



# Hierarchical Queueing Framework (HQF) Overview and Changes on Quality of Service (QoS)

Sarala Akella CCIE #29921

June 5<sup>th</sup>, 2012

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# Polling Question 1

## What is your level of experience with QoS?

- a) No idea what is QoS
- b) I know some basic QoS concepts
- c) I know some basic QoS concepts however do not have any deployment experience
- d) I know most of the QoS concepts, topics, issues and have deployment experience
- e) I'm THE QoS Guru. What do you want?

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# Agenda

- **Introduction to QoS**
- **Hierarchical Queueing Framework (HQF)**
- **Feature changes compared previous to HQF**
- **Q&A**



# Introduction - QoS

# Classification

When creating a class map, there are two types of matching Match-all or Match-any

```
Router(config)#
```

```
Router(config)#class-map temp1
```

Or

```
Router(config)#class-map match-any GOLD
```

```
Router(config)#class-map match-all SILVER
```

If you do not specify (match-all or match-any) as the first example, the default will be match-all

## Example

```
class-map match-all SILVER
```

```
match ip dscp af41
```

```
match access-group 101
```

```
-----
```

```
class-map match-any GOLD
```

```
match ip dscp ef
```

```
match ip destination-address
```

# Marking and bandwidth allocation

## Set policies for classes

```
policy-map VOIP
  class voice
    priority 200
    set ip dscp ef
  !
  class gold
    bandwidth percent 30
  !
  class silver
    bandwidth percent 20
  class class-default
```

How the remaining bandwidth will be divided in this case?

Gold:Silver 3:2

# MQC

Enter MQC. MQC has three main components:

1. class-map match-anyTest-class1  
match ( access-list, protocol, interface, etc)
2. policy-map Test-policy1  
class Test-class1  
bandwidth, random-detect, fair-queue, police, etc.
3. interface serial 1  
service-policy Test-policy1 outbound

1. Identify the traffic

2. What do you want to do with the traffic?

3. Apply what you want to do, to an interface in or outbound.

# Bandwidth management

- Bandwidth
- Police
- Shape
- Priority

# service-policy

- Applying service-policy on physical interface Vs Sub-interface

```
interface serial 1/0  
  service-policy Test-policy1 outbound
```

```
interface serial 1/0.125  
  service-policy Test-policy1 outbound  
  ##We will get error message
```

```
Policy-map PARENT  
class class-default  
  shape average 128000000  
Service-policy Test-policy1 outbound
```

```
interface serial 1/0.125  
  service-policy out PARENT
```

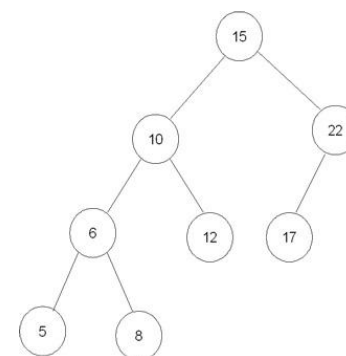




HQF

# What is HQF ?

*Hierarchical Queuing Framework is a general and scalable infrastructure for supporting a set of QoS features – shaping, low latency queuing, guaranteed bandwidth, flow-based fair queuing, WRED.*

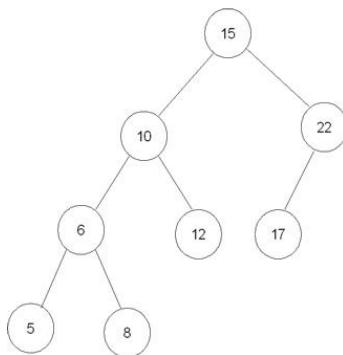




# Multi-level support

To provide support for multiple levels in the queuing hierarchy

- Physical interface level
- Logical interface level
- Class level



## Translation from user configuration to packet scheduling parameters:

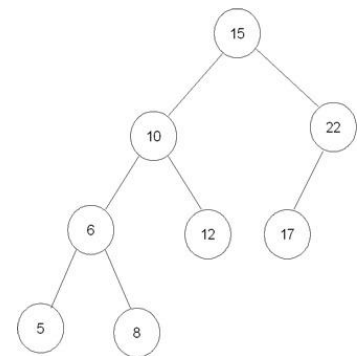
Minimum guarantee

Maximum rate

Excess sharing ratio

Priority level

- Consistent gathering and displaying of queuing statistics
- Clean separation between control and data plane
- Consistent semantics for queuing features



# HQF: support on IOS

- 7600 platform family started using this infrastructure (not LAN LC)
- Infrastructure brought in 12.0S to first introduce 7200 with hqf
- Added support for 7200 and c10k (PRE-3) in 12.2S derivatives
- HQF in 12.4(20)T for 7200 and low-end platforms

# HQF: Supported MQC features

- LLQ  
*Priority <kbps>/percent/level*
- Bandwidth  
*Bandwidth <kbps>/percent/remaining percent/remaining ratio*
- Shape  
*Shape average/peak <bps>/percent <value> <bc> ms <be> ms*
- Fair-Queue – Flow based!  
*fair-queue individual-limit*
- WRED  
*Random-detect precedence/dscp/cos/clp min-threshold <value> bytes/packets/ms max-threshold <value> bytes/packets/ms drop-probability <value>*
- Queue-limit  
*queue-limit <value> packets/bytes/ms*

