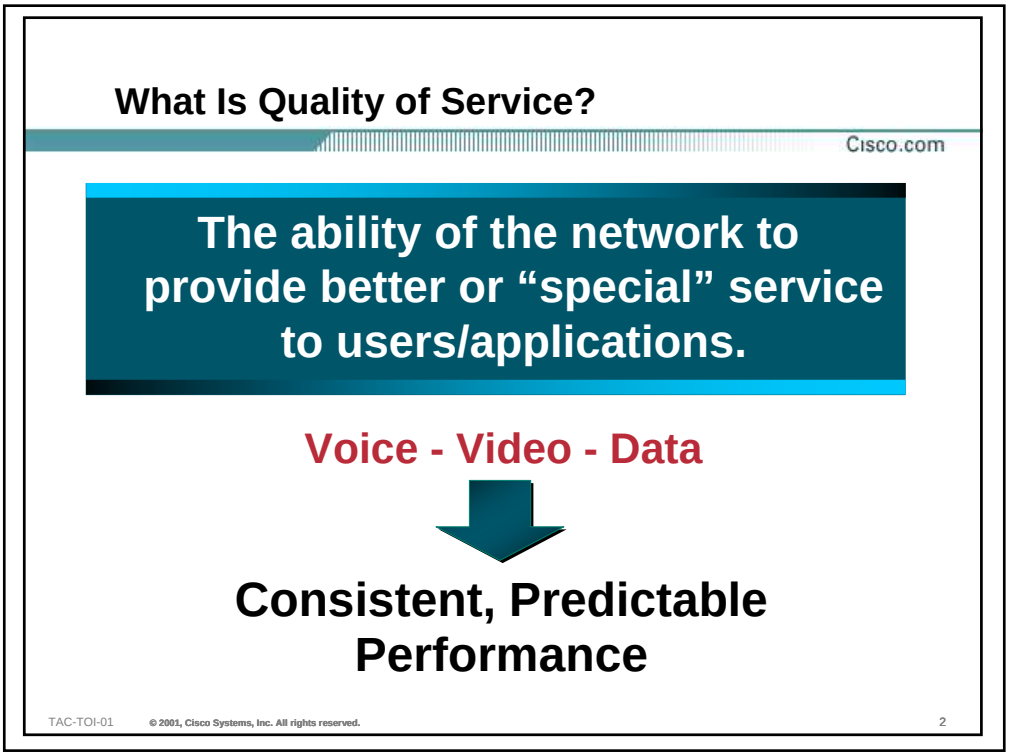

Not All Traffic Is Equal

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	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

Traffic Is Grouped into SLAs

Step 1: Identify Traffic and its Requirements

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- **Network audit**
  - **What is running and when?**
- **Business audit**
  - **How important is it for business?**
- **Application audit**
  - **What are it's requirements from network?**
- **Service levels required**

Step 2: Divide the Traffic into Classes and Color It

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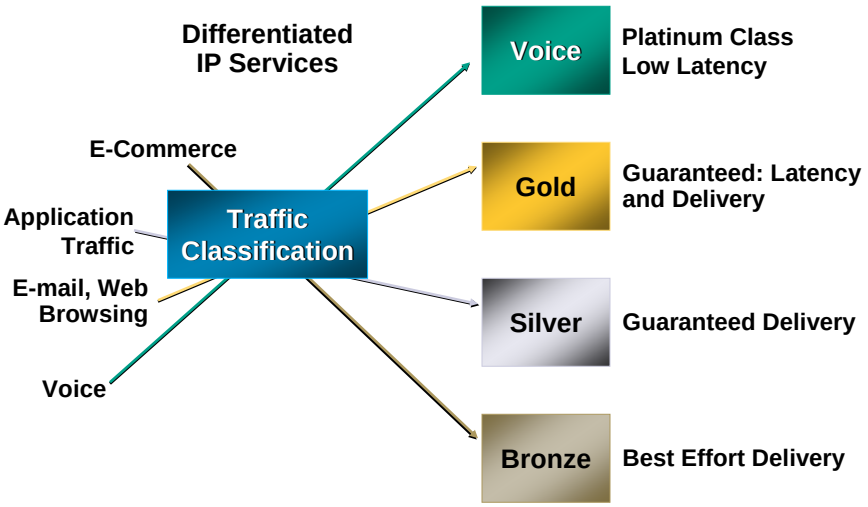

What Is a Class?

