



Implementing and Configuring the Solution

This chapter begins with tasks common to the 10-GE ring and hub-and-spoke topologies used in the Cisco Cisco Wireline Video/IPTV Solution:

- [Common Tasks, page 4-1](#)

It then presents the details of configuring each topology:

- [Configuring the 10-GE Ring Topology, page 4-5](#)
- [Configuring the Hub-and-Spoke Topology, page 4-32](#)



Note

For command references and best practices for the Layer 3 switches used, see the following:

— Cisco 7600 Series Routers:

http://www.cisco.com/en/US/products/hw/routers/ps368/tsd_products_support_series_home.html

— Cisco Catalyst 6500 Series Switches:

http://www.cisco.com/en/US/products/hw/switches/ps708/tsd_products_support_series_home.html

Common Tasks

The following common tasks have general applicability and should be considered early in the implementation process:

- [Configuring SSM Mapping with DNS Lookup](#)
- [\(Optional\) Enabling Option 82 on the ARs](#)

Configuring SSM Mapping with DNS Lookup

As discussed in [Multicast, page 3-15](#), Source Specific Multicast (SSM) is used simplify the configuration of a multicast network, and is common to both topologies. The solution uses edge devices that do not support IGMPv3. The switches accept IGMPv2 messages and convert these to IGMPv3 by resolving the source IP address of the multicast group by means of either a static mapping or a DNS resource record. This solution uses a DNS lookup method.

**Note**

For the details and an extended discussion of SSM mapping, see “Source Specific Multicast (SSM) Mapping” at the following URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_2/gtssmma.htm

The following tasks are presented:

- [Configuring DNS Servers](#)
- [Configuring SSM Mapping on All Switches](#)
- [Configuring the Edge Switches for DNS Queries](#)

Configuring DNS Servers

The following steps are general. Refer to your DNS server documentation for details.

-
- Step 1** For background, refer to “DNS-Based SSM Mapping” in “Source Specific Multicast (SSM) Mapping,” referenced above.
- Step 2** Configure the following parameters, as appropriate:
- a. Resource records for the first multicast IP address associated with a source
 - b. All other multicast IP addresses from the same source
 - c. The multicast domain
 - d. The timeout (optional)
-

Configuring SSM Mapping on All Switches

Configure the following on all switches (the DER and the ARs) in both topologies.

-
- Step 1** Enable multicast routing.

```
ip multicast routing
```

- Step 2** Enable SSM mapping.

```
ip igmp ssm-map enable
```

**Note**

Although the document Source Specific Multicast (SSM) Mapping, referenced above, states that the **ip igmp ssm-map enable** command needs to be configured only on switches that are connected to IGMP clients, it was found that this led to inconsistent recovery times during solution network failure and recovery tests. A majority of the time, recovery was fast, but occasionally recovery times were poor. It was found that configuring this command on the headend switch, recovery times were more consistent, although slightly slower than the best recovery times when SSM mapping was not configured on the headend switch.

-
- Step 3** Enable SSM on the edge switches. The default IP address range for SSM is 232.0.0.0 to 232.255.255.255.

**Note**

The above command also enables the **ip igmp ssm-map query dns** command. By default, IGMPv2 is configured on the Layer 3 interfaces, so no commands are required to enable SSM mapping with DNS query on the interfaces connected to the device that receives multicast. Also, no special commands are required to enable SSM mapping with DNS query on the Cisco 7609 interfaces that connect to the DNS servers.

Configuring the Edge Switches for DNS Queries

On the edge switches that perform the DNS queries, you must configure the domain and IP addresses of the domain name servers. The domain for the multicast video in the following example is coronado.net. (Domain names will vary.) The switches send queries to the first DNS listed in the running configuration. If the first query fails, the next query is sent to the second DNS.

Step 1 Configure the domain for multicast video.

```
ip domain multicast coronado.net
```

Step 2 Configure the IP address of the first DNS.

```
ip name-server 10.1.10.10
```

Step 3 Configure the IP address of the second DNS.

```
ip name-server 10.1.11.10
```

(Optional) Enabling Option 82 on the ARs

The DHCP relay agent information option (option 82) enables a Dynamic Host Configuration Protocol (DHCP) relay agent to include information about itself when forwarding client-originated DHCP packets to a DHCP server. The DHCP server can use this information to implement IP address or other parameter-assignment policies.

**Note**

For more information, see “DHCP Option 82 Support for Routed Bridge Encapsulation” at the following URL:

http://www.cisco.com/en/US/products/sw/iosswrel/ps1839/products_white_paper09186a0080087ad8.shtml

The default behavior on the switches used in the solution is to reset the option 82 field in DHCP packets. If the gateway address is set to all zeros in the DHCP packet and the relay information option is already present in the packet, the DHCP relay agent discards the packet. Consequently, where DSLAMs are configured to insert option 82 in the DHCP packets from the set-top box (STB), this default behavior must be overridden. This is done on each aggregation router (AR) connected to a DSLAM that is configured to support option 82, with the following global command:

```
ip dhcp relay information trust-all
```

This configures all interfaces on the router as trusted sources of the DHCP relay information option.

Configuring the 10-GE Ring Topology

This section presents the following major topics:

- [Introduction](#)
- [Common Task: Configuring MPLS for HSD Service](#)
- [Configuring DER1](#)
- [Configuring DER2](#)
- [Configuring AR1](#)
- [Configuring AR2](#)
- [Configuring AR3](#)

Introduction

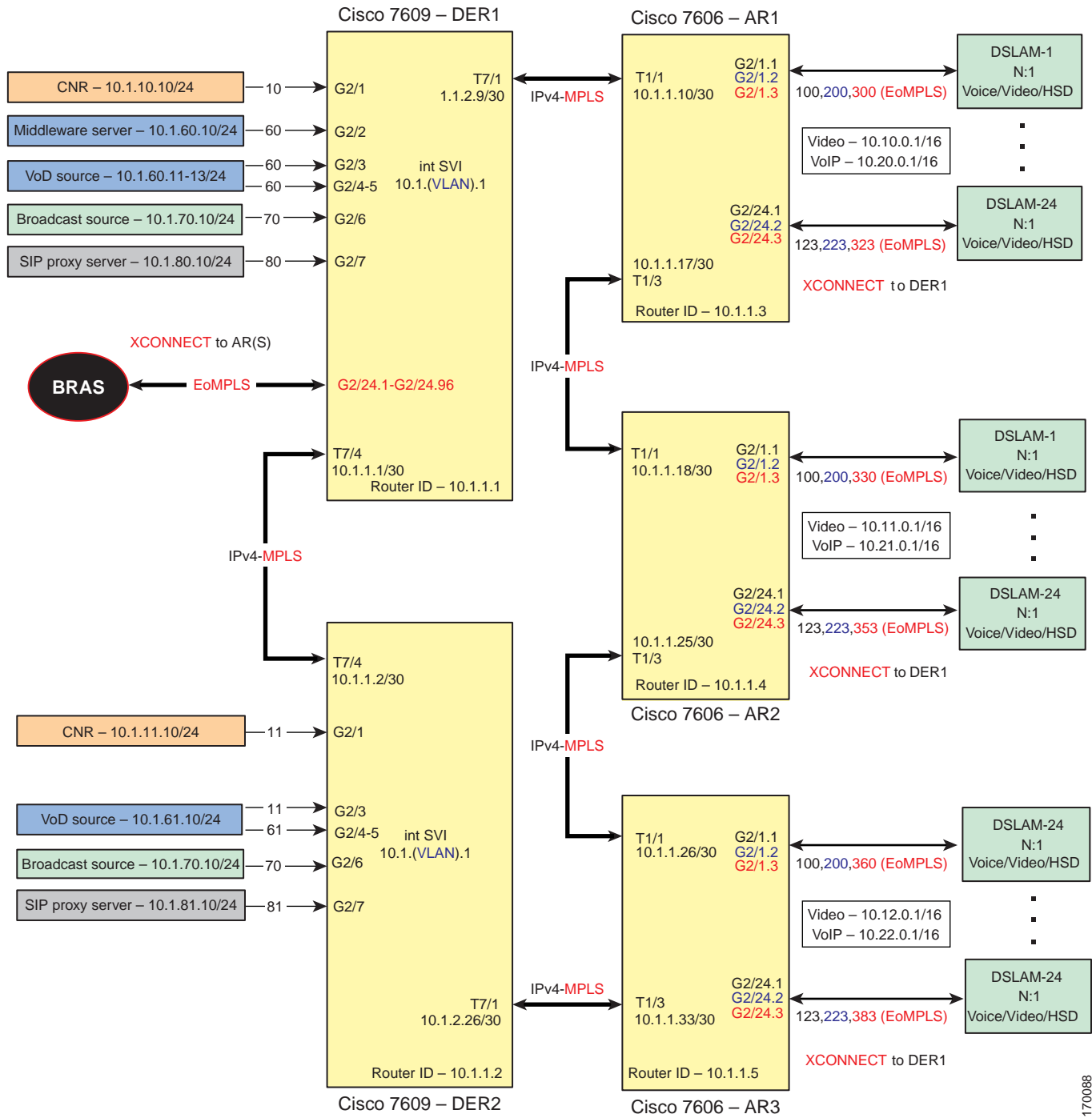
[Figure 4-1 on page 4-6](#) illustrates the 10-GE ring topology used in the solution. (See [Configuration 1: 10-GE Layer 3 Ring, page 3-38](#).) All video sources and VoIP servers are connected to ports on the distribution edge routers (DERs). With two DERs in the topology, we can provide source, node, and network redundancy for each of the aggregation routers (ARs). Policy maps are applied to the DER ingress ports in order to mark the DSCP values of the different service types. In this example, only DER1 is connected to a middleware server.

Traffic is routed among DERs and ARs through 10-GE bidirectional transport links. Transport links are Layer 3 ports, and carry both IPv4 and Multiprotocol Label Switching (MPLS) packets. Video and VoIP traffic is routed over the transport links as native IPv4 packets. HSD is routed over the same transport links, but is encapsulated in MPLS through Ethernet over MPLS (EoMPLS) point-to-point connections. A single OSPF process is needed for the routing protocol.

The topology assumes that each DSLAM is configured to use the N:1 model for the three services—video, VoIP, and high-speed data (HSD). Therefore, each DSLAM is assigned three unique VLANs, one VLAN per service. (Note that VLANs have local significance, and are not bridged between DSLAMs attached to a common AR.)

The residential gateways (RGs) used in the test bed provided service mapping based on physical ports, as described in [Physical Port-Based Traffic Mapping for the Multi-VC and VLAN Access Models, page 3-43](#).

Figure 4-1 10-GE Ring Topology



The switches in Figure 4-1 use the line cards, hardware versions, and IOS versions listed in Table 4-1 on page 4-7.

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Table 4-1 Hardware and IOS Versions for the 10-GE Ring Topology

Switch	Module	Line Card	Hardware Version	IOS Release	Submodule	Hardware Version
DER1, DER2	1	WS-X6724-SFP ¹	2.3	12.2(18)SXF2	WS-F6700-DFC3BXL	5.2
	2					
	5	WS-SUP720-BASE	3.1		WS-F6K-PFC3BXL	1.2
	7	WS-X6704-10-GE	2.2		WS-SUP720 (MFSC)	2.1
AR1	1	WS-X6704-10GE	2.2	12.2(18)SXF2	WS-F6700-DFC3BXL	4.0
	2	WS-X6724-SFP	2.3		WS-F6K-DFC3BXL	5.2
	5	WS-SUP720-3BXL	4.3		WS-F6K-PFC3BXL	1.6
					WS-SUP720 (MFSC)	2.3
AR2	1	WS-X6704-10GE	2.2	12.2(18)SXF2	WS-F6700-DFC3BXL	4.0
	2	WS-X6724-SFP	2.3		WS-F6700-DFC3BXL	5.2
	5	WS-SUP720-3BXL	4.3		WS-F6K-PFC3BXL	1.6
					WS-SUP720 (MFSC)	2.3
AR3	1	WS-X6704-10GE	2.2	12.2(18)SXF2	WS-F6700-DFC3BXL	4.0
	2	WS-X6724-SFP	2.3		WS-F6700-DFC3BXL	5.2
	5	WS-SUP720-3BXL	4.3		WS-F6K-PFC3BXL	1.6
					WS-SUP720 (MFSC)	2.3

1. WS-X6748-GE-TX line cards, version 2.2, were also tested. To simplify the configuration details, they are not shown here.

