

Welcome!

Quality of Service for Voice over IP (from a telephony point of view)

by
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About Bruce Enders

- Has been delivering voice-over training and consulting services for over 5 years.
- Began as a “telephone” person, became a “networking” person
- Has worked in many facets of the telecom/datacom industry
- Experienced in all 4 voice technologies

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Agenda

- **What is Quality of Service (QoS)?**
 - Qos and PBX
 - Traffic Types
- **What is Voice over IP (VoIP)?**
 - Traffic characteristics
 - VoIP concerns
- **Operation of QoS**
- **Implementing QoS**

What is Quality of Service?

“Quality of Service (QoS) on data-link layer (layer 2 of OSI Model) includes features for traffic prioritization and bandwidth management to minimize network delay using Class of Service (CoS) classification, marking, scheduling and policing.”

Or Put Another Way . . .

- **Quality of Service represents how good (or bad) the audio information in our voice networks sounds to the end users making phone calls**
- **“Beauty is in the ear of the beholder”**

Why Should You Care?

- **Your job might depend on it**
- **You, or your co-workers health or even lives might depend on it**
 - **Example 911 Service**
- **A telephone system without QoS is just a bunch of useless noise**
- **Voice on a data network needs QoS**

Does QoS exist in PBXs?

- **Yes, but not an issue in most PBXs**
- **Legacy PBX systems are based on circuit-switched technology**
 - All bandwidth on the circuit was dedicated to one call
 - Audio QoS was the default as the PBX connected the two end points
 - Operating in “real time” was easy
 - Only the Laws of Physics (and bad wiring practices) limited QoS

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PBX and QoS

- **Legacy PBXs utilize a separate network infrastructure to transport the voice information**
- **No requirement to co-exist with other information, other than call signaling**

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What is VoIP?

- **Not data traffic**
- **Not legacy voice on a PBX**
- **Integration of voice over data networks**

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Data traffic is ...

- **Inconsistent**
 - Sometimes a trickle
 - Sometimes a torrent
- **Not usually “real-time”**
 - If it encounters delays, there is no disaster
 - Most traffic has a “re-transmission” function

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Voice traffic is . . .

- **Consistent**
 - Traffic is predictable
 - The network bandwidth needed per call is “fixed”
- **“Real-time”**
 - Service is real-time stream of information
 - No re-transmission facility built-in
 - Delay degrades audio “QoS”

Voice Over IP (VoIP) traffic . . .

- **Runs on the same network infrastructure as “Data” information**
- **Effected by more than just the Laws of Physics in the PBX**
- **VoIP should “peacefully co-exist” with “Data”**
“Network” QoS makes this possible

Remember -- it's called Voice over IP

- VoIP is an “Overlay” technology
 - VoIP is applied **on top of** an IP Network
 - If the IP network is not working properly VoIP will simply be one more thing that is broken
- Make sure the IP network is working correctly **FIRST**
-- then implement VoIP

LAN Concerns

- Queuing delays
- Congestion at aggregation points causing packet delay or loss
- Establishing “Trust Boundaries” for traffic entering the network

WAN Concerns

- **Queuing delays**
- **Congestion delays**
- **Serialization delays on slow links**
<768Kbps
- **Service Provider packet drops**
- **Over subscription of bandwidth**
 - **Possible fixes**
 - **Consider using TCP and RTP header compression to reduce bandwidth consumption**
 - **Use Call Admission Control (CAC)**

VoIP Concerns

- **Packet drops**
 - **Packets get dropped?**
- **Latency**
 - **Fixed delay from end-to-end**
- **Jitter**
 - **Variable delay**
- **Priority**
 - **Waiting in line**

Packet Drop

- **“Dirty or unstable” networks will not support VoIP**
- **QoS won't repair unstable networks**
 - If the network is losing packets ...
 - FIX NETWORK
 - If congestion is causing queues to overflow ...
 - REMOVE CONGESTION
 - If your WAN Service Provider is dropping your packets ...
 - GET THEM TO CORRECT, OR GET NEW SP

Latency

- **Codec Delay**
- **Queuing Delay**
- **Serialization Delay**
- **De-Jitter Buffer Delay**
- **Processing Delay**
- **Propagation Delay due to distance**

When is Latency Excessive?