Cisco.com

- **Single user**
  - **MAC address, IP address…**
- **Department, customer**
  - **Sub net, interface…**
- **Application**
  - **Port numbers, URL…**

What Is Coloring? IP Precedence & DiffServ

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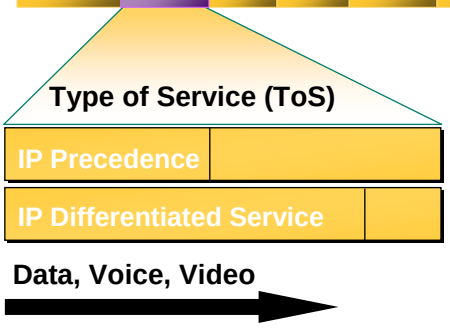
IP Packet



- Use ToS field to signal business QoS policies
- Differentiate network services across any media or topology

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Coloring at Layer 2 and Layer 3

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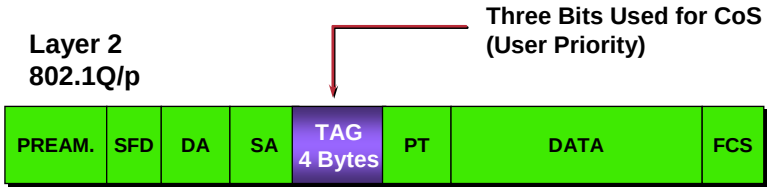
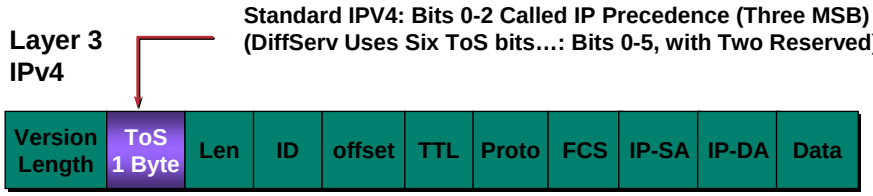
Layer 2
802.1Q/p



Layer 3
IPv4



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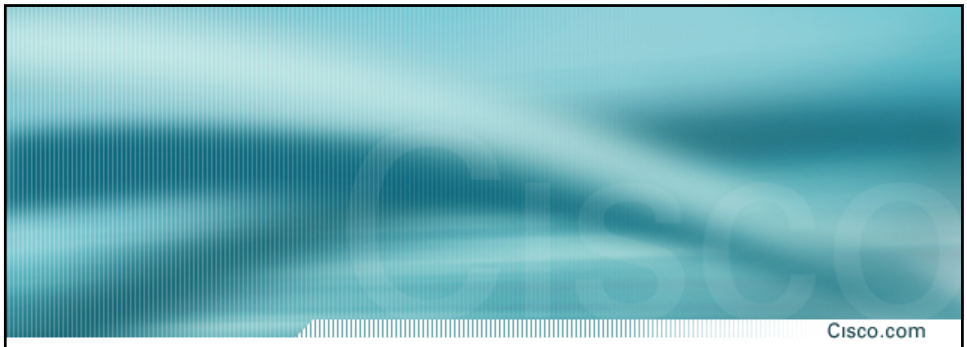

!! Detour !! Differentiated Services (DiffServ)

The Formula for Scalable QoS

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**

How DiffServ Works
Step 1: Classifying Packets into Classes

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- 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"

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

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- 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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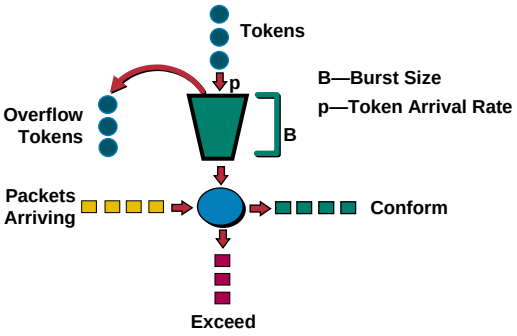
- Tokens keep pouring into the bucket at a pre-defined average-rate
- If Token available, can transmit a packet
- Used by policer and shape