Table 4-2 on page 4-8 lists VLANs, their descriptions (service types), and IP addresses, for the DER and ARs in Figure 4-1 on page 4-6. A range of VLANs is required for each AR, with one VLAN per DSLAM required to support EoMPLS for HSD.

**Note**

To simplify the configuration, only 11 DSLAMs per AR are shown.

Table 4-2 VLANs, Descriptions, and IP Addresses for the 10-GE Ring Topology

Node	VLAN	Description	IP Address	
DER1	10	Management: CNR (DHCP, DNS, FTP, TFTP, Syslog servers)	10.1.10.1/24	
	60	VoD sources and middleware	10.1.60.1/24	
	70	Digital broadcast sources	10.1.70.1/24	
	80	VoIP—SIP proxy server	10.1.80.1/24	
	300–323	HSD VLAN range for DSLAMs connected to AR1	Bridged	
	330–353	HSD VLAN range for DSLAMs connected to AR2		
	360–383	HSD VLAN range for DSLAMs connected to AR3		
	Routed		Transport to/from DER2	10.1.1.1/30
			Transport to/from AR1	10.1.1.9/30
To/from AR2			10.1.1.17/30	
DER2	11	Management: CNR (DHCP, DNS, FTP, TFTP, Syslog servers)	10.1.11.1/24	
	61	VoD sources	10.1.61.1/24	
	70	Digital broadcast sources	10.1.70.1/24	
	81	VoIP—SIP proxy server	10.1.81.1/24	
	Routed		To/from DER1	10.1.1.2/30
			To/from AR1	10.1.1.34/30
Routed (subinterface)		HSD traffic—to/from BRAS	Bridged	
AR1	Routed	To/from DER1	10.1.1.10/30	
		To/from AR2	10.1.1.17/30	
	Routed (subinterface)		Subscriber video (N:1)	10.10.0.1/16 10.20.0.1/16
			High-speed data (N:1) to/from UTStarcom DSLAM (EoMPLS)	Bridged (VLANs 300–323)
AR2	Routed	To/from AR1	10.1.1.18/30	
		To/from AR3	10.1.1.25/30	
	Routed (subinterface)		Subscriber video (N:1)	10.11.0.1/16 10.21.0.1/16
			High-speed data (N:1) to/from UTStarcom DSLAM (EoMPLS)	Bridged (VLANs 330–353)
AR3	Routed	To/from AR1	10.1.1.26/30	
		To/from DER2	10.1.1.33/30	
	Routed (subinterface)		Subscriber video (N:1)	10.12.0.1/16 10.22.0.1/16
			High-speed data (N:1) to/from UTStarcom DSLAM (EoMPLS)	Bridged (VLANs 360–383)

Table 4-3 lists the parameters used to configure the residential gateway (RG) tested in this topology.



Note See [RG Functions](#), page 3-41, and [Appendix C](#), “Configuring Ericsson DSL Equipment.”

Table 4-3 *RG Configuration Parameters*

Traffic	VLAN	RG Ports	PVC ¹	VPI ²	VCI ³	Encapsulation	Service Class	PCR ⁴	SCR ⁵	MBS ⁶
HSD	90	0	1	8	35	LLC	UBR	—	—	—
VoIP	1x0 ⁷	1	4	0	51		CBR	—	300	—
Video	1x1	2, 3	7	8	59		VBR-RT	1200	600	10

1. Permanent virtual connection
2. Virtual path identifier
3. Virtual connection identifier
4. Peak cell rate
5. Sustained cell rate
6. Maximum burst size
7. The *x* corresponds to the AR number 1, 2, or 3 in the corresponding VLAN

Common Task: Configuring MPLS for HSD Service

Because EoMPLS is used on the trunk to the BRAS (as well as between the ARs and the DSLAMs), MPLS is required to support high-speed data (HSD) on the transport links between the DER and AR nodes.



Note For more information, see “Ethernet over MPLS for the Cisco 7600 Series Internet Routers” at the following URL:

<http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121newft/121limit/121ex/121ex8a/eompls9.htm>

Table 4-4 lists the loopback addresses used for MPLS. Loopback3 is used throughout for this purpose.

Table 4-4 *Loopback Addresses for MPLS*

Node	Loopback3 Address
DER1	10.1.254.1/32
DER2	10.1.254.2/32
AR1	10.1.254.3/32
AR2	10.1.254.4/32
AR3	10.1.254.5/32

Do the following in global configuration mode to enable MPLS on all nodes. (Loopback interfaces are later established on each node for MPLS in interface configuration mode.)

-
- Step 1** Configure the default MPLS LDP protocol as LDP. Configure this command in global configuration mode to set all MPLS interfaces to LDP.
- ```
mpls label protocol ldp
```
- Step 2** Configure MPLS to advertise by means of the loopback interface.
- ```
tag-switching advertise-tags for LOOPBACK  
tag-switching tdp router-id Loopback3 force
```
- Step 3** Configure an access list to identify non-MPLS traffic. By default, all IPv4 packets are transmitted over MPLS. To prevent video and VoIP traffic from being routed over MPLS configure the following.
- ```
no tag-switching advertise-tags
ip access-list standard LOOPBACK
permit 10.1.254.0 0.0.0.255
```
- Step 4** To complete the configuration, proceed to “Establishing 10-GE Interfaces for Transport” for each node in the ring.
-

## Configuring DER1

This section addresses the configuration required on the switch labeled DER1 in [Figure 4-1 on page 4-6](#), to route multiple services from that switch to the ARs.

See [Configuring DNS Servers, page 4-2](#).



Note

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A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

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This section addresses the following:

- [Configuring QoS on DER1](#)
- [Establishing and Configuring Interfaces on DER1](#)
- [Configuring OSPF Routing for Video and Voice Traffic on DER1](#)



Note

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For a complete configuration example, see [Appendix A, “Sample DER and AR Switch Configurations for the 10-GE Ring Topology.”](#)

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## Configuring QoS on DER1

This section presents the following topics:

- [Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series](#)
- [Configuring Marking and Classification on DER1](#)
- [Configuring Mapping on DER1](#)

### Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series

This section addresses the configuration of quality of service (QoS) on the DER, through marking, classification, mapping, and queuing, to provide different degrees of quality of service for the different types of services supported by the solution architecture. For example, it is important to ensure the expeditious delivery of video and VoIP traffic, while providing only best-effort delivery for high-speed data (HSD).

By default, the Cisco 7600 series router and Cisco Catalyst 6500 series switch do not trust the incoming QoS markings, and therefore rewrite these bits with zeros. In this solution, packets at the network ingress ports are identified, classified, and marked according to type of traffic. The packets are marked with one of 64 possible Differentiated Services Code Point (DSCP) values at the ingress ports. These in turn are internally mapped to one of eight possible Class of Service (CoS) values, because CoS is used to determine the appropriate transmit queue for each packet. Queuing is configured on the individual 10-GE interfaces.



Note

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For more information on class of service, see “White Paper: Cisco IOS Software Features for Differentiated Class of Service for Internetworks,” at the following URL:

[http://www.cisco.com/warp/public/cc/pd/iosw/iore/tech/osfea\\_wp.htm](http://www.cisco.com/warp/public/cc/pd/iosw/iore/tech/osfea_wp.htm)

---

## Configuring Marking and Classification on DER1

Do the following to enable marking and classification on DER1.

- Step 1** Enable QoS in global configuration mode.

```
mls qos
```

- Step 2** Configure ingress multicast replication mode and disable automatic detection of the replication mode (enabled by default).

```
mls ip multicast replication-mode ingress
```



**Note** Ingress replication of multicast is required on both DER1 and DER2.

- Step 3** Create access lists to identify the different service types in the network

```
ip access-list extended acl_VoD_and_SIP_signaling
 permit tcp 10.1.60.0 0.0.0.255 any
 permit tcp 10.1.61.0 0.0.0.255 any
 permit tcp 10.1.80.0 0.0.0.255 any
 permit tcp 10.1.81.0 0.0.0.255 any

ip access-list extended acl_video_VoD
 permit udp 10.1.60.0 0.0.0.255 any
 20 permit udp 10.1.61.0 0.0.0.255 any

ip access-list extended acl_video_broadcast
 permit udp 10.1.70.0 0.0.0.255 232.0.0.0 0.255.255.255
```

- Step 4** Create class maps for the access lists created in Step 2.

```
class-map match-all class_VoIP
 match access-group name acl_VoIP
class-map match-all class_VoD_and_SIP_signaling
 match access-group name acl_VoD_and_SIP_signaling
class-map match-all class_video_broadcast
 match access-group name acl_video_broadcast
class-map match-all class_video_VoD
 match access-group name acl_video_VoD
```

- Step 5** Create a policy map to set the DSCP values of the different classes created in Step 4.

```
policy-map setDSCP
 description Mark DSCP values for ingress traffic
 class class_VoD_and_SIP_signaling
 set dscp cs3
 class class_video_broadcast
 set dscp af41
 class class_video_VoD
 set dscp af42
 class class_VoIP
 set dscp ef
```

- Step 6** Apply the policy map from Step 4 to the ingress interfaces by using the following command.

```
service-policy input setDSCP
```



**Note** Specific interface examples of this and other interface commands are shown in the interface provisioning sections.

- Step 7** To maintain the DSCP marking applied at the network ingress interface, configure all noningress transport interfaces to trust the incoming DSCP markings.

```
mls qos trust dscp
```

## Configuring Mapping on DER1

For background, see the following:

- QoS Packet Marking  
[http://www.cisco.com/en/US/tech/tk543/tk757/technologies\\_tech\\_note09186a00800949f2.shtml#scpandassuredforwardingclasses](http://www.cisco.com/en/US/tech/tk543/tk757/technologies_tech_note09186a00800949f2.shtml#scpandassuredforwardingclasses)
- Understanding and Configuring QoS  
[http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12\\_18a/config/qos.htm#59874](http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/12_18a/config/qos.htm#59874)

Do the following to configure mapping on DER1.

- Step 1** View the Cisco 7600 and Cisco Catalyst 6500 default DSCP-to-CoS mapping for the different services. Use the **show mls qos maps dscp-cos** command.



**Note** At the beginning of this section, we mentioned that there are 64 possible DSCP values and only 8 CoS values. This means that there could be more than one DSCP value for one CoS value. The following command shows the default DSCP-to-CoS mapping on the Cisco 7600 and Catalyst 6500.



**Note** In the map, d1 corresponds to the y-axis value of the table, and d2 to the x-axis value.

```
DER1# show mls qos maps dscp-cos
```

```
Dscp-cos map: (dscp= d1d2)
d1 : d2 0 1 2 3 4 5 6 7 8 9
0 : 00 00 00 00 00 00 00 00 01 01
1 : 01 01 01 01 01 01 02 02 02 02
2 : 02 02 02 02 03 03 03 03 03 03
3 : 03 03 04 04 04 04 04 04 04 04
4 : 05 05 05 05 05 05 05 05 06 06
5 : 06 06 06 06 06 06 07 07 07 07
6 : 07 07 07 07
```

This table shows the following default mapping (36 corresponds to DSCP AF41):

| Service Type    | DSCP | CoS |
|-----------------|------|-----|
| Broadcast video | 36   | 4   |

- Step 2** Change the Cisco 7600 and Cisco Catalyst 6500 DSCP-to-CoS mapping for broadcast video to match the specifications of the solution. (The other default mappings for other services do not need to be changed.)

