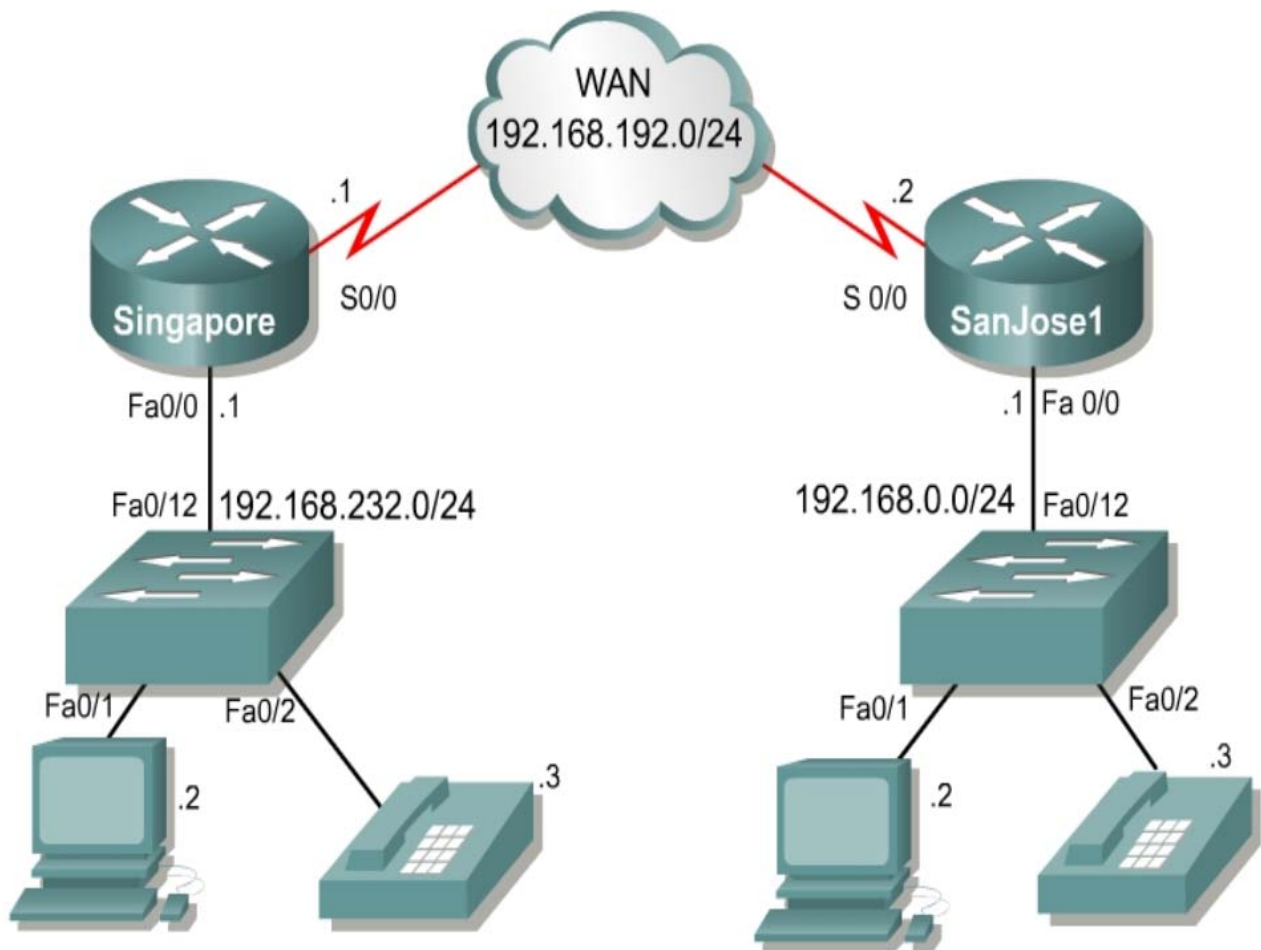


## Lab 8.1.10.7 Configuring Low Latency Queuing (LLQ)



### Objective

Low Latency Queuing (LLQ) enables the use of a single, strict priority queue within class-based weighted fair queuing (CBWFQ) at the class level. Any class can be made a priority queue by adding the **priority** keyword. Within a policy map, one or more classes can be given priority status. When multiple classes within a single policy map are configured as priority classes, all traffic from these classes is sent to the same, single, strict priority queue.