- **End-to-end delay exceeds 350-400msec**
- **If this is your network, change it**
 - Get your network infrastructure out of the '80s and into the '00s
- **If fixed delay is this high, go buy your users field telephones, the voice quality will be the same**

Jitter

- **Jitter is variable delay**
 - Usually caused by congestion or transmission delays
- **Can have more impact on VoIP QoS than latency**
- **Most common culprits**
 - Serialization delays on slow links
 - Queuing delays
- **Can cause packet drops**

Priority

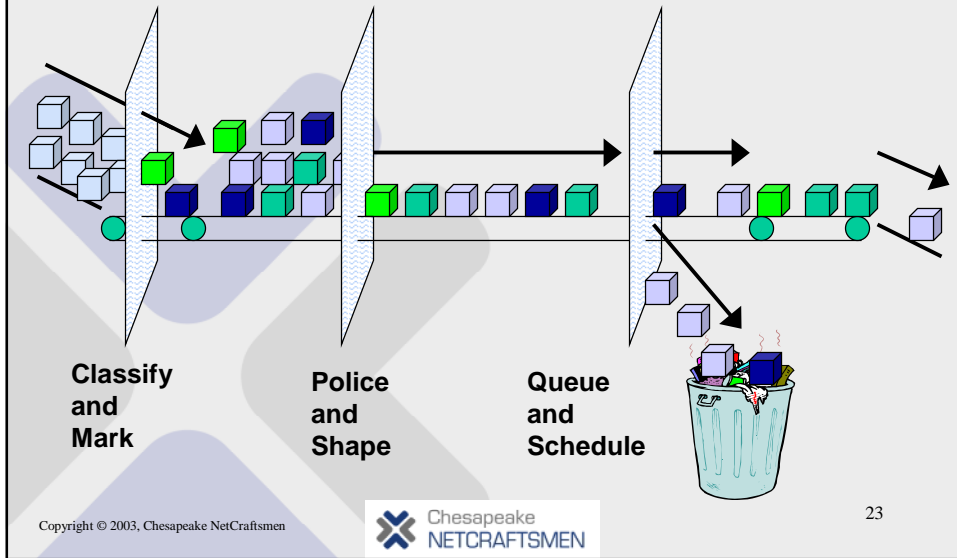
- Without priorities all traffic has to compete equally for available resources. **All** traffic “waits”
 - Can you say “Jitter”?
- With priorities, “VoIP” traffic can be given preference over “Data” traffic
 - Allows consistent smooth transmission
 - Helps maintain QoS levels

QoS to the Rescue

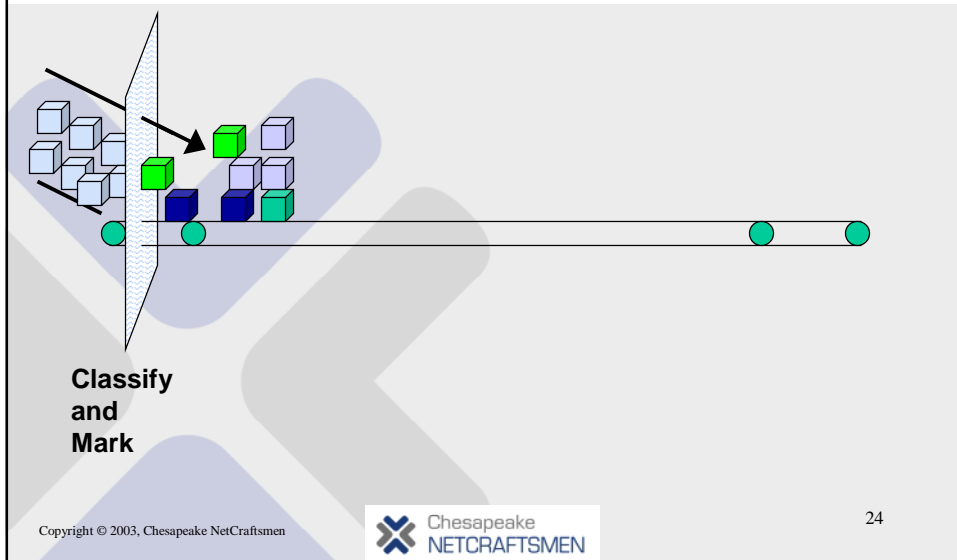
- QoS addresses these concerns!