The solution specifies the following DSCP-to-CoS mapping:

| Service Type    | DSCP | CoS |
|-----------------|------|-----|
| Broadcast video | 36   | 2   |

- a. Execute the following command on the Cisco 7600 and Cisco Catalyst 6500 to modify the DSCP-to-CoS mapping.

```
mls qos map dscp-cos 36 to 2
```

- b. Verify the changes to the DSCP-to-CoS mapping.

```
DER1# show mls qos maps dscp-cos

DSCP-CoS Mapping Table (dscp = d1d2)
d1 : d2 0 1 2 3 4 5 6 7 8 9
0 : 00 00 00 00 00 00 00 00 01 01
1 : 01 01 01 01 01 01 02 02 02 02
2 : 02 02 02 02 03 03 03 03 03 03
3 : 03 03 04 04 04 04 02 04 04 04
4 : 05 05 05 05 05 05 05 05 06 06
5 : 06 06 06 06 06 06 07 07 07 07
6 : 07 07 07 07
```

## Establishing and Configuring Interfaces on DER1

Refer to [Figure 4-1 on page 4-6](#).

This section addresses the following:

- [Establishing VLANs for Services on DER1](#)
- [Establishing an EoMPLS Interface to the BRAS](#)
- [Establishing 1-GE Interfaces for Servers and Management on DER1](#)
- [Establishing 10-GE Interfaces for Transport on DER1](#)

### Establishing VLANs for Services on DER1

Before the 1-GE interfaces can be configured, VLANs for the various services must be created. (See [Table 4-2 on page 4-8](#).)



#### Tip

For convenience in establishing these VLANs and others, you can establish all VLANs in global configuration mode first, and then configure all the interfaces in interface configuration mode.

#### Step 1

Establish VLANs and VLAN interfaces for management (including connectivity with DHCP, DNS, FTP, TFTP, Syslog, VoIP, and video servers.)

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 10
name VLAN_10_Management
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan10
 description Management VLAN (Middleware, DNS, DHCP, etc)
 ip address 10.1.10.1 255.255.255.0
 no ip redirects
 no ip unreachablees
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

- d. Repeat Step 1a through Step 1c, as appropriate, for the remaining management and video aggregation VLANs and interfaces. The abbreviated configurations are shown below.

### Unicast Video Aggregation

```
vlan 60
name VLAN_60_Unicast_Video
```

```
interface Vlan60
 description VoD server VLAN (Unicast Video)
 ip address 10.1.60.1 255.255.255.0
 no ip redirects
 no ip unreachablees
 load-interval 30
```

### VoIP

```
vlan 80
name VLAN_80_VoIP
```

```
interface Vlan80
 description VoIP gateway VLAN
 ip address 10.1.80.1 1 255.255.255.0
 no ip redirects
 no ip unreachablees
 load-interval 30
```

### Step 2 Establish a VLAN for multicast video aggregation.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 70
name VLAN_70_Multicast_Video
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan70
 description Broadcast video source VLAN (Multicast Video)
 ip address 10.1.70.1 255.255.255.0
 no ip redirects
 no ip unreachablees
```

- c. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast addressed.

```
ip pim sparse-mode
```

- d. Change the load interval from the default of 300.

```
load-interval 30
```

---

## Establishing an EoMPLS Interface to the BRAS

Do the following to establish an Ethernet over Multiprotocol Label Switching (EoMPLS) interface to the broadband remote access server (BRAS).



### Note

Connections to multiple BRASs are likely. This example illustrates only one connection.

---

- Step 1 Establish a 1-GE interface.

```
interface GigabitEthernet2/24
 description To/From BRAS for 10GE Ring EoMPLS
 no ip address
```

- Step 2 Configure interface link detection options, such as **carrier-delay** (to reduce the time to detect a link failure), and **dampening** (to minimize the effects of flapping links).

```
carrier-delay msec 0
dampening
```

- Step 3 Change the load interval from the default of 300.

```
load-interval 30
```

- Step 4 Configure Quality of Service (QoS) on the interface.



### Note

For a detailed discussion, see Step 2 of [Configuring QoS on DER1, page 4-11](#).

---

```
wrr-queue bandwidth 64 255 0
wrr-queue queue-limit 40 50 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```

- Step 5 Configure EoMPLS for HSD to the ARs.

- a. Establish a subinterface on AR1 for video services for DSLAM1. A subinterface is a Layer 3 port with a VLAN association. DSLAM1 will use VLAN 300 for video services. The dot1q ID is the same as the VLAN ID. (See [Table 4-2 on page 4-8](#).)

```
interface GigabitEthernet2/24.1
 description HSD to/from DSLAM1 on AR1
 encapsulation dot1q 300
```



### Note

No service policy is applied here. By default, HSD is treated as “untrusted” (DSCP = 0).

---

- b. Bind the attachment circuit to a pseudowire VC (in this case, the VLAN just established), using the **xconnect peer\_router\_id vcid encapsulation mpls** command. The VC maps a tunnel to a subinterface port.



```
xconnect 10.1.254.3 300 encapsulation mpls
```

- c. Repeat Step 5a and Step 5b for AR2 and AR3.

```
interface GigabitEthernet2/24.2
 description HSD to/from DSLAM1 on AR2
 encapsulation dot1Q 330
 xconnect 10.1.254.4 330 encapsulation mpls
!
interface GigabitEthernet2/24.3
 description HSD to/from DSLAM1 on AR3
 encapsulation dot1Q 360
 xconnect 10.1.254.5 360 encapsulation mpls
```

- d. Repeat Step 5a through Step 5c for the remaining HSD VLANs.

## Establishing 1-GE Interfaces for Servers and Management on DER1

VoD servers, high-speed data sources, and management resources connect to Layer 2 interfaces on DER, and their traffic is aggregated into the appropriate service VLANs.

The following is configured on DER1.

### Step 1 Establish an interface.

- a. Establish an interface for the Cisco Network Registrar (CNR) primary server.

```
interface GigabitEthernet2/1
 description CNR ingress/egress (DHCP, DNS, TFTP, SysLog)
 no ip address
```

- b. Configure the interface as a Layer 2 access port and assign it to VLAN 10.

```
switchport
switchport mode access
switchport access vlan 10
```

- c. Configure interface link detection options, such as **carrier-delay** (to reduce the time to detect a link failure), and **dampening** (to minimize the effects of flapping links).

```
carrier-delay msec 0
dampening
```

- d. Change the load interval from the default of 300.

```
load-interval 30
```

- e. Disable Cisco Discovery Protocol (CDP) on the interface.

```
no cdp enable
```

- f. Enable PortFast on the interface to bypass the listening and learning states in Spanning Tree Protocol (STP).



**Note** This allows the interface to move immediately from the blocking state to the forwarding state, rather than waiting for STP to converge.

```
spanning-tree portfast
```

- g. Configure the switch to disable any interfaces that are configured for PortFast and receive a Bridge Protocol Data Unit (BPDU).

```
spanning-tree bpduguard enable
```



**Note** This guards against a user accidentally connecting a switch to a switchport that is intended for a VoD server or other host. The switchport is disabled and the user must investigate why the port is down. If this command is not used and such an accidental connection were to happen, STP could reconverge and block other connections in the switch.

- h. Apply the “setDSCP” service policy to mark DSCP values in the inbound packets.

```
service-policy input setDSCP
```

**Step 2** Repeat Step 1a through Step 1g for the remaining server and management 1-GE interfaces and their associated VLANs, changing the value in **switchport access vlan *vlan-id*** as appropriate. Those configurations are shown abbreviated below.

#### Kasenna Middleware Server

```
interface GigabitEthernet2/2
 description Kasenna Middleware Server ingress/egress
 switchport
 switchport access vlan 10
```

#### Kasenna VoD Pump Management Port (Eth0)

```
interface GigabitEthernet2/3
 description VoD Pump ingress/egress
 switchport
 switchport access vlan 60
```

#### Kasenna VoD Pump (HPN0)

```
interface GigabitEthernet2/3
 description VoD Pump (HPN0) ingress/egress
 switchport
 switchport access vlan 60
```

#### Kasenna VoD Pump (HPN1)

```
interface GigabitEthernet2/3
 description VoD Pump (HPN1) ingress/egress
 switchport
 switchport access vlan 60
```

#### Broadcast Server (Multicast)

```
interface GigabitEthernet2/6
 description Broadcast Video ingress/egress
 switchport
 switchport access vlan 70
```

#### VoIP—SIP Proxy Server

```
interface GigabitEthernet2/7
 description SIP Proxy Server ingress/egress
 switchport
 switchport access vlan 80
```



**Note** In Kasenna's terminology, HPN0 stands for High-Performance Network interface 0.

## Establishing 10-GE Interfaces for Transport on DER1

The 10-GE trunk interfaces create the ring topology from DER1 through the ARs and back to the DER2. The following is configured on DER1.

**Step 1** Establish an interface to and from DER2.

a. Establish the interface.

```
interface TenGigabitEthernet7/4
 description Transport to/from Ring AR1 (TenGig1/1)
 ip address 10.1.1.1 255.255.255.252
```

b. Configure interface link detection options, such as **carrier-delay** (to reduce the time to detect a link failure), and **dampening** (to minimize the effects of flapping links).



**Note** The **restart** command option is applied on start up to reduce the possibility of routing “black holes” during startup (where upper layers converge before lower layers do).

```
carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000
```

c. Change the load interval from the default of 300.

```
load-interval 30
```

d. Change the PIM query interval from the default of 30 seconds.

```
ip pim query-interval 100 msec
```



**Note** It was determined in testing that convergence times improve if the PIM hello interval is less than one second. For more information about the **ip pim query-interval** command, see the following:

[http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3\\_i2gt.htm#wp1069550](http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3_i2gt.htm#wp1069550)

e. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast addressed. Change the PIM **query-interval** from the default of 30 seconds for PIM fast convergence.

```
ip pim sparse-mode
```

f. Configure OSPF on the transport VLAN interface.

```
ip ospf network point-to-point
ip ospf hello-interval 1
```



**Note** To avoid the election of the designated router (DR) and backup designated router (BDR), and prevent the origination of an unnecessary network link state advertisement (LSA), configure the transport VLAN as a point-to-point network. In addition, reduce the interval between OSPF hello messages from 10 seconds to 1 second. This improves reconvergence in the event of failure in the transport or in a neighboring switch.

**Step 2** Configure QoS on the interface.



**Note**

The 10-GE transport links from the DER to the ARs require modifications to the transmit queues. There are eight transmit queues, but this solution uses only three. For more information, see “Buffers, Queues, and Thresholds on Catalyst 6500 Series Ethernet Modules” at the following URL:

[http://www.cisco.com/warp/public/cc/pd/si/casi/ca6000/prodlit/buffe\\_wp.htm](http://www.cisco.com/warp/public/cc/pd/si/casi/ca6000/prodlit/buffe_wp.htm)

- a. View the default CoS-to-TxQueue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0
1 2 1
2 1 2
2 2 3 4
3 1 6 7
8 1 5
```

- b. Configure the CoS-to-TxQueue mapping on the 10-GE transport interfaces. HSD (CoS = 0) remains in TxQueue1 and VoIP (CoS = 5) remains in TxQueue8. Video is separated into two classes, one class for broadcast video (CoS = 4) and one class for VoD video (CoS = 2). The other three CoS values are associated with TxQueue2.