# Example

Assume 10 M interface:

```
policy-map cbwfbq
```

```
class voice
```

```
priority percent 10
```

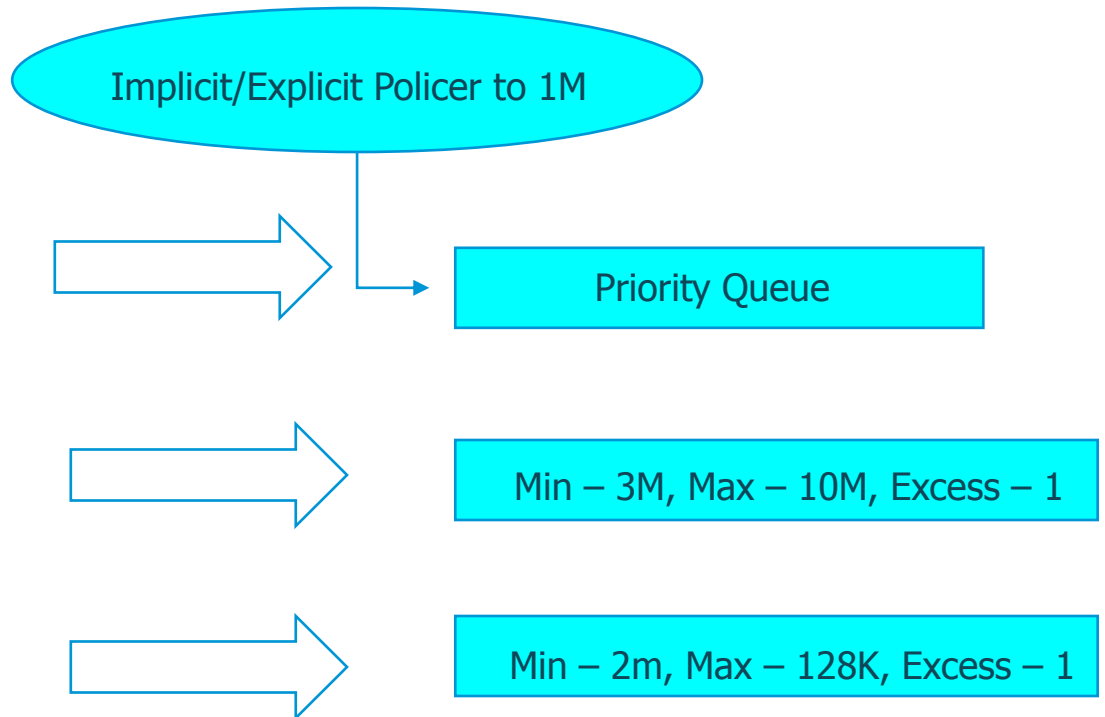
```
class GOLD
```

```
bandwidth percent 30
```

```
class SILVER
```

```
bandwidth percent 20
```

```
class class-default
```



# Example

Assume 10 M interface:

```
policy-map cbwfq
```

```
class voice
```

```
priority percent 10
```

```
class GOLD
```

```
bandwidth percent 60
```

```
class SILVER
```

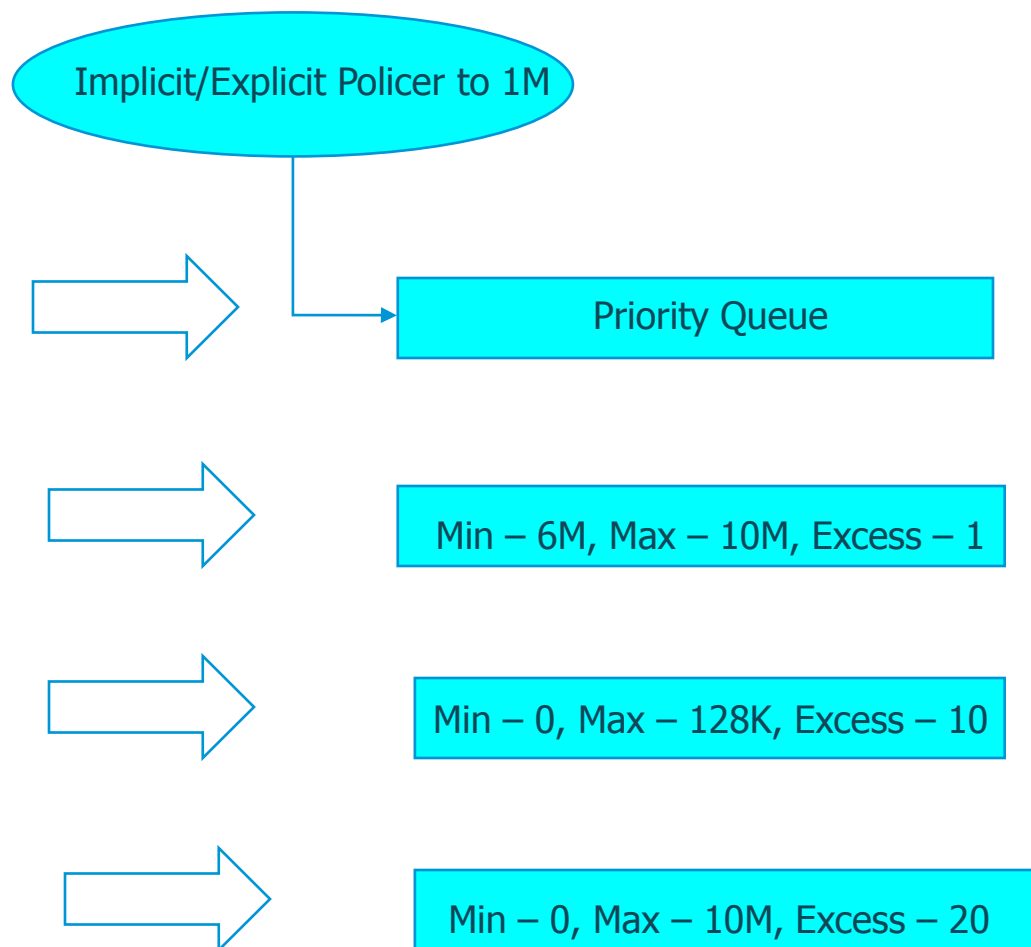
```
bandwidth remaining ratio 10
```

```
shape average 128000
```

```
class class-default
```

```
bandwidth remaining ratio 20
```

```
random-detect
```