Operation of QoS



Classifying and Marking



Classifying and Marking

- Use Layer 2 and Layer 3 marking to label “Express” traffic
- We can control the type of handling “Express” traffic receives
 - Low-end switches can use L2 marking
 - High-end switches can use L2 & L3 marking
 - Routers and WAN can use L3 marking

What are the Markings?

- Class of Service (CoS) – Layer 2
- Differentiated Services Code Point (DSCP) – Layer 3
- Each of these represent our “Express Handling” labels at their respective layers of the network

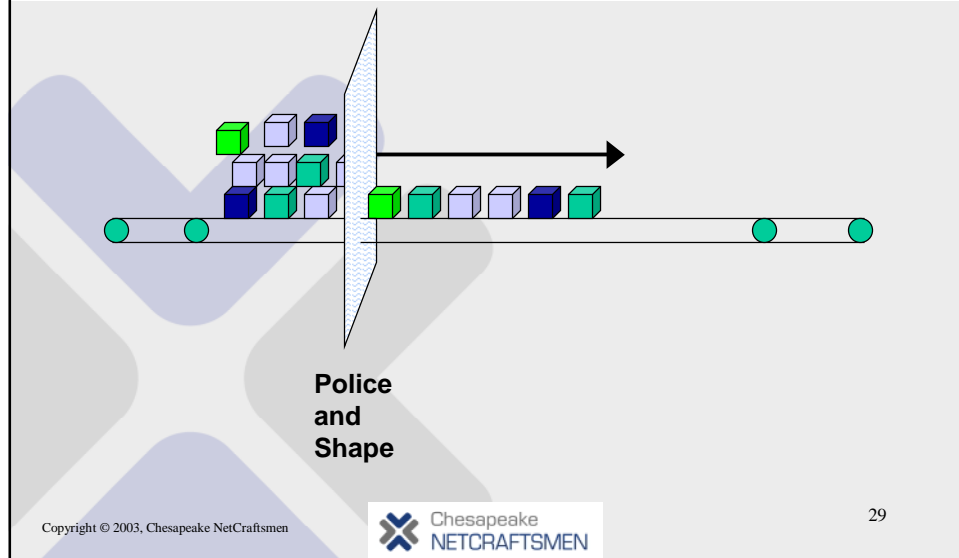
Where do I Mark?

- **Having phones or software doing the marking at the network “edge” is the key to QoS**
 - Establishing a “Trust Boundary”
- **Once labeled, “Express handling” can be established for our “Special” traffic at each interface within the enterprise network**

How do I Mark?

- **Cisco IP telephones mark their traffic by default**
- **You don't *have* to do anything**
- **You can change it if you find you need to**

Policing and Shaping



Policing and Shaping

- **Policies are established to determine which traffic is handled in what manner**
- **Traffic shaping can smooth transmissions and help avoid packet discards**

What is available? (buzz words)