```
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```



**Note** TxQueue1 and TxQueue8 use the default mappings. TxQueue2 has three thresholds: Threshold 1 = CoS 1, Threshold 2 = CoS 2, and Threshold 3 = CoS 3, 4, 6, and 7.

- c. Verify the modified CoS-to-Tx-Queue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0 1
2 1 2
2 2 3 4 6 7
8 1 5
```

- d. Configure the TxQueue thresholds.

TxQueue1 uses Weighted Random Early Drop (WRED) for queue-congestion management. Only HSD is queued in this queue, and when the amount of HSD in the queue reaches 75%, random packets are dropped in an attempt to keep the queue from reaching 100% utilization.

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100 100
```

TxQueue2 uses tail drop for queue congestion management. VoD is assigned to the threshold 1 and is dropped once the queue reaches 80% utilization. VoD signaling, network signaling, and broadcast video are assigned to the third threshold 2 and are dropped once the queue reaches 100% utilization.

```
wrr-queue threshold 2 80 100 100 100 100 100 100 100
no wrr-queue random-detect 2
```

- e. Configure the bandwidth of the weighted queues.

The weighted queues need to be modified to handle our modified TxQueue mappings. The ratio between TxQueue2 and TxQueue1 is  $255/64 = 4$ , so TxQueue2 needs four times as much bandwidth as TxQueue1. Therefore, TxQueue1 is allocated 20% of the bandwidth on the interface, and TxQueue2 is allocated 80% of the bandwidth.

```
wrr-queue bandwidth 64 255 0 0 0 0 0
```

- f. Configure the size of the weighted queues.

Each line card has a limited amount of buffer for the transmit queues. For this interface, 40% of the buffer is allocated for TxQueue1, and 50% of the buffer is allocated for TxQueue2.

```
wrr-queue queue-limit 40 50 0 0 0 0 0
```

- g. Configure this interface (and all noningress transport interfaces) to trust the incoming DSCP markings. (This maintains the DSCP marking applied at the network ingress interface.)

```
mls qos trust dscp
```

- Step 3** Establish an interface to and from AR1.

- h. Establish the interface to AR1

```
interface TenGigabitEthernet7/1
 description Transport to/from Ring AR1 (TenGig1/1)
```

- i. Proceed as in Step 1b through Step 2 of this task.

- Step 4** Configure MPLS on the transport interfaces.



**Note**

Ensure that MPLS is enabled globally. See [Common Task: Configuring MPLS for HSD Service, page 4-9](#).

- a. Establish a loopback interface for MPLS.

```
interface loopback 3
 description Loopback interface for MPLS
 ip address 10.1.254.1 255.255.255.255
```

- b. Enable MPLS on the transport interface.

```
tag-switching ip
```

- c. Set the size of the maximum transmission unit (MTU) to account for the additional packet overhead required for MPLS.

```
mtu 9216
```

## Configuring OSPF Routing for Video and Voice Traffic on DER1

Routing advertisements are enabled on the transport VLANs, but are turned off on the aggregation VLANs by means of the **passive-interface** command.

**Step 1** Define an OSPF routing process to route video traffic.

```
router ospf 100
router-id 10.1.1.1
log-adjacency-changes
```

- a. The OSPF timers are modified to provide fast convergence. The following command enables OSPF SPF throttling: **timers throttle spf** *spf-start spf-hold spf-max-wait*

```
timers throttle spf 10 100 1000
```

- b. The following command sets the rate-limiting values for OSPF link-state advertisement (LSA) generation: **timers throttle lsa** *all start-interval hold-interval max-interval*

```
timers throttle lsa all 1 10 1000
```

- c. The following command controls the minimum interval for accepting the same LSA: **timers lsa arrival** *milliseconds*

```
timers lsa arrival 100
```

If an instance of the same LSA arrives sooner than the interval that is set, the LSA is dropped.

- d. The following command sets incremental SPF (iSPF) updates for LSA type 1 and LSA type 2 within an area. Enabling iSPF can minimize the affect of SPF changes within an area to only those routers where the change is relevant, thus reducing the time spent calculating SPF.

```
ispf
```

- e. Apply the **passive-interface** command to the aggregation VLANs.

```
passive-interface Vlan10
passive-interface Vlan60
passive-interface Vlan70
passive-interface Vlan80
```

- f. Advertise the networks in the first OSPF routing process.

```
network 10.1.1.0 0.0.0.3 area 0
network 10.1.1.8 0.0.0.3 area 0
network 10.1.10.0 0.0.1.255 area 0
network 10.1.60.0 0.0.0.255 area 0
network 10.1.70.0 0.0.0.255 area 0
network 10.1.70.0 0.0.0.255 area 0
network 10.1.80.0 0.0.0.255 area 0
```

- g. To support load sharing, set the maximum number of parallel routes the IP routing protocol supports (installs in a routing table).

```
maximum-paths 8
```

## Configuring DER2

The configuration on DER2 is essentially the same as that on DER1, except that IP addresses and VLAN IDs differ, and no connection is made to a BRAS. The topics are summarized, with references, below.

- [Configuring QoS on DER2](#)
- [Establishing and Configuring Interfaces on DER2](#)
- [Configuring OSPF Routing for Video and Voice Traffic on DER2](#)

### Configuring QoS on DER2

Proceed as in [Configuring QoS on DER1, page 4-11](#).

### Establishing and Configuring Interfaces on DER2

Proceed as in [Establishing and Configuring Interfaces on DER1, page 4-14](#).

For IP addresses and VLAN IDs, see [Table 4-2 on page 4-8](#).

For MPLS on transport interfaces, see [Common Task: Configuring MPLS for HSD Service, page 4-9](#).

### Configuring OSPF Routing for Video and Voice Traffic on DER2

Proceed as in [Configuring OSPF Routing for Video and Voice Traffic on DER1, page 4-22](#)

## Configuring AR1

This section addresses the configuration required on the switch labeled AR1 in [Figure 4-1 on page 4-6](#), to route multiple services from AR1 to DER1 and AR2.

See [Configuring DNS Servers, page 4-2](#).

**Note**

A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

This section addresses the following:

- [Configuring QoS on AR1](#)
- [Establishing and Configuring Interfaces on AR1](#)
- [Configuring OSPF Routing for Video and Voice Traffic on AR1](#)

**Note**

For a complete configuration example, see [Appendix A, “Sample DER and AR Switch Configurations for the 10-GE Ring Topology.”](#)

## Configuring QoS on AR1

See [Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series, page 4-11](#). This section presents the following topics:

- [Configuring Marking and Classification on AR1](#)
- [Configuring Mapping on AR1](#)

### Configuring Marking and Classification on AR1

Do the following to enable marking and classification on AR1.

**Step 1** Enable QoS in global configuration mode.

```
mls qos
```

**Step 2** Create access lists to identify the different service types in the network.

```
ip access-list extended acl_VoD_and_SIP_signaling
 permit ip any host 10.1.10.10
 permit ip any host 10.1.60.0 0.0.0.255
 permit ip any host 10.1.61.10 0.0.0.255
 permit ip any host 10.1.80.10 0.0.0.255
 permit ip any host 10.1.81.10 0.0.0.255
```

```
ip access-list extended acl_VoIP
 permit udp any any range 16384 32767
 permit udp any range 16384 32767 any
```

**Step 3** Create class maps for the access lists created in Step 2.

```
class-map match-all class_VoIP
 match access-group name acl_VoIP
class-map match-all class_VoD_and_SIP_signaling
 match access-group name acl_VoD_and_SIP_signaling
```



**Step 4** Create a policy map to set the DSCP values of the different classes created in Step 3.

```
policy-map setDSCP
 description Mark DSCP values for ingress traffic
 class class_VoIP
 set dscp ef
 class class_VoD_and_SIP_signaling
 set dscp cs3
```

**Step 5** Apply the policy map from Step 4 to the ingress interfaces by using the following command:

```
service-policy input setDSCP
```



**Note** Specific interface examples of this and other interface commands are shown in the interface provisioning sections.

**Step 6** To maintain the DSCP marking applied at the network ingress interface, configure all noningress transport interfaces to trust the incoming DSCP markings.

```
mls qos trust dscp
```

## Configuring Mapping on AR1

To configure mapping on AR1, proceed as in [Configuring Mapping on DER1, page 4-13](#).

## Establishing and Configuring Interfaces on AR1

Refer to [Figure 4-1 on page 4-6](#).

This section addresses the following:

- [Establishing VLANs for Services on AR1](#)
- [Establishing 10-GE Interfaces for Transport on AR1](#)
- [Configure Service Mapping for Video and VoIP Services on AR1](#)
- [Establishing 1-GE Subinterfaces to DSLAMs on AR1](#)

### Establishing VLANs for Services on AR1

Proceed as in [Establishing VLANs for Services and Transport on DER1, page 4-39](#), but make changes to IP addresses and VLAN IDs as indicated in [Table 4-2 on page 4-8](#).

### Establishing 10-GE Interfaces for Transport on AR1

The 10-GE trunk interfaces provide the transport between AR1 and DER1 and AR2.



**Note** For additional details, see [Establishing 10-GE Interfaces for Transport on DER1, page 4-19](#).

**Step 1** Establish a Layer 3 interface on AR1 to and from DER1.

- Establish the Layer 3 interface. (See [Table 4-2 on page 4-8](#).)

```
interface TenGigabitEthernet1/1
```

```

description Transport to/from DER1 (TenGig7/1)
dampening 5 1000 2000 20 restart 16000
ip address 10.1.1.10 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
carrier-delay msec 0

```

- b. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1, page 4-19](#).

```

wrr-queue bandwidth 64 255 0 0 0 0 0
wrr-queue queue-limit 40 50 0 0 0 0 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
mls qos trust dscp

```

- Step 2** Repeat Step 1, as appropriate, to establish a Layer 3 interface on AR1 to and from AR2.

```

interface TenGigabitEthernet1/3
description Transport to/from AR2 (TenGig1/1)
dampening 5 1000 2000 20 restart 16000
ip address 10.1.1.17 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
carrier-delay msec 0
wrr-queue bandwidth 64 255 0 0 0 0 0
wrr-queue queue-limit 40 50 0 0 0 0 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
mls qos trust dscp

```

## Configure Service Mapping for Video and VoIP Services on AR1

Service mapping on each DSLAM is achieved by using VLANs, with a single set of VLANs allocated to each DSLAM. There is a single VLAN per DSLAM, meaning that a VLAN defined on an AR will not span multiple DSLAMs on the AR. One VLAN is for video service, a second VLAN is for VoIP services, and a third VLAN is for high-speed data (HSD) services. (See [Table 4-2 on page 4-8](#).)

IP unnumbered is used to reduce the operational overhead associated with assigning unique IP subnets per VLAN. With IP unnumbered we can reduce operational overhead on the AR by assigning one /16 subnet to a service for all DSLAMs aggregated by the AR. With the exception of HSD, all interfaces are Layer 3 subinterfaces. HSD subinterfaces use EoMPLS at Layer 2 to bridge traffic across an MPLS transport link to a BRAS.



### Note

For additional details, see [Establishing VLANs for Services on AR1, page 4-25](#).

Do the following to configure service mapping for video and VoIP services on AR1.

- Step 1** In global configuration mode, establish and configure loopback interfaces as follows.
- Establish two loopback interfaces, one for video services and one for VoIP services.

```
interface Loopback0
 description Address block for Video Services on AR1
 ip address 1.10.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

```
interface Loopback1
 description Address block for VoIP services on AR1
 ip address 1.20.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

- In global configuration mode, configure IP unnumbered to use “connected” host routes.

```
ip dhcp route connected
```

### Establishing 1-GE Subinterfaces to DSLAMs on AR1

Do the following to establish 1-GE subinterfaces to DSLAMs on AR1.