# Queue Hierarchy

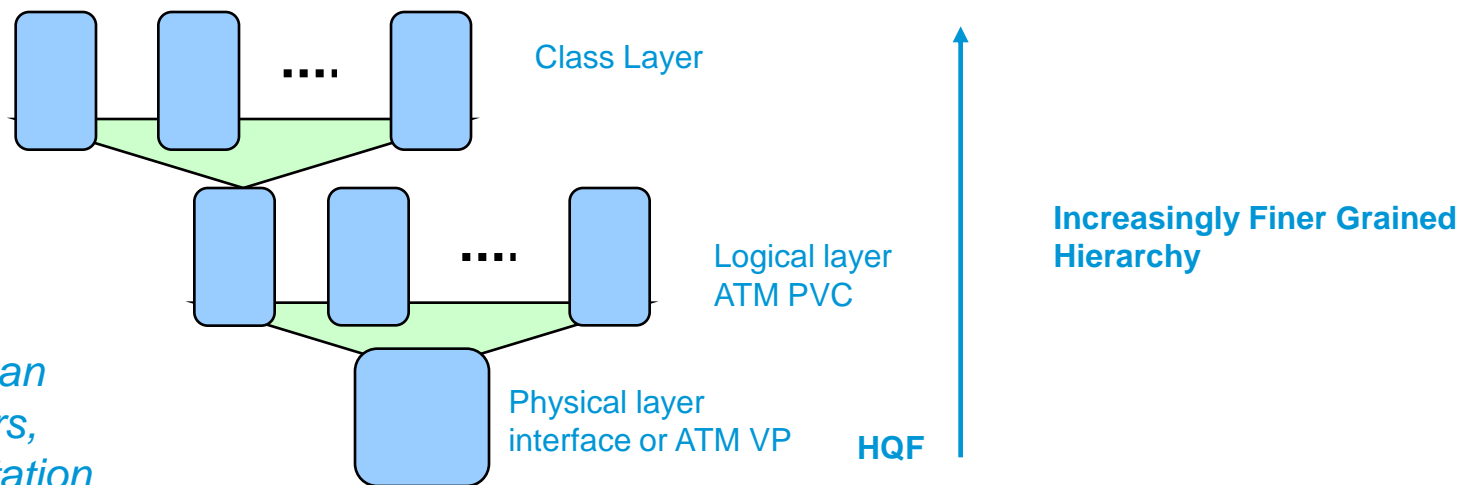
To define how packets will be scheduled.

*Tree structures made of nodes leaves root.*

- Every level in the HQF hierarchy **always has a default queue** that captures un-classified traffic at that level

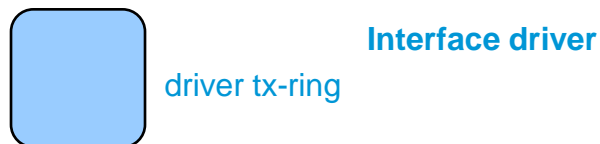
# Three layers of Hierarchy

- The queuing hierarchy is defined from bottom to top
- The packets are enqueued to the appropriate leaf queue depending on the classification information



*While the model can scale up to  $n$  layers, current implementation limits HQF to  $3/4^*$  layers.*

*Future code changes may remove this limitation*





# Admission control

*Control-plane checks verifying validity of the QoS policy*

To prevent installing a policy that can not be serviced accordingly (i.e. oversubscription).