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

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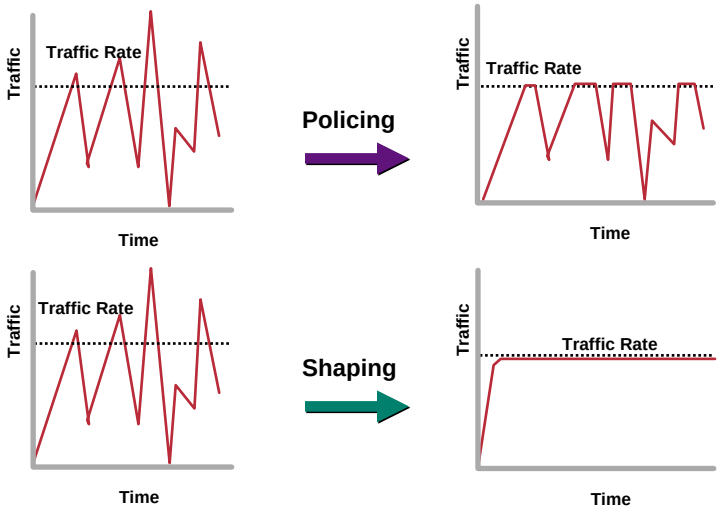

On Policing…

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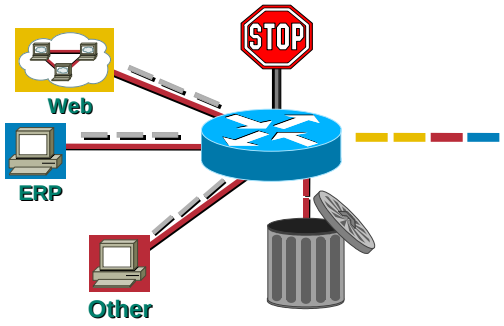
- Policing is used not only to drop out-of-profile packets, but also to re-mark them, and indicate to dropping mechanisms downstream that they should be dropped ahead of the in-profile packets!



Direction of Traffic Flow

On Shaping…

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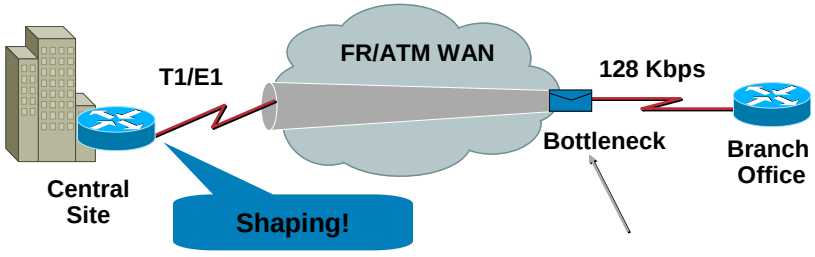
- Shaping is commonly used where speed-mismatches exist (e.g.: Going from a HQ site with a T1/E1 connection to a Frame-Relay Network, down to a remote site with a 128Kbps connection)
- Shaping involves buffering, and various queuing/scheduling techniques may be used when the shaped rate is reached!



Direction of Traffic Flow

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

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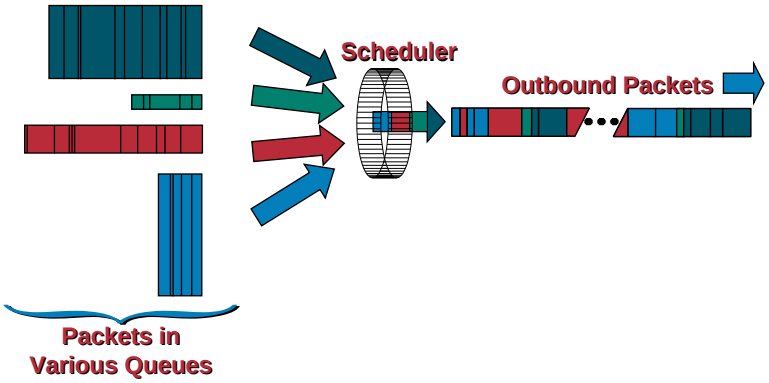
- **Queuing refers to: (congestion management)**
  - **Buffering packets when interface is congested**
  - **Scheduling packets out of the buffer onto the link (Algorithms: FIFO, CBQ, WRR, etc…)**