- Step 1** Establish an interface on AR1 to DSLAM1.
- Establish the interface and corresponding three subinterfaces for each service.

```
interface GigabitEthernet2/1
 description 802.1q Interface To DSLAM-1
 no ip address
```

- Disable Cisco Discovery Protocol on the interface.

```
no cdp enable
```

- Change the load-interval from the default of 300 seconds.

```
load-interval 30
```

- Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1](#), page 4-19.

```
wrr-queue bandwidth 64 255 0
wrr-queue queue-limit 40 50 0
wrr-queue threshold 2 80 100 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```



**Note** The cos-map value 2 2 2 is a default setting on 1-GE interfaces.

- e. Establish a subinterface on AR1 for video services for DSLAM1. A subinterface is a Layer 3 port with a VLAN association. DSLAM1 will use VLAN100 for video services.

```
interface GigabitEthernet2/1.1
 description Video edge VLAN
 encapsulation dot1Q 100
 ip unnumbered Loopback0
 ip helper-address 10.1.10.10
```

- f. Apply the policy map established in [Configuring Mapping on AR1, page 4-25](#), to the subinterface.

```
service-policy input setDSCP
```

- g. Enable PIM sparse mode. This is the aggregation VLAN for video traffic to the DSLAMs, and broadcast video is multicast addressed.

```
ip pim sparse-mode
```

- h. Configure OSPF on the transport VLAN interface.

```
ip ospf network point-to-point
ip ospf hello-interval 1
```

- i. To ensure consistently fast PIM convergence times, statically join the aggregation VLAN for video at the AR to the multicast groups.

```
ip igmp static-group 232.1.1.1 source ssm-map
ip igmp static-group 232.1.1.2 source ssm-map
ip igmp static-group 232.1.1.3 source ssm-map
ip igmp static-group 232.1.1.4 source ssm-map
ip igmp static-group 232.1.1.5 source ssm-map
ip igmp static-group 232.1.1.6 source ssm-map
ip igmp static-group 232.1.1.7 source ssm-map
ip igmp static-group 232.1.1.8 source ssm-map
ip igmp static-group 232.1.1.9 source ssm-map
ip igmp static-group 232.1.1.10 source ssm-map
```



**Note** For more information, see “Source Specific Multicast (SSM) Mapping” at the following URL:

[http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t\\_2/gtssmma.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_2/gtssmma.htm)

- j. Change the ARP timeout from the default.

```
arp timeout 250
```



**Note** The default timeout for an entry in the ARP cache is 4 hours. The default timeout for an entry in the MAC address table is only 5 minutes. Because video traffic is mostly unidirectional, the MAC address table may not be refreshed within the 5-minute timeout. This causes video traffic to be flooded until the destination MAC address is found. To prevent this, reduce the ARP cache timeout to 250 seconds. This forces the switch to re-ARP for the entries in the ARP cache before the entries in the MAC address table time out, avoiding the disruptive behavior.

- k. Establish a subinterface on AR1 for VoIP services for DSLAM1. DSLAM1 will use VLAN200 for VoIP services.

```
interface GigabitEthernet2/1.2
 description Voice edge VLAN
 encapsulation dot1Q 200
 ip unnumbered Loopback1
 ip helper-address 10.1.10.10
```

- l. Apply the policy map established in [Configuring Mapping on AR1, page 4-25](#), to the subinterface.

```
service-policy input setDSCP
```

- m. Establish a subinterface on AR1 for HSD services for DSLAM1. DSLAM1 uses EoMPLS for HSD services.

```
interface GigabitEthernet2/1.3
description HSD edge VLAN
encapsulation dot1Q 300
```




---

**Note** No service policy is applied here. By default, HSD is treated as “untrusted” (DSCP = 0).

---

- n. Bind the attachment circuit to a pseudowire VC (in this case, the VLAN just established), using the **xconnect** *peer\_router\_id vcid encapsulation mpls* command. The VC maps a tunnel to a subinterface port to the same loopback address.

```
xconnect 10.1.254.3 300 encapsulation mpls
```




---

**Note** For example, you configure a corresponding **xconnect** to AR1 on *peer\_router\_id* 1.1.254.3.

---

**Step 2** Configure MPLS on the transport interfaces.




---

**Note** Ensure that MPLS is enabled globally. See [Common Task: Configuring MPLS for HSD Service, page 4-9](#).

---

- a. Establish a loopback interface for MPLS.

```
interface loopback 3
description Loopback interface for MPLS
ip address 10.1.254.2 255.255.255.255
```

- b. Enable MPLS on the transport interface.

```
tag-switching ip
```

- c. Set the size of the maximum transmission unit (MTU) to account for the additional packet overhead required for MPLS.

```
mtu 9216
```

---

## Configuring OSPF Routing for Video and Voice Traffic on AR1

For background and details, refer to [Configuring OSPF Routing for Video and Voice Traffic on DER1, page 4-22](#).

Do the following to configure OSPF routing for video and voice traffic on AR1.

- Step 1** Define an OSPF routing process on AR1. This process associates the transport VLANs for video and VoIP VLANs for all DSLAMs to be served by AR1.