1. Check against the explicit minimum guarantee rate if parent has one.
2. Else check against  $\min(\text{Implicit Rate}^*, \text{Shape Rate})$

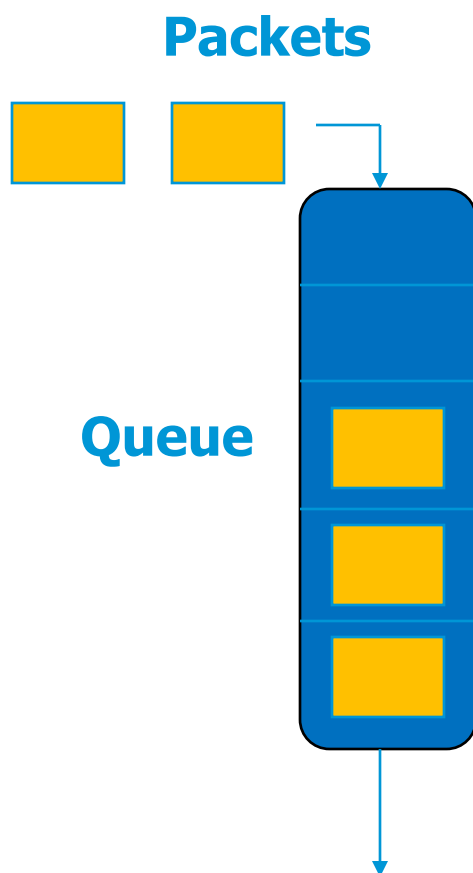
- \* Control plane's admission control prevents us from having more than 100% of rate guarantee.
- \* Implicit rate is not always straightforward, no standard rule but case by case.
- \* Priority without rate = priority with full implicit parent rate, so no other reservation accepted by control-plane.

# Enqueuing packets

To prevent spending precious CPU cycles on packets that will be dropped in the end

- Initial check against **rate**.
- That rate depends on the **parent node** configured parameters.
- Check implicit /explicit policers, etc
- Once the decision to enqueue a packet is made, packet **will not be dropped**.

# Definition of a Queue



## What controls the depth of the queue:

- Active Queue management (e.g., WRED)
- Tail drop (queue-limit)

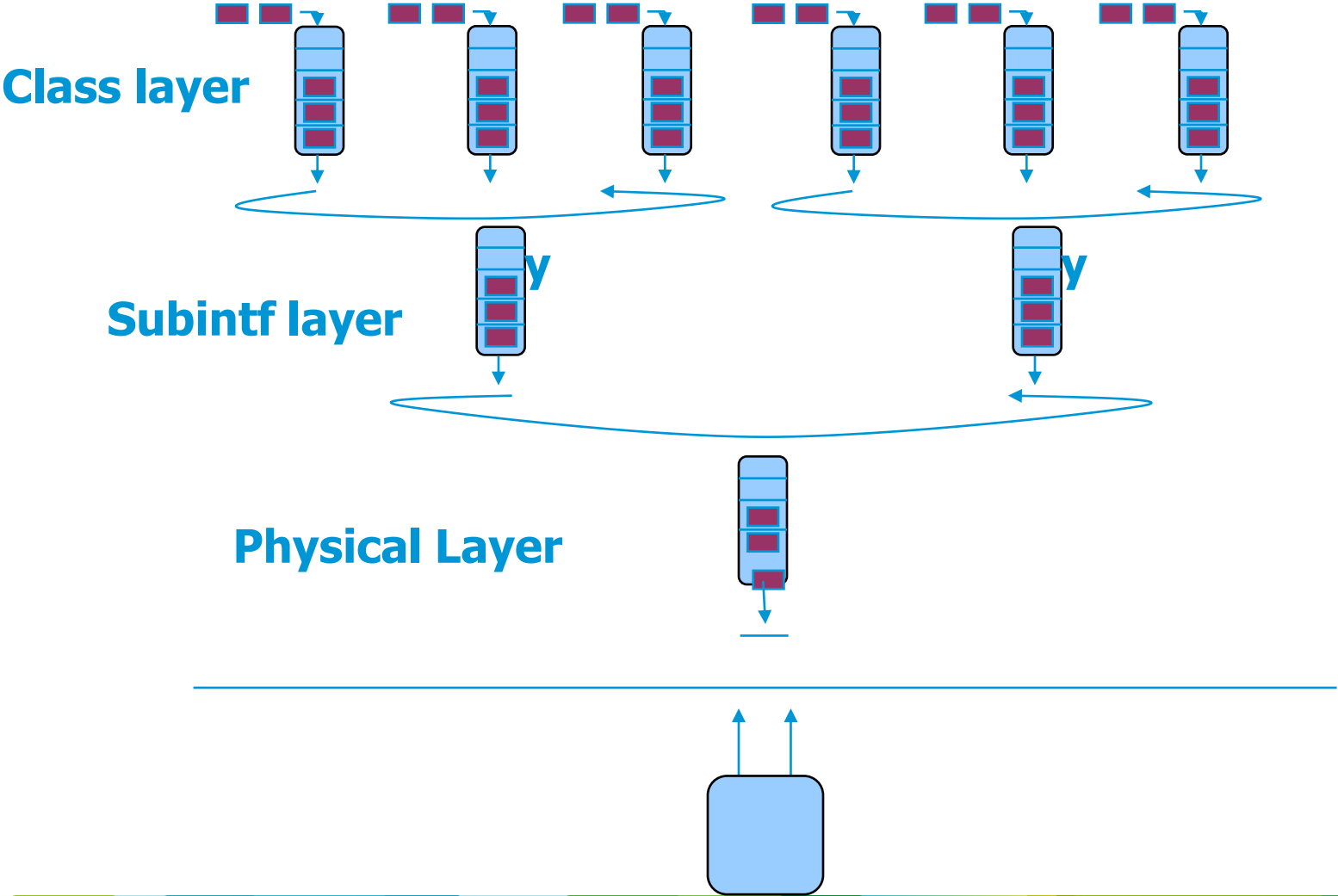
## What controls the servicing of the queue