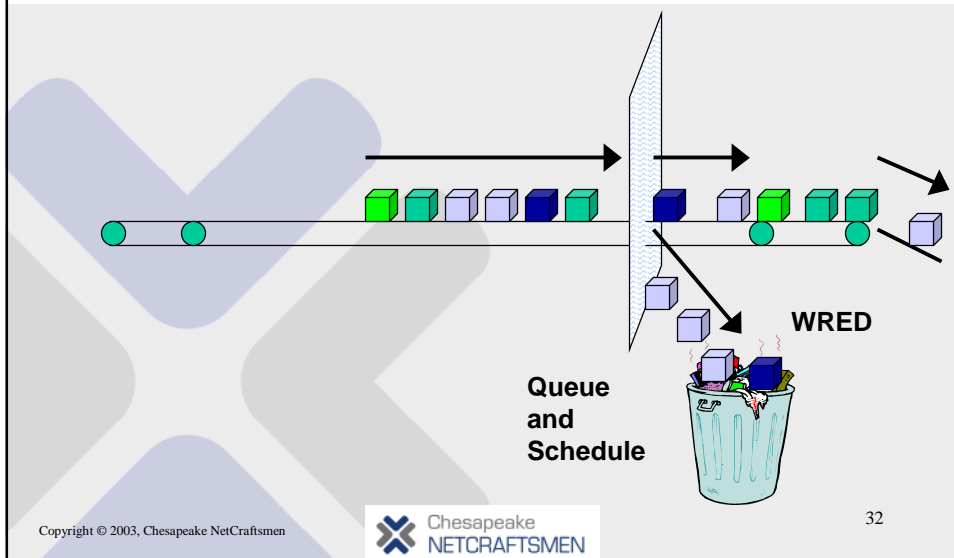
- CAR can establish rate limits at the interfaces
- GTS and FRTS to avoid traffic discards
- LLQ can set absolute priorities up to a point
- CBWFQ can establish minimum bandwidth available for VoIP

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Queuing, Scheduling, and Packet Dropping



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Queuing Techniques – Historical

- FIFO
- Priority Queuing (PQ)
- Custom Queuing (CQ)
- Weighted Fair Queuing (WFQ)



Queuing Techniques – Modern (buzz words)

- Class-Based Weighted Fair Queuing (CBWFQ)
 - dWFQ, FdWFQ (Flow dWFQ), ToS-WFQ
- Weighted Round Robin (WRR)
- Modified Deficit Round Robin (MDRR)
- *Weights determine frequency of queue servicing (WFQ, CBWFQ) or ratio of queue servicing (WRR)*

Packet Scheduling: Prioritization

- **PQ-WFQ (Priority Queuing for WFQ)**
 - First attempt
- **LLQ (Priority Queuing for CBWFQ)**
 - Final cut

Packet Dropping Techniques

- **Tail Drop**
- **Weighted Random Early Detection (WRED)**
 - Distributed:
dWRED
 - FBWRED
(Flow-Based WRED)



Where should you implement network QoS?

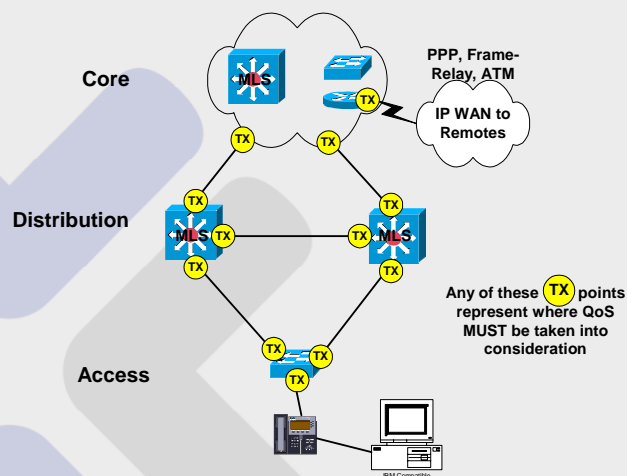
- At all transmission points
 - At the WAN edge
 - Anywhere there is a speed mismatch
 - Slow WAN links
 - “Many-to-One” aggregation points
 - Anywhere voice traffic may have to “wait” for non Real-Time traffic to be sent

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Network Example



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Sounds Like a Lot of Work!