```
router ospf 100
router-id 10.1.1.3
ispf
log-adjacency-changes
timers throttle spf 10 100 1000
timers throttle lsa all 1 10 1000
timers lsa arrival 100
network 10.1.1.8 0.0.0.3 area 0
network 10.1.1.16 0.0.0.3 area 0
network 10.1.254.3 0.0.0.0 area 0
network 10.10.0.1 0.0.255.255 area 0
network 10.20.0.1 0.0.255.255 area 0
```

## Configuring AR2

The configuration on AR2 is essentially the same as that on AR1, except that IP addresses differ. The topics are summarized, with references, below.

- [Configuring QoS on AR2](#)
- [Establishing and Configuring Interfaces on AR2](#)
- [Configuring OSPF Routing for Video and Voice Traffic on AR2](#)

## Configuring QoS on AR2

Proceed as in [Configuring QoS on DER1, page 4-11](#).

## Establishing and Configuring Interfaces on AR2

Proceed as in [Establishing and Configuring Interfaces on DER1, page 4-14](#).

For IP addresses and VLAN IDs, see [Table 4-2 on page 4-8](#).

For MPLS on transport interfaces, see [Common Task: Configuring MPLS for HSD Service, page 4-9](#).

## Configuring OSPF Routing for Video and Voice Traffic on AR2

Proceed as in [Configuring OSPF Routing for Video and Voice Traffic on DER1, page 4-22](#)

## Configuring AR3

The configuration on AR3 is essentially the same as that on AR1 and AR2, except that IP addresses differ. The topics are summarized, with references, below.

- [Configuring QoS on AR3](#)
- [Establishing and Configuring Interfaces on AR3](#)
- [Configuring OSPF Routing for Video and Voice Traffic on AR3](#)

### Configuring QoS on AR3

Proceed as in [Configuring QoS on DER1, page 4-11](#).

### Establishing and Configuring Interfaces on AR3

Proceed as in [Establishing and Configuring Interfaces on DER1, page 4-14](#).

For IP addresses and VLAN IDs, see [Table 4-2 on page 4-8](#).

For MPLS on transport interfaces, see [Common Task: Configuring MPLS for HSD Service, page 4-9](#).

### Configuring OSPF Routing for Video and Voice Traffic on AR3

Proceed as in [Configuring OSPF Routing for Video and Voice Traffic on DER1, page 4-22](#)

# Configuring the Hub-and-Spoke Topology

This section presents the following major topics:

- [Introduction, page 4-32](#)
- [Common Task: Configuring QinQ and Spanning Tree](#)
- [Configuring DER1, page 4-36](#)
- [Configuring DER2, page 4-23](#)
- [Configuring AR1, page 4-58](#)
- [Configuring AR2, page 4-67](#)

## Introduction

[Figure 4-2 on page 4-33](#) illustrates the hub-and-spoke topology used in the solution. (See [Configuration 2: 1-GE plus 10-GE Hub and Spoke, page 3-39](#).) All video sources and VoIP servers are connected to ports on the distribution edge routers (DERs). With two DERs in the topology we are able to provide source, node, and network redundancy for each of the aggregation routers (ARs). Policy maps are applied to the DER ingress ports in order to mark the DSCP values of the different service types. In this example, only DER1 is connected to a middleware server.

Traffic is routed among DERs and ARs over 10-GE bidirectional and Nx1-GE transport links. Transport links are Layer 2 switchports that are defined as IEEE 802.1q trunks. Each transport link or trunk carries two VLANs; video and VoIP traffic is in one VLAN, and HSD or Internet traffic is in the second VLAN. IEEE 802.1q is needed, because HSD traffic is bridged on the transport links.

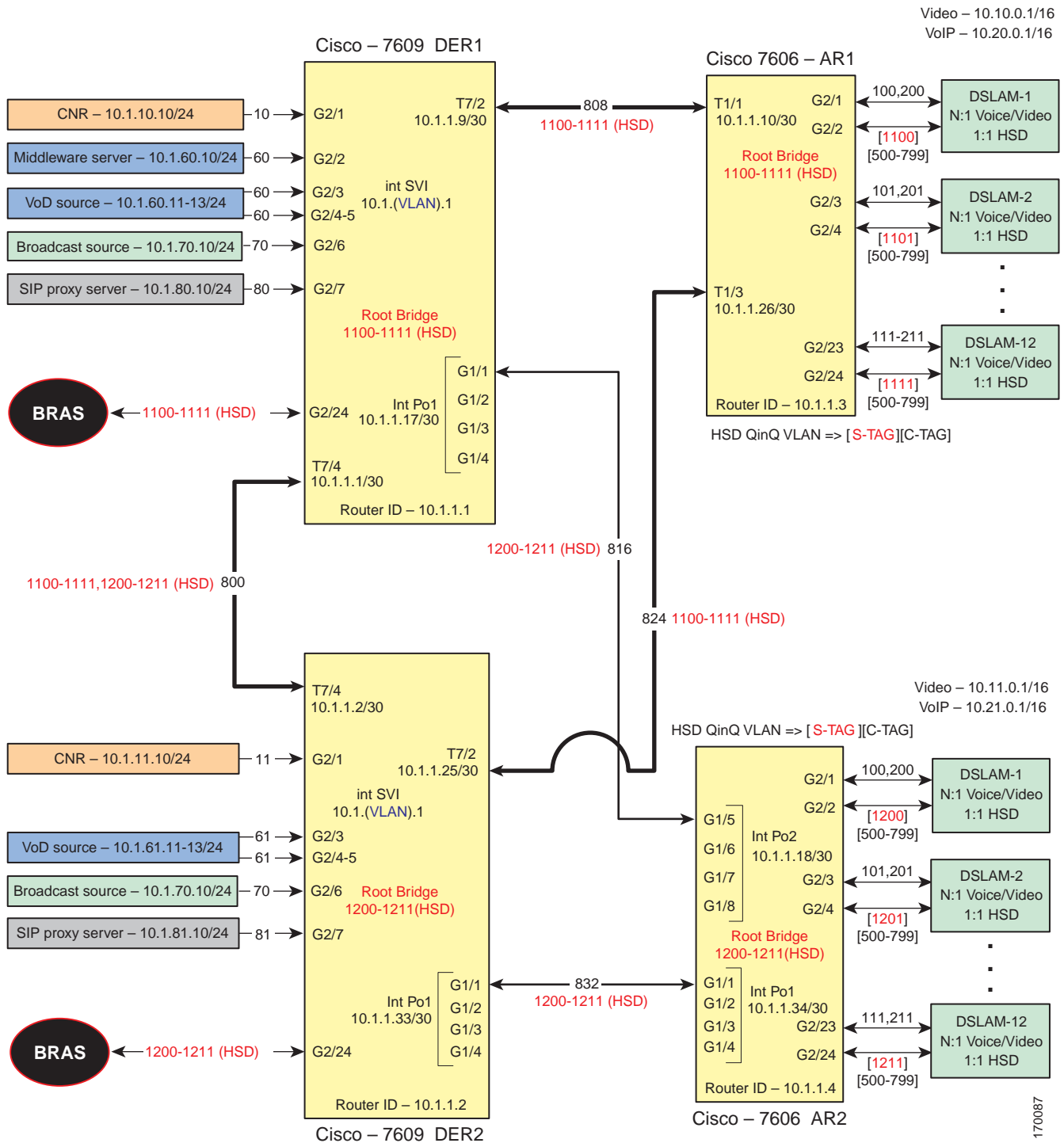
The hub-and-spoke topology assumes that each DSLAM uses the N:1 model for video and voice services, (one VLAN per service), and uses the 1:1 model for HSD services (one VLAN per subscriber). (Note that VLANs have local significance, and are not be bridged between DSLAMs attached to a common AR.)

The 1:1 model for HSD traffic does not scale, because of the number of service provider VLANs required to implement this model. Dot1q tunneling (QinQ) is used to reduce the number of VLANs required in the service provider network for HSD.

The residential gateways (RGs) used in the test bed provided service mapping based on physical ports, as described in [Physical Port-Based Traffic Mapping for the Multi-VC and VLAN Access Models, page 3-43](#).



Figure 4-2 Hub-and-Spoke Topology



The switches in Figure 4-2 use the line cards, hardware versions, and IOS versions listed in Table 4-6 on page 4-34.

**Table 4-5** Hardware and IOS Versions for the Hub-and-Spoke Topology

| Switch        | Module | Line Card      | Hardware Version | IOS Release       | Submodule         | Hardware Version |
|---------------|--------|----------------|------------------|-------------------|-------------------|------------------|
| DER1,<br>DER2 | 1      | WS-X6724-SFP   | 2.3              | 12.2(18)SXF2      | WS-F6700-DFC3BXL  | 5.2              |
|               | 2      |                |                  |                   | WS-F6700-DFC3BXL  | 4.0              |
|               | 5      | WS-SUP720-BASE | 3.1              |                   | WS-F6K-PFC3BXL    | 1.2              |
|               | 7      | WS-X6704-10-GE | 2.2              |                   | WS-SUP720 (MFSC3) | 2.1              |
| AR1           | 1      | WS-X6704-10-GE | 2.2              | WS-F6700-DFC3BXL  | 4.0               |                  |
|               | 2      | WS-X6724-SFP   | 2.3              | WS-F6700-DFC3BXL  | 5.2               |                  |
|               | 5      | WS-SUP720-BASE | 3.1              | WS-F6K-PFC3BXL    | 1.6               |                  |
|               |        |                |                  | WS-SUP720 (MFSC3) | 2.3               |                  |
| AR2           | 1      | WS-X6704-10GE  | 2.2              | WS-F6700-DFC3BXL  | 4.0               |                  |
|               | 2      | WS-X6724-SFP   | 2.2              | WS-F6700-DFC3BXL  | 5.2               |                  |
|               | 5      | WS-SUP720-BASE | 3.1              | WS-F6K-PFC3BXL    | 1.6               |                  |
|               |        |                |                  | WS-SUP720 (MFSC3) | 2.3               |                  |

Table 4-2 lists VLANs, their descriptions (service types), and IP addresses, for the DER and ARs in Figure 4-2 on page 4-33.

**Table 4-6** VLANs, Descriptions, and IP Addresses for the Hub-and-Spoke Topology

| Node | VLAN      | Description                                                                  | IP Address               |
|------|-----------|------------------------------------------------------------------------------|--------------------------|
| DER1 | 10        | Management: CNR (DHCP, DNS, FTP, TFTP, Syslog servers),<br>middleware server | 10.1.10.1/24             |
|      | 60        | VoD sources                                                                  | 10.1.60.1/24             |
|      | 70        | Digital broadcast sources                                                    | 10.1.70.1/24             |
|      | 80        | VoIP—SIP proxy server                                                        | 10.1.80.1/24             |
|      | 800       | To/from DER2                                                                 | 10.1.1.1/30              |
|      | 808       | To/from AR1                                                                  | 10.1.1.9/30              |
|      | 816       | To/from AR2                                                                  | 10.1.1.17/30             |
|      | 1100–1111 | HSD traffic to/from BRAS                                                     | Bridged                  |
| DER2 | 11        | Management: CNR (DHCP, DNS, FTP, TFTP, Syslog servers)                       | 10.1.11.1/24             |
|      | 61        | VoD sources                                                                  | 10.1.61.1/24             |
|      | 70        | Digital broadcast sources                                                    | 10.1.70.1/24             |
|      | 81        | VoIP—SIP proxy server                                                        | 10.1.81.1/24             |
|      | 800       | To/from DER1                                                                 | 10.1.1.2/30              |
|      | 824       | To/from AR1                                                                  | 10.1.1.25/30             |
|      | 832       | To/from AR2                                                                  | 10.1.1.33/30             |
|      |           | 1200–1111                                                                    | HSD traffic to/from BRAS |

**Table 4-6** VLANs, Descriptions, and IP Addresses for the Hub-and-Spoke Topology (continued)

| Node | VLAN      | Description                                                | IP Address   |
|------|-----------|------------------------------------------------------------|--------------|
| AR1  | 808       | To/from DER1                                               | 10.1.1.10/30 |
|      | 824       | To/from DER2                                               | 10.1.1.26/30 |
|      | 100–111   | Subscriber video (N:1)                                     | 10.10.0.1/16 |
|      | 200–211   | Subscriber voice (N:1)                                     | 10.20.0.1/16 |
|      | 1100–1111 | High-speed data (1:1) to/from UTStarcom DSLAM (QinQ—S-TAG) | Bridged      |
| AR2  | 816       | To/from DER1                                               | 10.1.1.18/30 |
|      | 832       | To/from DER2                                               | 10.1.1.34/30 |
|      | 100–111   | Subscriber video (N:1)                                     | 10.11.0.1/16 |
|      | 200–211   | Subscriber voice (N:1)                                     | 10.21.0.1/16 |
|      | 1200–1211 | High-speed data (1:1) to/from UTStarcom DSLAM (QinQ—S-TAG) | Bridged      |

Table 4-3 on page 4-9 lists the parameters used to configure the residential gateway (RG). They are the same as those for the 10-GE symmetric topology.



Note

See [RG Functions, page 3-41](#).

## Common Task: Configuring QinQ and Spanning Tree

QinQ is used to connect HSD subscribers to a BRAS on one of the DER nodes, where dot1q tunnels terminate on the BRAS. This supports the requirement to have 1:1 VLANs on the DSLAM, where one VLAN is assigned to each subscriber for HSD. Assuming there are 300 subscribers per DSLAM, this would require 300 VLANs per DSLAM—making VLAN scalability an issue for the service provider. The AR port connecting the DSLAM to the service provider network adds an outer S-TAG to inner C-TAG, meaning one service provider VLAN is required per DSLAM.

HSD VLANs are bridged on the service provider network. In a hub-and-spoke network, each AR creates a Layer 2 loop that forces the provider to run spanning tree. Disable MAC address learning on the DER to conserve on MAC forwarding entries. MAC address learning is not needed when a logical topology consists of only two physical ports, because each MAC frame that arrives at one port is always sent on the other port. To create a two-port topology on the DER, configure each AR as the spanning tree root for its HSD VLANs. This causes Spanning Tree Protocol (STP) to block at the transport link between DER1 and DER2, creating point-to-point Layer 2 links between DER and AR. To improve STP time, the four switches are configured for IEEE 802.1w Rapid Spanning Tree Protocol (RSTP).

VLANs defined on AR1 are used for HSD traffic, with one service provider VLAN per DSLAMs. Each AR supports a maximum of 30 DSLAMs. Table 4-7 lists the VLAN ranges for the ARs.

**Table 4-7** VLAN Ranges for ARs

| Node | VLAN Range |
|------|------------|
| AR1  | 1100–1111  |
| AR2  | 1200–1211  |

## Configuring DER1

This section addresses the configuration required on the switch labeled DER1 in [Figure 4-2 on page 4-33](#), to route multiple services from that switch to the ARs.

See [Configuring DNS Servers, page 4-2](#).



Note

A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

This section addresses the following:

- [Configuring QoS on DER1](#)
- [Establishing and Configuring Interfaces on DER1](#)
- [Configuring OSPF Routing for Video and Voice Traffic on DER1](#)
- [Configuring QinQ and Spanning Tree on DER1](#)



Note

For a complete configuration example, see [Appendix B, “Sample DER and AR Switch Configurations for the Hub-and-Spoke Topology.”](#)

## Configuring QoS on DER1

This section presents the following topics:

- [Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series](#)
- [Configuring Marking and Classification on DER1](#)
- [Configuring Mapping on DER1](#)



Note

For more information specific to QoS as applied to the solution, see [Appendix C, “Configuring Ericsson DSL Equipment.”](#)

### Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series

This section addresses the configuration of quality of service (QoS) on the DER, through marking, classification, mapping, and queueing, to provide different degrees of quality of service for the different types of services supported by the solution architecture. For example, it is important to ensure the expeditious delivery of video and VoIP traffic, while providing only best-effort delivery for high-speed data (HSD).

By default, the Cisco 7600 series router and Cisco Catalyst 6500 series switch do not trust the incoming QoS markings, and therefore rewrite these bits with zeros. In this solution, packets at the network ingress ports are identified, classified, and marked according to type of traffic. The packets are marked with one of 64 possible Differentiated Services Code Point (DSCP) values at the ingress ports. These in turn are internally mapped to one of eight possible Class of Service (CoS) values, because CoS is used to determine the appropriate transmit queue for each packet. Queueing is configured on the individual 10-GE interfaces.

**Note**

For more information on class of service, see “White Paper: Cisco IOS Software Features for Differentiated Class of Service for Internetworks,” at the following URL:

[http://www.cisco.com/warp/public/cc/pd/iosw/iore/tech/osfea\\_wp.htm](http://www.cisco.com/warp/public/cc/pd/iosw/iore/tech/osfea_wp.htm)

## Configuring Marking and Classification on DER1

Do the following to enable marking and classification on DER1.

**Step 1** Enable QoS in global configuration mode.

```
mls qos
```

**Step 2** Configure ingress multicast replication mode and disable automatic detection of the replication mode (enabled by default).

```
mls ip multicast replication-mode ingress
```

**Note**

For more information, see “Configuring IPv4 Multicast VPN Support” at the following URL:

[http://www.cisco.com/en/US/products/hw/routers/ps368/products\\_configuration\\_guide\\_chapter09186a0080435d12.html](http://www.cisco.com/en/US/products/hw/routers/ps368/products_configuration_guide_chapter09186a0080435d12.html)

**Step 3** Create access lists to identify the different service types in the network.

```
ip access-list extended acl_VoD_and_SIP_signaling
 permit tcp 10.1.60.0 0.0.0.255 any
 permit tcp 10.1.61.0 0.0.0.255 any
 permit tcp 10.1.80.0 0.0.0.255 any
 permit tcp 10.1.81.0 0.0.0.255 any
```

```
ip access-list extended acl_video_VoD
 permit udp 10.1.60.0 0.0.0.255 any
 permit udp 10.1.61.0 0.0.0.255 any
```

```
ip access-list extended acl_video_broadcast
 permit udp 10.1.70.0 0.0.0.255 232.0.0.0 0.255.255.255
```

**Step 4** Create class maps for the access lists created in Step 2.