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

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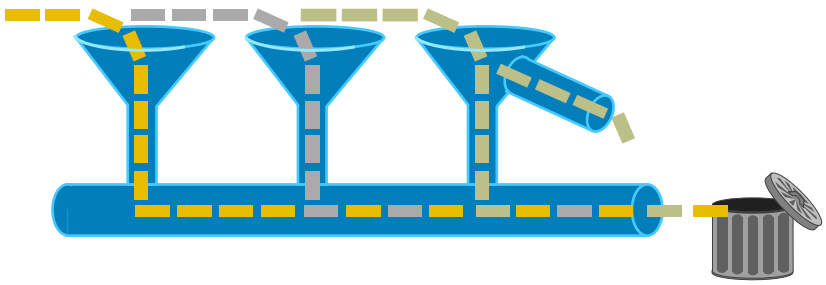
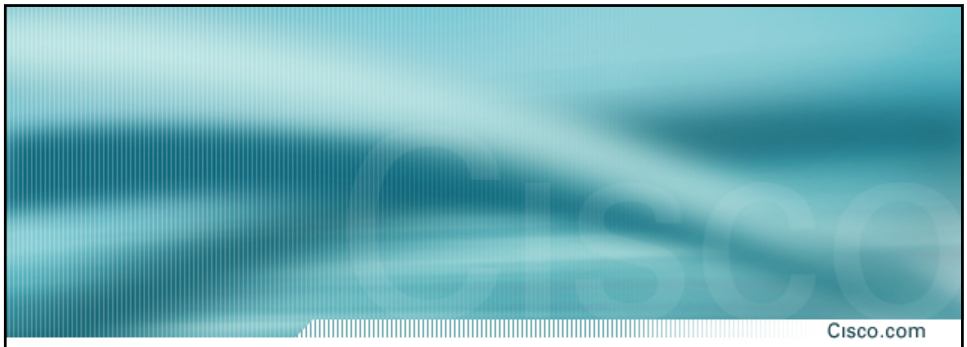
- **Dropping can happen:**
  - **At the edge when policing**
  - **In the edge/core when buffers are exhausted and signal congestion to the end-nodes for back-off (Tail Drop)**
  - **In the edge/core to do congestion avoidance and signal congestion to the end-nodes that can back-off**





Back on Track

Step 3: Define Policies for the Classes

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- **Set minimum bandwidth guarantee**
  - **This is the minimum guaranteed bandwidth to the class all the time**
- **Set maximum bandwidth limits**
  - **This is the maximum amount of bandwidth class will ever get**
- **Assign priorities to each class**
  - **Class is treated in a strict priority manner**
- **Manage congestion**

Scheduling

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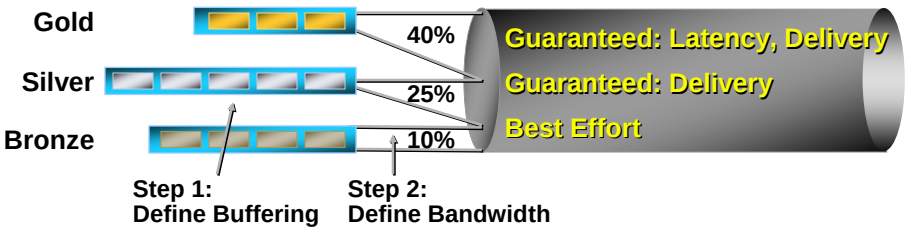

- Weights guarantee minimum bandwidth
- Buffering controls latency
- Unused capacity is shared amongst the other classes
- Each queue can be separately configured for QoS
- Benefits:
  - Maximize transport of paying traffic
  - No loss of service class guarantees
  - No wasted bandwidth as with PVCs

Low Latency Queuing

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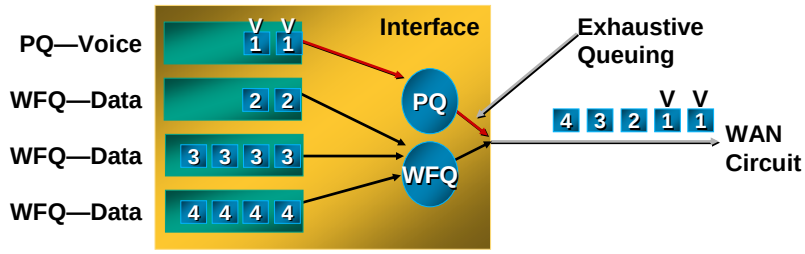