- Priority Level
- Min BW guarantee
- Max BW (Shape rate)
- Excess BW (Bandwidth Remaining percent/ratio)

# Servicing the Queue

- Priority – low delay, **strict priority** queue. Gets to send its data ahead of all others queues with lower priority. **Strictly policed** to configured rate.
- Min BW guaranteed- the queue **is guaranteed the specified BW**. Gets to send before Excess BW, but after all levels of Priority traffic.
- Max BW (Shape value) – **Shape** the traffic. This is the max BW the queue receives.
- Excess BW (BW remaining) – specify how to **allocate leftover BW** among queues that already sent more than the Min but less than Max.

# Scheduling pkts



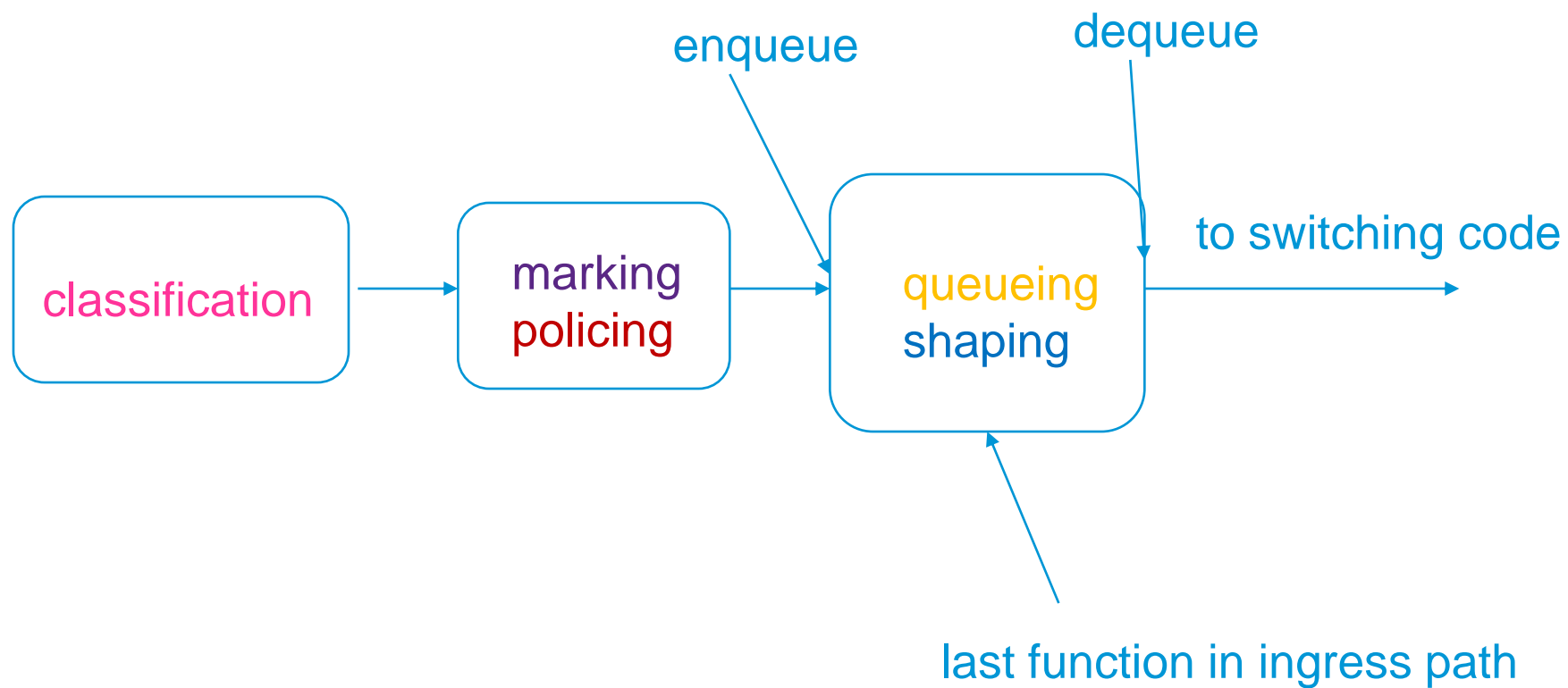
# Queueing components

We will look into following components

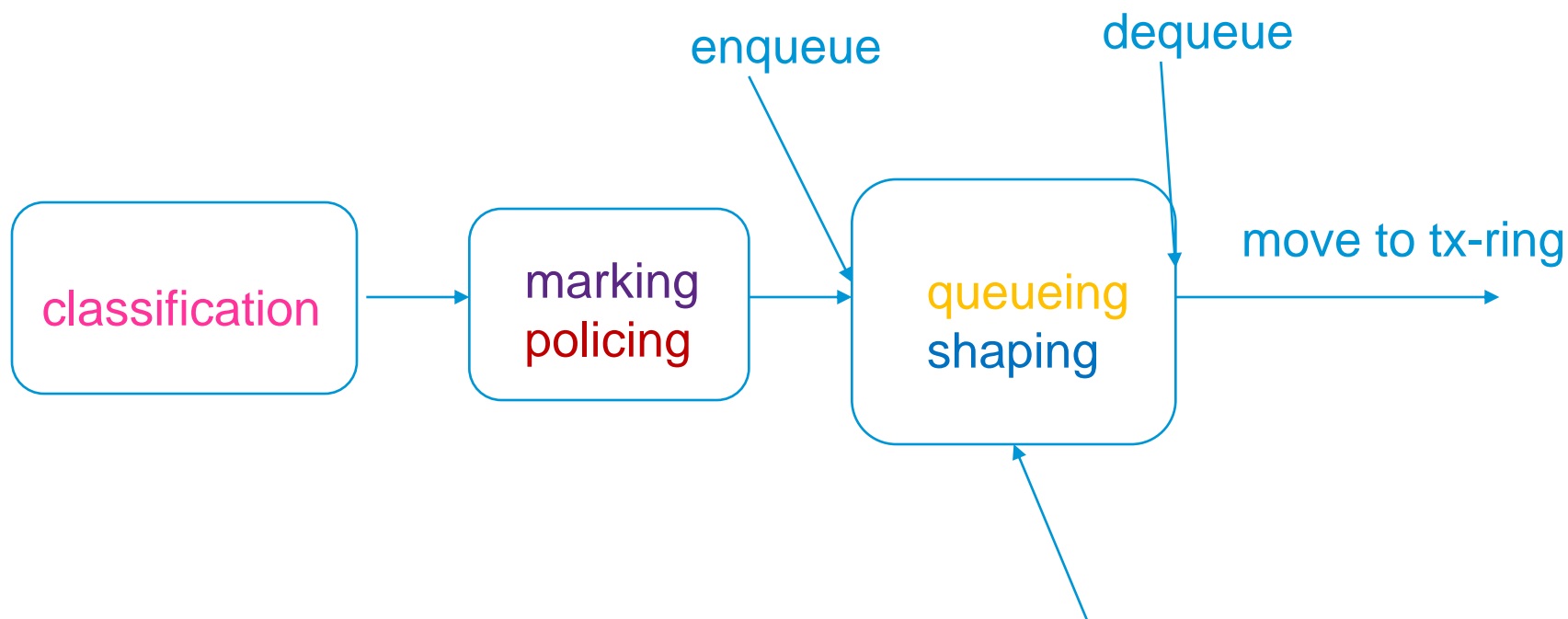
- Drop discipline at en-queue time
- En-queue
- Scheduler
- De-queue