```
class-map match-all class_VoIP
 match access-group name acl_VoIP
class-map match-all class_VoD_and_SIP_signaling
 match access-group name acl_VoD_and_SIP_signaling
class-map match-all class_video_broadcast
 match access-group name acl_video_broadcast
class-map match-all class_video_VoD
 match access-group name acl_video_VoD
```

**Step 5** Create a policy map to set the DSCP values of the different classes created in Step 3.

```
policy-map setDSCP
 description Mark DSCP values for ingress traffic
 class class_VoD_and_SIP_signaling
 set dscp cs3
 class class_video_broadcast
 set dscp af41
 class class_video_VoD
```

```

set dscp af42
class class_VoIP
set dscp ef

```

**Step 6** Apply the policy map from Step 4 to the ingress interfaces using the following command.

```
service-policy input setDSCP
```



**Note** Specific interface examples of this and other interface commands are shown in the interface provisioning sections.

**Step 7** To maintain the DSCP marking applied at the network ingress interface, configure all noningress transport interfaces to trust the incoming DSCP markings.

```
mls qos trust dscp
```

## Configuring Mapping on DER1

Do the following to configure mapping on DER1.

**Step 1** View the Cisco 7600/Catalyst 6500 default DSCP-to-CoS mapping for the different services. Use the **show mls qos maps dscp-cos** command.



**Note** At the beginning of this section, we mentioned that there are 64 possible DSCP values and only 8 CoS values. This means that there could be more than one DSCP value for one CoS value. The following command shows the default DSCP-to-CoS mapping on the Cisco 7600 and Catalyst 6500.



**Note** In the map, d1 corresponds to the y-axis value of the table, and d2 to the x-axis value.

```

DER# show mls qos maps dscp-cos

Dscp-cos map: (dscp= d1d2)
d1 : d2 0 1 2 3 4 5 6 7 8 9

0 : 00 00 00 00 00 00 00 00 01 01
1 : 01 01 01 01 01 01 02 02 02 02
2 : 02 02 02 02 03 03 03 03 03 03
3 : 03 03 04 04 04 04 04 04 04 04
4 : 05 05 05 05 05 05 05 05 06 06
5 : 06 06 06 06 06 06 07 07 07 07
6 : 07 07 07 07

```

This table shows the following mapping (36 corresponds to AF41):

| Service Type    | DSCP | CoS |
|-----------------|------|-----|
| Broadcast video | 36   | 4   |

- Step 2** Change the Cisco 7600/Catalyst 6500 DSCP-to-CoS mapping for broadcast video to match the specifications of the solution.

The solution specifies the following DSCP-to CoS-mappings:

| Service Type    | DSCP | CoS |
|-----------------|------|-----|
| Broadcast video | 36   | 2   |

- a. Execute the following command on the Cisco 7600 and Cisco Catalyst 6500 to modify the DSCP-to-CoS mapping.

```
mls qos map dscp-cos 36 to 2
```

- b. Verify the changes to the DSCP-to-CoS mappings.

```
DER1# show mls qos maps dscp-cos
DSCP-CoS Mapping Table (dscp = d1d2)
d1 : d2 0 1 2 3 4 5 6 7 8 9

0 : 00 00 00 00 00 00 00 00 01 01
1 : 01 01 01 01 01 01 02 02 02 02
2 : 02 02 02 02 03 03 03 03 03 03
3 : 03 03 04 04 04 04 02 04 01 04
4 : 05 05 05 05 05 05 05 05 06 06
5 : 06 06 06 06 06 06 07 07 07 07
6 : 07 07 07 07
```

## Establishing and Configuring Interfaces on DER1

Refer to [Figure 4-2 on page 4-33](#).

This section addresses the following:

- [Establishing VLANs for Services and Transport on DER1](#)
- [Establishing 1-GE Interfaces for Servers and Management on DER1](#)
- [Establishing 10-GE Interfaces for Transport on DER1](#)
- [Establishing Nx1-GE Interfaces for Transport on DER1](#)

### Establishing VLANs for Services and Transport on DER1

Before the 1-GE and 10-GE interfaces can be configured, VLANs for the various services must be created. With the exception of the VLAN range for high-speed data (HSD), these are all Layer 3 VLANs. (See [Table 4-6 on page 4-34](#).)

Do the following to establish VLANs for services and transport on DER1.



**Tip**

For convenience in establishing these VLANs and others, you can establish all VLANs in global configuration mode first, then configure all the interfaces in interface configuration mode.

**Step 1** Establish a VLAN and VLAN interface for management (including connectivity with DHCP, DNS, FTP, TFTP, Syslog, VoIP, and video servers).

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 10
name VLAN_10_Management
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan10
description Management VLAN (Middleware, DNS, DHCP, etc)
ip address 10.1.10.1 255.255.255.0
no ip redirects
no ip unreachableables
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

- d. Establish a VLAN for unicast video aggregation.

```
vlan 60
name VLAN_60_Unicast_Video
```

```
interface Vlan60
description VoD server VLAN (Unicast Video)
ip address 10.1.60.1 255.255.255.0
no ip redirects
no ip unreachableables
load-interval 30
```

- e. Establish a VLAN for VoIP.

```
vlan 80
name VLAN_80_VoIP
```

```
interface Vlan80
description VoIP gateway VLAN
ip address 10.1.80.1 1 255.255.255.0
no ip redirects
no ip unreachableables
load-interval 30
```

**Step 2** Establish a VLAN for multicast video aggregation.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 70
name VLAN_70_Multicast_Video
```

- b. In interface configuration mode, create and configure the VLAN interfaces.

```
interface Vlan70
description Broadcast video source VLAN (Multicast Video)
ip address 10.1.70.1 255.255.255.0
no ip redirects
no ip unreachableables
```

- c. Change the PIM query interval from the default of 30 seconds.

```
ip pim query-interval 100 msec
```





**Note** It was determined in testing that convergence times improve if the PIM hello interval is less than one second. For more information about the **ip pim query-interval** command, see the following:

[http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3\\_i2gt.htm#wp1069550](http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3_i2gt.htm#wp1069550)

- d. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast traffic.

```
ip pim sparse-mode
```

- e. Change the load interval from the default of 300.

```
load-interval 30
```

**Step 3** In global configuration mode, establish a range of VLANs for HSD. (No Layer 3 interface is required.)

```
vlan 1100-1111,1200-1211
```

**Step 4** Establish VLANs for transport. The first is to and from DER1.

- a. In global configuration mode, add the VLAN to the VLAN database

```
vlan 800
 name Video/Voice_To/From_DER2
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan800
 description Transport VLAN to/from DER2
 ip address 10.1.1.1 255.255.255.252
```

- c. Change the PIM query interval from the default of 30 seconds.

```
ip pim query-interval 100 msec
```

- d. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast traffic.

```
ip pim sparse-mode
```

- e. Configure OSPF on the transport VLAN interface.

```
ip ospf network point-to-point
 ip ospf hello-interval 1
```



**Note** To avoid the election of the designated router (DR) and backup designated router (BDR), and prevent the origination of an unnecessary network link state advertisement (LSA), configure the transport VLAN as a point-to-point network. In addition, reduce the interval between OSPF hello messages from 10 seconds to 1 second. This improves reconvergence in the event of failure in the transport or in a neighboring switch.

- f. Change the load interval from the default of 300.

```
load-interval 30
```

**Step 5** Establish the remaining transport VLANs and configure the interfaces as in Step 2.

**Voice/Video to/From AR1**

```

vlan 808
 name Video/Voice_To/From_AR1

interface Vlan808
 description Transport VLAN to/from AR1
 ip address 10.1.1.9 255.255.255.252
 ip pim query-interval 100 msec
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30

```

**Voice/Video to/From AR2**

```

vlan 816
 name Video/Voice_To/From_AR2

interface Vlan816
 description Transport VLAN to/from AR2
 ip address 10.1.1.17 255.255.255.252
 ip pim query-interval 100 msec
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30

```

- g. Because the transport links are point-to-point, there is no risk of Layer 2 loops, so Spanning Tree Protocol (STP) can be disabled on these VLANs.

```
no spanning-tree vlan 800,808,816
```

**Establishing a Tunnel to the BRAS**

Do the following to establish a dot1q tunnel interface to the broadband remote-access server (BRAS). (See [Common Task: Configuring QinQ and Spanning Tree](#), page 4-35.)

**Note**

Connections to multiple BRASs are likely. This example illustrates only one connection.

**Step 1** Establish a 1-GE interface.

```

interface GigabitEthernet2/24
 description BRAS for HSD (Dot1q-Tunnel)
 switchport
 switchport mode trunk
 no ip address

```

- h. Configure the trunk for 802.1q encapsulation.
- ```
switchport trunk encapsulation dot1q
```
- i. Assign the trunk to the HSD VLAN ranges, 1100–1111 and 1200–1211.
- ```
switchport trunk allowed vlan 1100-1111,1200-1211
```
- j. Change the load interval from the default of 300.

```
load-interval 30
```

- k. Configure interface link detect options, such as **carrier-delay**, to reduce the time to detect a link failure, and **dampening** to minimize the effects of flapping links.

**Step 2** Repeat Step 1, as required, for additional BRAS interfaces.

---

## Establishing 1-GE Interfaces for Servers and Management on DER1

VoD servers, high-speed data sources, and management resources connect to Layer 2 interfaces on DER1, and their traffic is aggregated into the appropriate service VLANs.

The following is configured on DER1.

---

**Step 1** Establish an interface.

- a. Establish an interface for the CNR server.

```
interface GigabitEthernet2/1
 description CNR ingress/egress (DHCP, DNS, TFTP, SysLog)
 no ip address
```

- b. Configure the interface as a Layer 2 access port and assign it to VLAN 10.

```
switchport
switchport mode access
switchport access vlan 10
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

- d. Disable Cisco Discovery Protocol (CDP) on the interface.

```
no cdp enable
```

- e. Enable PortFast on the interface to bypass the listening and learning states in Spanning Tree Protocol (STP). This allows the interface to move immediately from the blocking state to the forwarding state, rather than waiting for STP to converge.

```
spanning-tree portfast
```

- f. Configure the switch to disable any interface that is configured for PortFast and receives a Bridge Protocol Data Unit (BPDU).

```
spanning-tree bpduguard enable
```



**Note** This guards against a user accidentally connecting a switch to a switchport that is intended for a VoD server or other host. The switchport is disabled and the user must investigate why the port is down. If this command is not used and such an accidental connection were to happen, STP could reconverge and block other connections in the switch.

---

- g. Apply the “setDSCP” service policy to mark DSCP values in the inbound IP packets.

```
service-policy input setDSCP
```

**Step 2** Repeat Step 1a through Step 1g for the remaining server and management 1-GE interfaces and their associated VLANs, changing the value in **switchport access vlan *vlan-id*** as appropriate. The abbreviated configurations are shown below.

**Cisco Network Registrar (CNR)—Primary Server**

```
interface GigabitEthernet2/1
 description CNR ingress/egress (DHCP, DNS, TFTP, SysLog)
 switchport
 switchport access vlan 10
```

**Kasenna Middleware Server**

```
interface GigabitEthernet2/2
 description Kasenna Middleware Server ingress/egress
 switchport
 switchport access vlan 60
```

**Kasenna VoD Pump Management Port (Eth0)**

```
interface GigabitEthernet2/3
 description VoD Pump ingress/egress
 switchport
 switchport access vlan 60
```

**Kasenna VoD Pump (HPN0)**

```
interface GigabitEthernet2/4
 description VoD Pump (HPN0) ingress/egress
 switchport
 switchport access vlan 60
```

**Kasenna VoD Pump (HPN1)**

```
interface GigabitEthernet2/5
 description VoD Pump (HPN1) ingress/egress
 switchport
 switchport access vlan 60
```

**Broadcast Server (multicast)**

```
interface GigabitEthernet2/6
 description Broadcast Video ingress/egress
 switchport
 switchport access vlan 70
```

**VoIP—SIP Proxy Server**

```
interface GigabitEthernet2/7
 description SIP Proxy Server ingress/egress
 switchport
 switchport access vlan 80
```




---

**Note** In Kasenna's terminology, HPN0 stands for High-Performance Network interface 0.

---

**Establishing 10-GE Interfaces for Transport on DER1**

The 10-GE trunk interfaces create the hub-and-spoke topology from DER1 to AR1 and DER2. Both bidirectional and unidirectional trunking interfaces and VoD unidirectional transport are established.

Do the following to establish 10-GE transport interfaces on DER1.

**Step 1** Establish an interface to and from AR1.

- a. Establish the interface.