### Scenario

Management would like to reduce costs by routing IP voice packets across the WAN. The Access layer switches will mark the voice packets in the network with a DSCP value of 40. The routers will ensure that these voice packets are guaranteed 80 kbps of WAN bandwidth. In order to achieve the lowest latency, create a priority queue for the voice traffic.

## Step 1

Build and configure the physical topology as shown in the diagram. Before beginning a lab, the configurations on all the routers should be cleared and then reloaded or power cycled to reset their default configurations. Delete the **vlan.dat** and startup configuration files on the switches before reloading them.

Configure the hostnames and interfaces on the routers. The WAN link should use a clock rate of 1,000,000 bps. Enable Enhanced Interior Gateway Protocol (EIGRP) with an autonomous system (AS) of 100 as the routing protocol. Initially the switches can be left with their default configuration. Use a PC to simulate an IP phone connected to interface 0/2 of each switch.

Confirm connectivity by pinging between the hosts.

```
Router(config)#hostname Singapore
Singapore(config)#interface serial 0/0
Singapore(config-if)#ip address 192.168.192.1 255.255.255.0
Singapore(config-if)#clock rate 1000000
Singapore(config-if)#no shutdown
Singapore(config-if)#interface fastethernet 0/0
Singapore(config-if)#ip add 192.168.232.1 255.255.255.0
Singapore(config-if)#no shutdown
Singapore(config-if)#router eigrp 100
Singapore(config-router)#network 192.168.192.0 0.0.0.255
Singapore(config-router)#network 192.168.232.0 0.0.0.255
```

```
Router(config)#hostname SanJose1
SanJose1(config)#interface serial 0/0
SanJose1(config-if)#ip address 192.168.192.2 255.255.255.0
SanJose1(config-if)#clock rate 1000000
SanJose1(config-if)#no shutdown
SanJose1(config-if)#interface fastethernet 0/0
SanJose1(config-if)#ip add 192.168.0.1 255.255.255.0
SanJose1(config-if)#no shutdown
SanJose1(config-if)#router eigrp 100
SanJose1(config-router)#network 192.168.192.0 0.0.0.255
SanJose1(config-router)#network 192.168.0.0 0.0.0.255
```

## Step 2

Configure the Access Layer switches with hostnames.

```
Switch(config)#hostname SingaporeSwitch

Switch(config)#hostname SanJose1Switch
```

Mark the voice traffic on entry into the network. A service-policy will be used to assign the voice traffic a DSCP value of 40. The IP addresses of the phones generating the voice packets need to be identified. Configure a standard named access-list called **PHONE** to identify traffic from the phone.

```
SingaporeSwitch(config)#ip access-list standard PHONE
SingaporeSwitch(config-std-nacl)#permit 192.168.232.3

SanJose1Switch(config)#ip access-list standard PHONE
SanJose1Switch(config-std-nacl)#permit 192.168.0.3
```

Configure a class-map named **VOICE-CLASS** and match the ACL to it.

```
SingaporeSwitch(config-std-nacl)#class-map match-all VOICE-CLASS
SingaporeSwitch(config-cmap)#match access-group name PHONE

SanJose1Switch(config-std-nacl)#class-map match-all VOICE-CLASS
SanJose1Switch(config-cmap)#match access-group name PHONE
```

Configure a policy map called **VOICE-POLICY** and include the **VOICE-CLASS** class to set the IP DSCP to 40 making it the most critical traffic type and therefore the least likely to get dropped in times of congestion.

```
SingaporeSwitch(config-cmap)#policy-map VOICE-POLICY
SingaporeSwitch(config-pmap)#class VOICE-CLASS
SingaporeSwitch(config-pmap-c)#set ip dscp 40

SanJose1Switch(config-cmap)#policy-map VOICE-POLICY
SanJose1Switch(config-pmap)#class VOICE-CLASS
SanJose1Switch(config-pmap-c)#set ip dscp 40
```