Shaping integrated with scheduler

# Ingress packet path



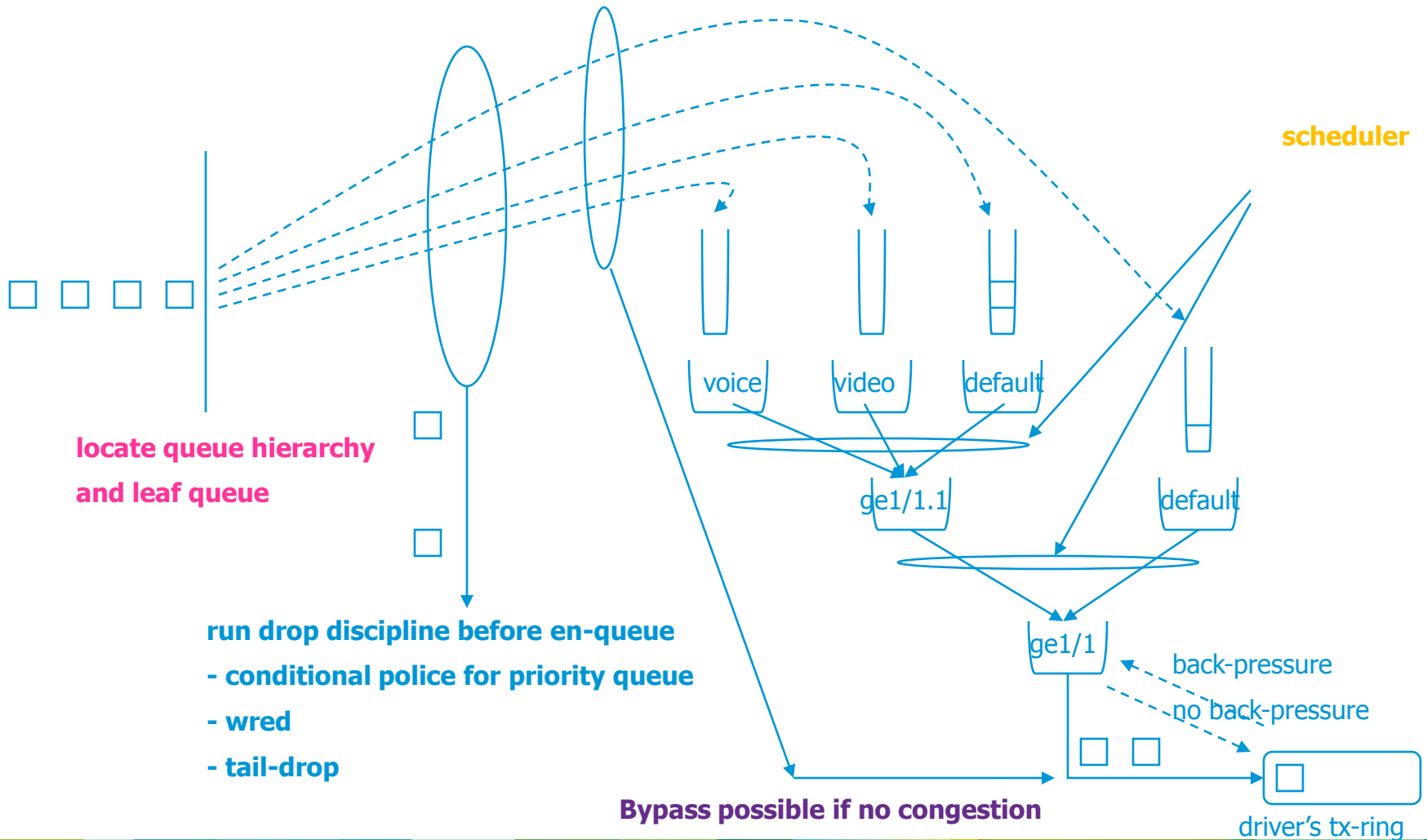
# Egress packet path



last function in egress path  
*few exceptions (eg. fragmentation)*



# Queuing components



# Polling Question 2

**What command should be used to allocate bandwidth for voice traffic?**

- a) Bandwidth
- b) Police
- c) A and B together
- d) Priority
- e) Shape

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# Changes in feature functionality

# Fair-queuing behavior

- **Pre-HQF:** Fair-queue was weighted by default  
Flow with higher precedence will have lower weight.
- **HQF:** Fair-queue schedules all flow equally, no weight difference between flows.

# Class-default reserved bandwidth

- **Pre-HQF:** Class-default used weighted fair queuing as default, with all flows competing with the user-defined classes.
- **HQF:** Class-default uses FIFO queuing as default, this means that by default it will have the bandwidth not reserved by the other classes guaranteed.

# Max-reserved-bandwidth

- **Pre-HQF:** A policy could reserve up to (max-reserved-bandwidth) % of the interface bandwidth. IOS default was 75%.
- **HQF:** max-reserved bandwidth parameter **deprecated**. Policy can reserve up to 100% of the bandwidth (99% if class-default is not explicitly defined).

Nb: CLI is still there, it just does nothing.

PAK priority traffic protected by HQF, no need to keep BW for them.

# Priority Queue now visible

- **Pre-HQF:** Priority queue was somehow 'hidden' from the show commands, and had a fixed length of 64 packets.
- **HQF:** Priority queue can now be seen in CLI outputs, and its length can be modified:

```
Service-policy output: llq
```

```
queue stats for all priority classes:
```

```
queue limit 64 packets  
(queue depth/total drops/no-buffer drops) 0/0/0  
(pkts output/bytes output) 0/0
```

```
Class-map: prec-2 (match-all)  
0 packets, 0 bytes  
30 second offered rate 0 bps, drop rate 0 bps  
Match: ip precedence 2  
Priority: 1000 kbps, burst bytes 25000, b/w exceed drops: 0
```



# Queue-limit and Random-detect

- **Pre-HQF:** Configuring random-detect (WRED) takes over queuing, and can't coexist with queue-limit (which sets the FIFO queue-limit length).
- **HQF:** Queue-limit and WRED can now be configured together. Queue-limit sets the maximum for all WRED classes, preventing huge buffer usage and no-buffer drops.

Default queue-limit is 64, default WRED max-threshold is usually 40.

Queue-limit must be at least as large as the largest max-threshold.

# Queuing in Class-default

- **Pre-HQF:** Fair-queue default queuing mode in class-default.  
per-flow queue-limit is 64  
no bandwidth reservation, competes with user defined classes
- **HQF:** FIFO default queuing mode in class-default.  
Default reserved bandwidth of leftover from other classes  
Implicit 1% bandwidth from parent reserved if not defined.

