QoS
- Statistics for active MQC configuration on a per-policy/ per-interface or PVC basis
- Monitor pre- and post- policy bit rates

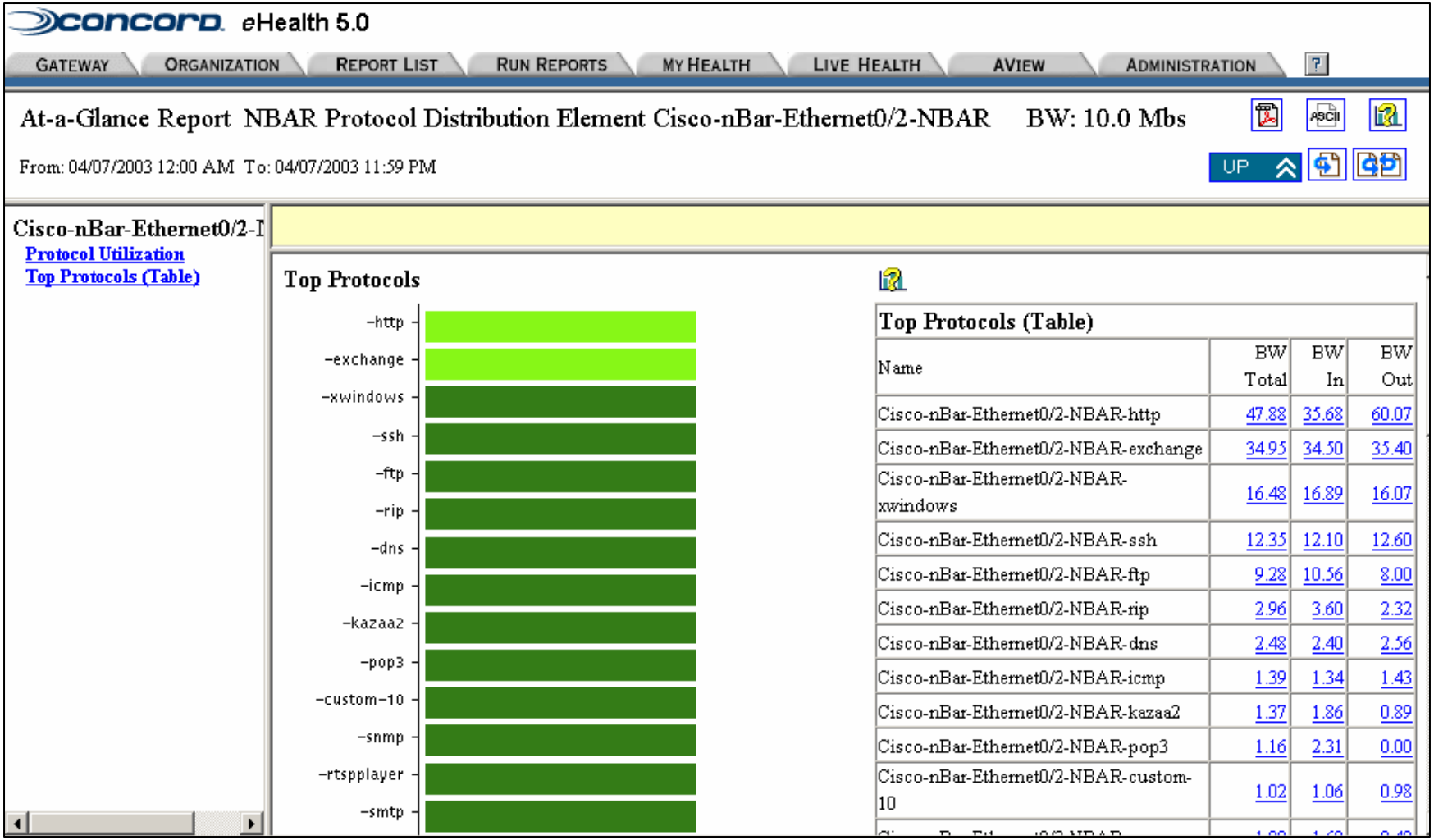
  For example, “How many packets are being dropped or marked?”
- Read access only, no SNMP configuration
- Support introduced in Cisco IOS® Software Release 12.1(5)T

  ftp://ftp.cisco.com/pub/mibs/v2/CISCO-CLASS-BASED-QOS-MIB.my

QoS Deployment for Converged Networks - Cisco NBAR Protocol Discovery MIB

- Benefits
  - Real-time applications statistics
  - Per-interface, per-application, bi-directional (input and output) statistics: bit rate (bps), packet bounts (pps), byte counts
  - User can set thresholds on individual protocols on an interface, or on a statistic regardless of protocol
  - If the threshold is breached, the information is stored for prolonged period of time
  - A notification (trap) is generated and sent to the user with a summary of threshold information

Cisco NBAR Protocol Discovery MIB Top Application Bandwidth Usage



Agenda

- Introduction
- Cisco AutoQoS Framework
- Automation with Cisco AutoQoS
- Cisco AutoQoS for the Enterprise - Deployment Case Study
- Summary

Highlights – Cisco AutoQoS in the WAN

- Simplifies QoS configuration for voice, video, and data with a two-step process
  - AutoDiscovery
  - Provisioning
- End-to-end simplification, automation, and intelligence
  - Classifies VoIP bearer and signaling traffic, real-time and streaming video and data traffic
  - Provisioning based on Cisco best practices
- Generated parameters and configuration can be modified by the user

Highlights – Cisco AutoQoS in the WAN (Cont.)

- Intelligent policy generation
  - Based on available bandwidth, traffic profile and underlying L2 technology
  - Automatically provisions up to 10 different classes of service
  - Decides on fragmentation settings (FRF.12, MLP/LFI) and enables RTP header compression, if required
- Supported on FR, ATM, HDLC, PPP and FR-to-ATM links
- Provides RMON alerts, for packet drops in VoIP class

The Cisco Advantage – Comprehensive QoS Functionality

- First to ship advanced Differentiated Services (DiffServ) toolkit in 2000
- Comprehensive QoS language framework via MQC
- First to ship intelligent, application-level classification (NBAR)
- Complete QoS monitoring and reporting support with Cisco Works QPM 3.0, Concord, and SDM
- Broadest QoS hardware support (switches and routers)
- Full interoperability across the LAN and WAN DiffServ nodes
- Provides complete end-to-end DiffServ solution

First to ship QoS automation & simplification

Availability

	Hardware	Software
Switches	Cisco Catalyst® 2950EI Cisco Catalyst 3550	Release 12.1(12c)EA1
	Cisco Catalyst 4500 Series	Release 12.1(19)E
	Cisco Catalyst 6500 Series	Cisco Catalyst Operating System 7.5.1
Routers	Cisco 1700 Series Cisco 1800 Series Cisco 2600XM Series Cisco 2800 Series Cisco 3700 Series Cisco 3800 Series Cisco 7200 Series Cisco 7500 Series	Cisco AutoQoS VoIP: Release 12.2(15)T Cisco AutoQoS Enterprise: Release 12.3(7)T

References

- QoS Home Page

  www.cisco.com/go/qos

- Cisco AutoQoS Enterprise Technical Documentation

  www.cisco.com/en/US/products/sw/iosswrel/ps5207/products_feature_guide09186a00802000a7.html

- Cisco IOS Software Release 12.4 mainline

  http://www.cisco.com/en/US/products/ps6350/prod_bulletin09186a0080457b39.html