Apply the service policy to the interface.

```
SingaporeSwitch(config-pmap-c)#interface fastethernet 0/2
SingaporeSwitch(config-if)#service-policy input VOICE-POLICY
SingaporeSwitch(config-if)#^Z

SanJose1Switch(config-pmap-c)#interface fastethernet 0/2
SanJose1Switch(config-if)#service-policy input VOICE-POLICY
SanJose1Switch(config-if)#^Z
```

---

**Note** As an alternative, the voice traffic could also be identified by using the Class of Service (CoS) value. This would be accomplished by using the `mls qos cos 0` command on interface Fa0/1 and `mls qos cos 5` on Fa0/2.

---

Use the `show class-map` and the `show policy-map` commands to verify the QoS settings on the switches.

```
SanJose1Switch#show class-map

Class Map match-any class-default (id 0)
  Match any
Class Map match-all VOICE-CLASS (id 2)
  Match access-group name PHONE

SanJose1Switch#show policy-map
Policy Map VOICE-POLICY
  class VOICE-CLASS
    set ip dscp 40

SingaporeSwitch#show class-map
Class Map match-any class-default (id 0)
  Match any
Class Map match-all VOICE-CLASS (id 2)
  Match access-group name PHONE

SingaporeSwitch#show policy-map
Policy Map VOICE-POLICY
  class VOICE-CLASS
    set ip dscp 40
```

The switches are now configured properly. The next step is to configure the routers to support the QoS requirements.

### Step 3

After marking the traffic at the access layer, create a policy on the routers for the treatment of the traffic within the WAN. Configure a class map on each router to classify frames with a CoS of 5 as voice:

```
Singapore(config)#class-map VOICE-CLASS
Singapore(config-cmap)#match ip dscp 40

SanJose1(config)#class-map VOICE-CLASS
SanJose1(config-cmap)#match ip dscp 40

Singapore#show class-map
Class Map match-any class-default (id 0)
  Match any

Class Map match-all VOICE-CLASS (id 1)
  Match ip dscp cs5

SanJose1#show class-map
Class Map match-any class-default (id 0)
  Match any

Class Map match-all VOICE-CLASS (id 1)
  Match ip dscp cs5
```

### Step 4

Now that the traffic has been classified, create a policy map called **WAN-POLICY** and determine a policy for all traffic that is not voice. An efficient scheme for queuing general traffic is weighted fair queuing (WFQ). This traffic class will be the **class-default**. It will be a catchall for traffic that has not been classified as voice:

```
SanJose1(config)#policy-map WAN-POLICY
SanJose1(config-pmap)#class class-default
SanJose1(config-pmap-c)#fair-queue

Singapore(config)#policy-map WAN-POLICY
Singapore(config-pmap)#class class-default
Singapore(config-pmap-c)#fair-queue
```

### Step 5

Create a class called VOICE-CLASS in the WAN-POLICY for the treatment of voice traffic. Apply the appropriate command to enable Low Latency Queuing (LLQ). Allow 80kbps of the WAN bandwidth and specify that priority queuing be used for this class of traffic.

The command that provides this functionality is the **priority bandwidth** option of the policy map:

```
SanJose1(config)#policy-map WAN-POLICY
SanJose1(config-pmap)#class VOICE-CLASS
SanJose1(config-pmap-c)#priority 80

Singapore(config)#policy-map WAN-POLICY
Singapore(config-pmap)#class VOICE-CLASS
```

```
Singapore(config-pmap-c)#priority 80
```

Voice traffic queued to the priority queue is User Datagram Protocol (UDP) based and therefore not adaptive to the early packet drop characteristic of weighted random early detection (WRED). Because WRED is ineffective, the WRED **random-detect** command cannot be used with the **priority** command. In addition, because policing is used to drop packets and a queue limit is not imposed, the **queue-limit** command cannot be used with the **priority** command.