# Scheduling Parameters

- **Pre-HQF:** Only 2 parameters can be configured for scheduling: Min BW (bandwidth command) and Max BW (shape command).
  - Third parameter, Excess BW, is proportional to Min BW by default, can NOT be changed.
  - Resulting behavior is remaining BW allocated to classes proportionally to their reserved bandwidth .
- **HQF:** Excess BW (bandwidth remaining command) now considered. This parameters defines how remaining BW is allocated between classes.
  - Default *should* be 1, meaning by default the remaining bandwidth is distributed evenly between classes.
  - CLI *should* be adjusted to allow proper Excess BW config.

# Default queue lengths

Type	Default value	CLI
Physical	1000 (*)	hold-queue out
ATM PVC	500	vc-hold-queue
Frame-relay map class	600	frame-relay holdq
Shaper on interface	1000	hold-queue-out / queue-limit (*)
Shaper on subinterface	512	NA
Class (parent)	64	queue-limit
Class (child)	varies (*)	queue-limit
WRED max-threshold	40	random-detect

(\*) When a service-policy is applied, if not it is set to 40.

(\*) Set by the minimum of the sum of all queue-limits in child policies or the interface output hold queue.

(\*) % of parent class queue-limit based on relative bandwidth

# HQF Multiple Policy Support

## HQF Multiple Policy Support

- Enables you to configure queuing service policies at the tunnel (logical) interface level **AND** at the physical interface level simultaneously
- tunnel traffic is mapped to the class-default of the physical interface policy-map
- Provides low latency propagation from the tunnel to the main interface for voice traffic.

# Deprecated commands

- shape max-buffers → queue-limit
- max-reserved-bandwidth
- show queuing, show queue, show traffic-shape queue

# References

- **Cisco Support Community**  
<https://supportforums.cisco.com>
- **Applying QoS Features to Ethernet Subinterfaces**  
[http://www.cisco.com/en/US/tech/tk543/tk545/technologies\\_tech\\_note09186a0080114326.shtml](http://www.cisco.com/en/US/tech/tk543/tk545/technologies_tech_note09186a0080114326.shtml)
- **QoS---HQF Multiple Policy Support**  
[http://www.cisco.com/en/US/docs/ios/qos/configuration/guide/qos\\_hqf\\_mply\\_support.html](http://www.cisco.com/en/US/docs/ios/qos/configuration/guide/qos_hqf_mply_support.html)
- **Hierarchical Queuing Framework**  
[http://www.cisco.com/en/US/prod/collateral/iosswrel/ps6537/ps6558/white\\_paper\\_c11-481499.html](http://www.cisco.com/en/US/prod/collateral/iosswrel/ps6537/ps6558/white_paper_c11-481499.html)

# Polling Question 3

## Why do I need QoS in my network?

- a) Classification
- b) Avoid congestion
- c) Marking
- d) Rate-limiting
- e) All the above



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Topic: Cisco Nexus 5000 and 2000

Tuesday, June 12, 2012

7:00 a.m. Pacific

3:00 p.m. Lisbon

11:00 a.m. Brasilia City

Join Cisco Expert:

**Pedro Ivo Santos Mauri**

During the live event you will learn from Cisco Expert Pedro Ivo Santos Mauri about the features of the data center switch Cisco Nexus 5000 and FEX (Cisco Nexus 2000), as well as the benefits they bring to the access layer to aggregate the data center.

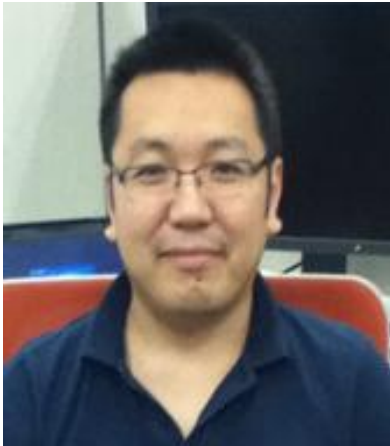
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# Expert Series Webcast in Japanese

**Topic: Troubleshooting on Routing Protocol Neighbor Down**



**Tuesday, June 19, 2012**

**10:00 a.m. Tokyo**

**Monday, June 18th**

**6:00 p.m Pacific Time**

Join Cisco Expert:

**Takashi Higashimura**

During the live event, Cisco subject matter expert Takashi Higashimura will discuss several troubleshooting examples for neighbor down of some major routing protocols including EIGRP and OSPF.

**Register for this live Webcast at**

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# Next Expert Series Webcast (English)

## Topic: Cisco TelePresence Management Suite Extension for Microsoft Exchange (TMSXE 3.0): Installation Overview



**Tuesday, June 26, at**  
**8:00 a.m. Pacific Time**  
**5:00 p.m. Paris**  
**11:00 a.m. New York**

Join Cisco Expert:

**Tim Walker**

This session provides an overview of how to properly install the Cisco TelePresence Management Suite Extension for Microsoft Exchange (TMSXE 3.0). A live demo will be performed. Tim will also discuss how to troubleshoot common installation problems, as well as provide best practices for this product.

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<http://itunes.apple.com/us/app/cisco-technical-support/id398104252?mt=8>



[https://play.google.com/store/apps/details?id=com.cisco.swtg\\_android](https://play.google.com/store/apps/details?id=com.cisco.swtg_android)



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