- **Configuring QoS at each and every interface in the network can be a daunting task**
- **Missing just one transmission point can have a negative impact on QoS for all traffic that crosses that point**
- **“The complexity is beyond me”**

Cisco and QoS

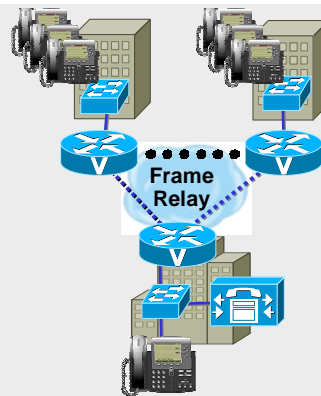
- **Cisco supports QoS from end-to-end**
- **Cisco gives you all the QoS tools and services you need to maintain Quality of Service within your network**
- **All the knobs and buttons are available to insure good QoS**

QoS is integrated

- Cisco routers and switches are built with QoS in mind
- WFQ, CBWFQ, LLQ, LFI, DSCP, FRTS, and more
- All you have to do is turn it on
- Modular QoS Command Line (MQC) is one method you can use

Configuration Starting Point

```
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
```



QoS with MQC - Example

```

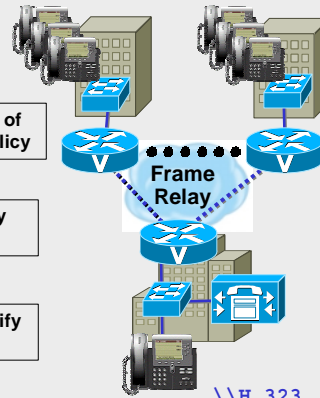
class-map VoIP-Bearer
  match protocol rtp audio
class-map VoIP-Control
  match access-group 101
!
policy-map QoS-Policy
  class VoIP-Bearer
    priority percent 30
    set ip dscp ef
  class VoIP-Control
    bandwidth percent 5
    set ip dscp af31
  class class-default
    fair-queue
!
Access-list 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
Access-list 101 permit tcp any any range 2000 2002 //Skippy

```

Classify the traffic of interest for QoS Policy

Define QoS Policy Treatment

Define ACLs to classify VoIP Signaling



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QoS with MQC – Cont.

Enabling FRTS, FRF.12 & CRTP

```

interface Serial4/0
  encapsulation frame-relay
  frame-relay traffic-shaping
!
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 VoIP
  frame-relay ip rtp header-compression
!
map-class frame-relay VoIP
  frame-relay cir 256000
  frame-relay bc 2560
  frame-relay be 0
  frame-relay mincir 256000
  service-policy output QoS-Policy
  frame-relay fragment 320

```

Enable Frame Relay Traffic Shaping

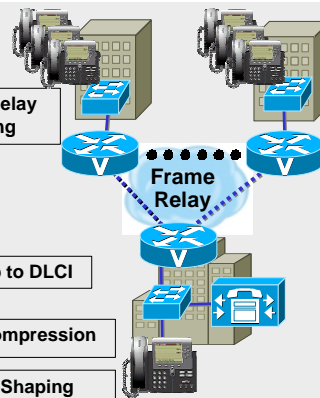
Apply FR class-map to DLCI

Enable RTP Header Compression

Frame Relay Traffic Shaping

Apply QoS Policy

Enable FRF.12



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Lots of commands

- That was roughly 28 strings of CLI
- Some level of planning had to take place for you to know where to type what
- *Someone* had to determine a policy in advance
- That was one router and one interface

HOLY Mackerel!
Give me back my Butt-set and punch tool!
Tip and Ring was never like this!

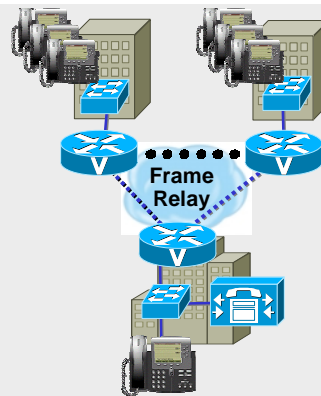


Let's try that again ...