Large Packets "Freeze Out" Voice

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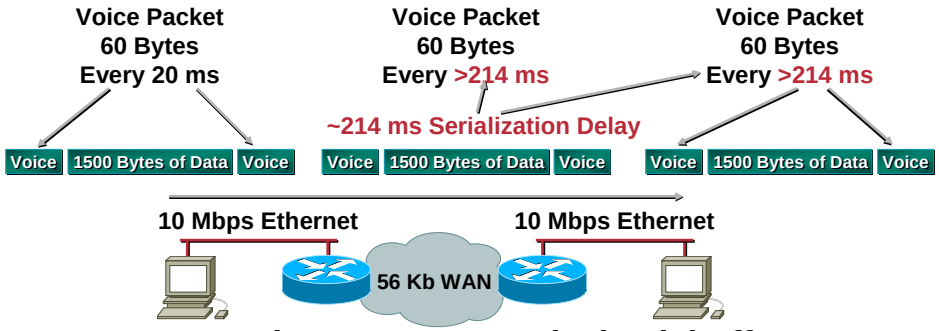

- Large packets can cause playback buffer underrun, resulting in slight voice degradation
- Jitter or playback buffer can accommodate some delay/delay variation

Fragmentation Recommendations

Assuming 10 ms Max Blocking Delay "Rules of Thumb"

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10 ms/Time for 1 Byte at BW = Fragment Size

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

X

Fragmentation Not Needed if Max Frame Size Is 1500 Bytes

Link Fragmentation and Interleaving (LFI)

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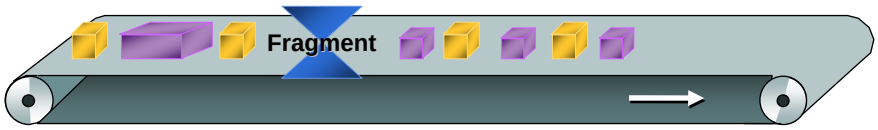

- Fragment large packets and interleave with voice packets over WAN links
- Reassemble at other end of link
- Reduces voice delay and jitter

Maximum Rate Limiting

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Policy required:

Make sure my bronze traffic does not get more than *x* kbps of bandwidth at any time

Traffic Policing vs. Shaping

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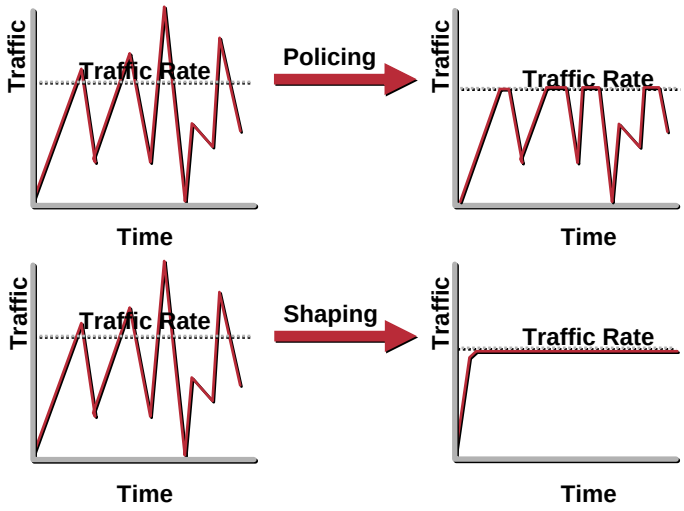

Policer

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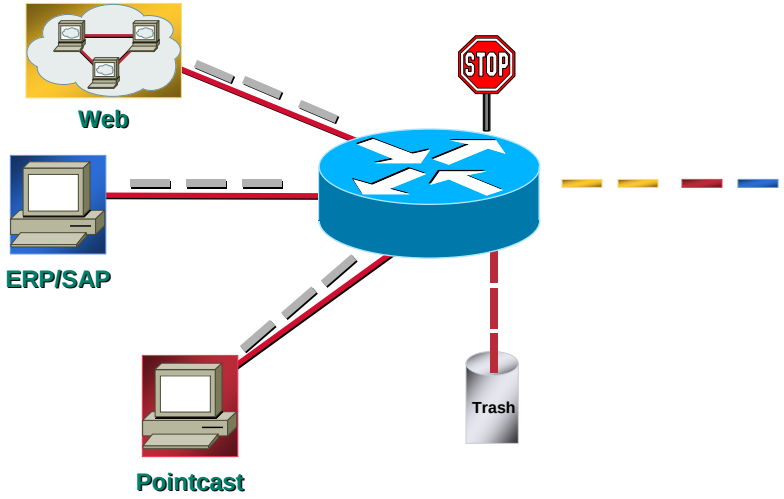