Use the **show policy-map** command to verify the configuration.

```
WAN-POLICYVOICE-CLASS
Singapore#show policy-map
Policy Map WAN-POLICY
Class VOICE-CLASS
  Strict Priority
  Bandwidth 80 (kbps) Burst 2000 (Bytes)
Class class-default
  Flow based Fair Queueing Max Threshold 64 (packets)

SanJose1#show policy-map
Policy Map WAN-POLICY
Class VOICE-CLASS
  Strict Priority
  Bandwidth 80 (kbps) Burst 2000 (Bytes)
Class class-default
  Flow based Fair Queueing Max Threshold 64 (packets)
```

## Step 6

The final step in configuring quality of service (QoS) using the MQC is to apply the policy to an interface. Apply the policy to the outgoing serial interface on each router using the **service-policy** command:

```
SanJose1(config)#interface s0/0
SanJose1(config-if)#service-policy output WAN-POLICY

Singapore(config)#interface s0/0
Singapore(config-if)#service-policy output WAN-POLICY
```

## Step 7

When the **priority** command is specified for a class, it takes a *bandwidth* argument that specifies the maximum bandwidth in kbps. This parameter specifies the maximum amount of bandwidth allocated for packets belonging to the class configured. The bandwidth parameter both guarantees bandwidth to the priority class and restrains the flow of packets from the priority class. In the event of congestion, policing is used to drop packets when the bandwidth is exceeded.

Use the **debug priority** command to monitor LLQ and determine if the priority queue is overloaded and dropping packets.

Turn on priority debugging on the Singapore router:

```
Singapore#debug priority
```

At this stage no traffic is flowing so no drops from the priority queue should be seen.

```
Singapore#debug priority
Priority output queueing debugging is on
Singapore#
```

## Step 8

Verify the configuration of LLQ using the following commands:

```
Router#show queue interface-type interface-number
Router#show policy-map interface interface-name
```

The **show policy-map interface** command displays the configuration of all classes configured for all traffic policies on the specified interface. It shows if packets and bytes were discarded or dropped for the priority class in the traffic policy attached to the interface.

```
Singapore#show policy-map interface serial 0/0
Serial0/0

Service-policy output: WAN-POLICY

Class-map: VOICE-CLASS (match-all)
  0 packets, 0 bytes
  5 minute offered rate 0 bps, drop rate 0 bps
  Match: ip dscp cs5
  Queueing
    Strict Priority
    Output Queue: Conversation 40
    Bandwidth 80 (kbps) Burst 2000 (Bytes)
    (pkts matched/bytes matched) 0/0
    (total drops/bytes drops) 0/0

Class-map: class-default (match-any)
  154 packets, 9612 bytes
  5 minute offered rate 0 bps, drop rate 0 bps
  Match: any
  Queueing
    Flow Based Fair Queueing
    Maximum Number of Hashed Queues 32
    (total queued/total drops/no-buffer drops) 0/0/0
Singapore#
```

Notice that there are no matches for the **VOICE-CLASS** class map.

```
Singapore#show queueing
Current fair queue configuration:
```

Interface	Discard threshold	Dynamic queues	Reserved queues	Link queues	Priority queues
Serial0/0	64	32	256	8	1
Serial0/1	64	32	0	8	1

```
Current DLCI priority queue configuration:
Current priority queue configuration:
Current custom queue configuration:
Current random-detect configuration:
```

```
Singapore#show queue serial 0/0
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
  Conversations 0/1/32 (active/max active/max total)
  Reserved Conversations 0/0 (allocated/max allocated)
  Available Bandwidth 16 kilobits/sec
```

## Step 9

Configure the workstations to allow file sharing. Copy a large file from the PC at Singapore to the PC at SanJose. Simultaneously copy a file from the Telephone PC at Singapore to the Telephone PC at SanJose.

1. Are there any differences in the bandwidth utilization of the PC verses the telephone?
2. Are any packets being dropped?