- **Only this time with AutoQoS!**
 - You don't have to be a QoS expert
 - You don't have to be a network GURU
- **AutoQoS helps make you "QoS Smart"**

Configuration Starting Point

```
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
```



QoS With AutoQoS

```

interface Serial4/0
 encapsulation frame-relay
 frame-relay traffic-shaping
!
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 AutoQoS-VoIP-FR-Serial4/0-100
 auto qos voip
 frame-relay ip rtp header-compression
!
map-class frame-relay AutoQoS-VoIP-FR-Serial4/0-100
 frame-relay cir 256000
 frame-relay bc 2560
 frame-relay be 0
 frame-relay mincir 256000
 service-policy output AutoQoS-Policy-UnTrust
 frame-relay fragment 320
    
```

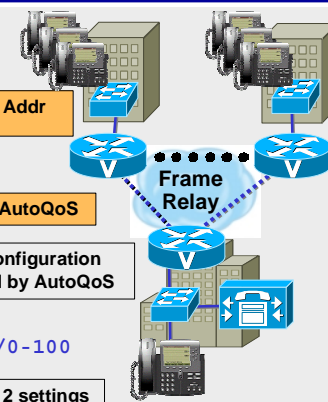
FRTS enabled by AutoQoS

You specify BW, IP Addr & FR DLCI

You enable AutoQoS

CRTP configuration generated by AutoQoS

FRTS & FRF.12 settings generated by AutoQoS



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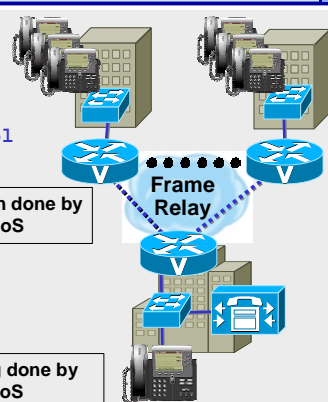
QoS With AutoQoS – Cont.

```

class-map match-any AutoQoS-VoIP-RTP-Untrust
 match protocol rtp audio
 match access-group name AutoQoS-VoIP-RTCP
class-map AutoQoS-VoIP-Control-Untrust
 match access-group name AutoQoS-VoIP-Control
class-map match-any AutoQoS-VoIP-Remark
 match ip dscp ef
 match ip dscp af31
!
policy-map AutoQoS-Policy-Untrust
 class-map AutoQoS-VoIP-RTP-Untrust
  priority percent 70
  set dscp ef
 class AutoQoS-VoIP-Control-Untrust
  bandwidth percent 5
  set dscp af31
 class AutoQoS-VoIP-Remark
  set dscp default
class class-default
 fair-queue
    
```

Classification done by AutoQoS

Provisioning done by AutoQoS



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Simple is good!

All the QoS configurations were done
with one CLI statement

auto qos voip

All the rest were added automatically
(I guess that is why they call it
AutoQoS)

Wow! That's pretty slick!

You don't have to develop a QoS policy –
basic policy is done for you

You get to take advantage of lots of VoIP
implementation experience

You get to set up QoS based on all of the
“Best Practices” developed during those
implementations

You can still do your own fine tuning if you
see the need

In Summary

- QoS is necessary for a successful “Voice” network of any type
- There are lots of QoS considerations
- There are lots of tools in MQC
- AutoQoS can allow them to be used without being a network or QoS “Expert”

For More Information ...

Cisco QoS Home Page

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

IP Telephony Solutions

http://cisco.com/univercd/cc/td/doc/product/voice/ip_tele/index.htm

Main index at CCO

<http://cisco.com/univercd/cc/td/doc/product/voice/index.htm>

Questions

Any Questions?

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THANK YOU FOR YOUR ATTENTION

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