Shaper

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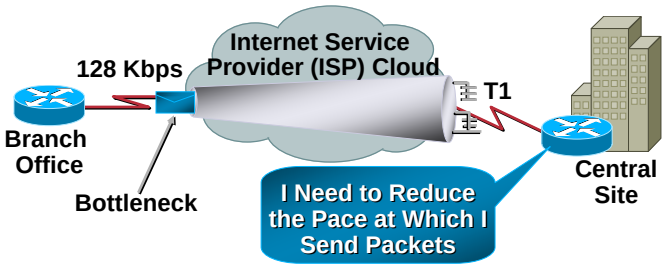

- Reduces outbound traffic flow to avoid congestion (via buffering)
- Eliminates bottlenecks in topologies with data rate mismatch
- Provides mechanism to partition interfaces to match far-end requirements

Congestion Avoidance

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"

Policy required:

Make sure my bronze or silver traffic gets dropped when there is congestion and not gold traffic

"

Weighted Random Early Detection

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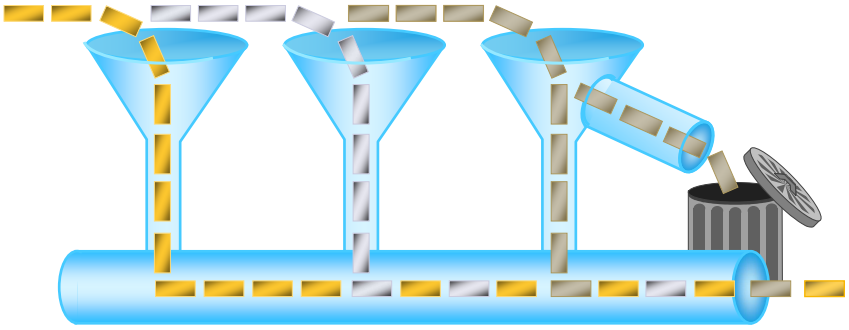
Gold
High Precedence
Guarantee Mission-Critical Apps, e.g., ERP, Customer Care, Unified Messaging

Silver
Medium Precedence
E-Mail, Interactive Video, Web

Bronze
Low Precedence
E-Fax, FTP



Putting it All Together

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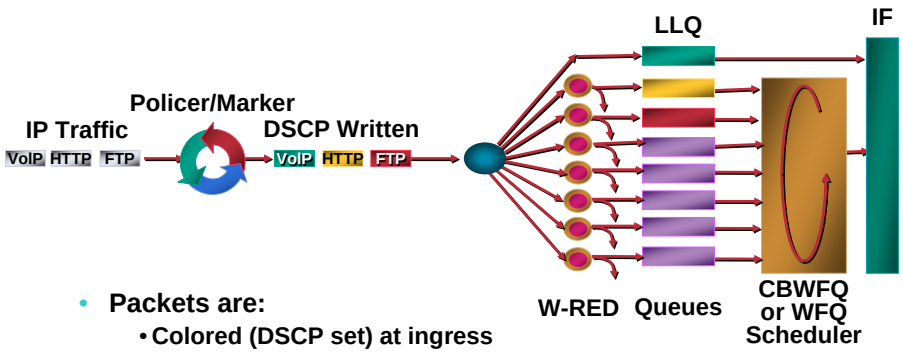

- **Packets are:**
  - Colored (DSCP set) at ingress
  - Classified and potentially discarded by WRED (congestion management)
  - Assigned to the appropriate outgoing queue
  - Scheduled for transmission by CBWFQ

For More Information

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Cisco IOS Technologies

Cisco IOS Software	http://www.cisco.com/warp/public/732/ http://www.cisco.com/warp/public/732/Tech/
Quality-Of-Service	http://www.cisco.com/warp/public/732/Tech/quality.shtml
Overview: Network-Based Application Recognition	http://wwwin.cisco.com/cmc/cc/so/neso/ienesv/cxne/nbar_ov.htm

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