```
interface TenGigabitEthernet7/1
 description Transport to/from AR1 (TenGig7/1)
 no ip address
```

- b. Configure the trunk for 802.1q encapsulation.

```
switchport trunk encapsulation dot1q
```

- c. Configure the port as a switchport IEEE 802.1q trunk.

```
switchport
switchport mode trunk
```

- d. Assign VLAN 808, and VLAN range 1100–1111 to the trunk. (See
- [Table 4-6 on page 4-34](#)
- .)

```
switchport trunk allowed vlan 808,1100-1111
```

- e. Configure interface link detection options, such as
- carrier-delay**
- (to reduce the time to detect a link failure), and
- dampening**
- (to minimize the effects of flapping links).



**Note** The **restart** command option is applied on start up to reduce the possibility of routing “black holes” during startup (where upper layers converge before lower layers do).

```
carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000
```



**Note** The above nondefault settings are applied to transport links only.

- f. Change the load interval from the default of 300.

```
load-interval 30
```

**Step 2** Configure QoS on the interface.

**Note** The 10-GE transport links from DERs to the ARs require modifications to the transmit queues. There are eight transmit queues, but this solution uses only three.

- a. View the default CoS- to-TxQueue mapping. The following information was extracted from the
- show queueing interface**
- command.

```
queue thresh cos-map

1 1 0
1 2 1
2 1 2
2 2 3 4
3 1 6 7
8 1 5
```

- b. Configure the CoS-to TxQueue mapping on the transport interfaces. HSD (CoS = 0) remains in TxQueue1 and VoIP (CoS = 5) remains in TxQueue8. The other six CoS values are associated with TxQueue2.

```
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```



**Note** TxQueue1 and TxQueue8 use the default mappings. TxQueue2 has three thresholds: Threshold 1 = CoS 1, Threshold 2 = CoS 2, and Threshold 3 = CoS 3, 4, 6, and 7.

- c. Verify the modified CoS-to-Tx-Queue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0 1
2 1 2
2 2 3 4 6 7
8 1 5
```

- d. Configure the TxQueue thresholds.

TxQueue1 uses Weighted Random Early Drop (WRED) for queue-congestion management. Only HSD is queued in this queue, and when the amount of HSD in the queue reaches 75%, random packets are dropped in an attempt to keep the queue from reaching 100% utilization.

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
```

TxQueue2 uses tail drop for queue congestion management. VoD is assigned to threshold 1 and is dropped once the queue reaches 80% utilization. VoD signaling, network signaling, and broadcast video are assigned to the third threshold 2 and are dropped once the queue reaches 100% utilization.

```
wrr-queue threshold 2 80 100 100 100 100 100 100
no wrr-queue random-detect 2
```

- e. Configure the bandwidth of the weighted queues.

The weighted queues need to be modified to handle our modified TxQueue mappings. The ratio between TxQueue2 and TxQueue1 is  $255/64 = 4$ , so TxQueue2 needs four times as much bandwidth as TxQueue1. Therefore, TxQueue1 is allocated 20% of the bandwidth on the interface, and TxQueue2 is allocated 80% of the bandwidth.

```
wrr-queue bandwidth 64 255 0 0 0 0 0
```

- f. Configure the size of the weighted queues.

Each line card has a limited amount of buffer for the transmit queues. For this interface, 40% of the buffer is allocated for TxQueue1, and 50% of the buffer is allocated for TxQueue2.

```
wrr-queue queue-limit 40 50 0 0 0 0 0
```

- g. Configure this interface (and all noningress transport interfaces) to trust the incoming DSCP markings. (This maintains the DSCP marking applied at the network ingress interface.)

```
mls qos trust dscp
```

- Step 3** Proceed as in Step 1 through Step 3 above to establish an interface to and from DER2, but with the following differences in interface and allowed VLANs.

```
interface TenGigabitEthernet7/4
description Transport to/from DER2 (TenGig7/4

switchport trunk allowed vlan 800,1100-1111,1200-1211
```

## Establishing Nx1-GE Interfaces for Transport on DER1

The Nx1-GE trunk interfaces create the hub-and-spoke topology. A single 1-GE interface is illustrated below, but up to eight such interfaces can be used to establish eight equal-cost paths that use Cisco Express Forwarding (CEF) load balancing. (See [Table 4-6 on page 4-34.](#))

Do the following to configure a single 1-GE interface on DER1.

**Step 1** Establish a 1-GE interface to and from AR2.

- a. Establish the interface.

```
interface GigabitEthernet1/1
 description Transport to/from AR2 (Gig1/5)
 switchport
 switchport mode trunk
 no ip address
```

- b. Configure the trunk for 802.1q encapsulation.

```
switchport trunk encapsulation dot1q
```

- c. Assign the trunk to VLANs 816 and 1200–1211.

```
switchport trunk allowed vlan 816,1200-1211
```

- d. Change the load interval from the default of 300.

```
load-interval 30
```

- e. Configure interface link detection options, such as **carrier-delay** to reduce the time to detect a link failure, and **dampening** to minimize the effects of flapping links.



**Note** The **restart** command option is applied on start up to reduce the possibility of routing “black holes” during startup (where upper layers converge before lower layers do).

```
carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000
```

**Step 2** Repeat Step 1 for any additional 1-GE transport interfaces as required.

**Step 3** Configure QoS on the first port in the 4x1-GE port channel.



**Note** The Nx1-GE transport links from DER1 to the ARs require modifications to the transmit queues. There are eight transmit queues, but this solution uses only three.

- a. View the default CoS-to-TxQueue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0
1 2 1
2 1 2
2 2 3 4
3 1 6 7
4 1 5
```

- b. Configure the CoS-to-TxQueue mapping on the 10-GE transport interfaces. HSD (CoS = 0) remains in TxQueue1 and VoIP (CoS = 5) remains in TxQueue8. Video is separated into two classes, one class for broadcast video (CoS = 4) and one class for VoD video (CoS = 2). The other three CoS values are associated with TxQueue2.

```
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```

TxQueue1 and TxQueue8 use the default mappings. TxQueue2 has three thresholds: Threshold 1 = CoS 1, Threshold 2 = CoS 2, and Threshold 3 = CoS 3, 4, 6, and 7.

- c. Verify the modified CoS-to-Tx-Queue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0 1
2 1 2
2 2 3 4 6 7
4 1 5
```

- d. Configure the TxQueue thresholds.

TxQueue1 uses Weighted Random Early Drop (WRED) for queue-congestion management. Only HSD is queued in this queue, and when the amount of HSD in the queue reaches 75%, random packets are dropped in an attempt to keep the queue from reaching 100% utilization.

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100 100
```

TxQueue2 uses tail drop for queue congestion management. VoD is assigned to the threshold 1 and is dropped once the queue reaches 80% utilization. VoD signaling, network signaling, and broadcast video are assigned to the third threshold 2 and are dropped once the queue reaches 100% utilization.

```
wrr-queue threshold 2 80 100 100 100 100 100 100 100
no wrr-queue random-detect 2
```

- e. Configure the bandwidth of the weighted queues.

The weighted queues need to be modified to handle our modified TxQueue mappings. The ratio between TxQueue2 and TxQueue1 is  $255/64 = 4$ , so TxQueue2 needs four times as much bandwidth as TxQueue1. Therefore, TxQueue1 is allocated 20% of the bandwidth on the interface, and TxQueue2 is allocated 80% of the bandwidth.

```
wrr-queue bandwidth 64 255 0 0 0 0 0
```

- f. Configure the size of the weighted queues.

Each line card has a limited amount of buffer for the transmit queues. For this interface, 40% of the buffer is allocated for TxQueue1, and 50% of the buffer is allocated for TxQueue2.

```
wrr-queue queue-limit 40 50 0 0 0 0 0
```

- g. Configure this interface (and all noningress transport interfaces) to trust the incoming DSCP markings. (This maintains the DSCP marking applied at the network ingress interface.)

```
mls qos trust dscp
```

**Step 4** For the remaining three ports, proceed as in Step 3a through Step 3g.



## Configuring OSPF Routing for Video and Voice Traffic on DER1

Routing advertisements are enabled on the transport VLANs, but they are turned off on the aggregation VLANs by means of the **passive-interface** command.

Do the following to configure OSPF for video and voice traffic on DER1.

---

**Step 1** Define an OSPF routing process to route video traffic.

```
router ospf 100
router-id 10.1.1.1
log-adjacency-changes
```

**Step 2** Modify various timer parameters.

a. Use the following command to enable OSPF SPF throttling, modifying the timers, and provide fast convergence: **timers throttle spf** *spf-start spf-hold spf-max-wait*

```
timers throttle spf 10 100 1000
```

b. Use the following command to set the rate-limiting values for OSPF link-state advertisement (LSA) generation: **timers throttle lsa all** *start-interval hold-interval max-interval*

```
timers throttle lsa all 1 10 1000
```

c. Use the following command to control the minimum interval for accepting the same LSA: **timers lsa arrival** *milliseconds*

```
timers lsa arrival 100
```

If an instance of the same LSA arrives sooner than the interval that is set, the LSA is dropped.

**Step 3** Use the following command to set incremental SPF updates for LSA type 1 and LSA type 2 within an area. Enabling iSPF can minimize the effect of SPF changes within an area to only those routers where the change is relevant, thus reducing the time spent calculating SPF.

```
ispf
```

**Step 4** Apply the **passive-interface** command to the aggregation VLANs.

```
passive-interface Vlan10
passive-interface Vlan60
passive-interface Vlan70
passive-interface Vlan80
```

**Step 5** Advertise the networks in the first OSPF routing process.

```
network 10.1.1.0 0.0.0.3 area 0
network 10.1.1.8 0.0.0.3 area 0
network 10.1.10.0 0.0.1.255 area 0
network 10.1.60.0 0.0.0.255 area 0
network 10.1.70.0 0.0.0.255 area 0
network 10.1.80.0 0.0.0.255 area 0
```

**Step 6** To support load sharing, set the maximum number of parallel routes the IP routing protocol supports (installs in a routing table).

```
maximum-paths 8
```

---

## Configuring QinQ and Spanning Tree on DER1

Do the following in global configuration mode to configure QinQ and spanning tree parameters on DER1. (See [Common Task: Configuring QinQ and Spanning Tree](#), page 4-35.)

---

**Step 1** Create the HSD VLAN ranges for AR1 and AR2, respectively.

```
vlan 1100-1111,1200-1211
```

**Step 2** Enable QinQ tunneling.

```
vlan dot1q tag native
```

**Step 3** Disable MAC address learning globally for the HSD VLANs.

```
no mac-address-table learning vlan 1100-1111,1200-1211
```

**Step 4** Configure DER1 as the primary root node for all HSD VLANs defined on AR1, using the **root primary** option.

```
spanning-tree vlan 1100-1111 root primary diameter 2
```

**Step 5** Configure RSTP.

```
spanning-tree mode rapid-pvst
```

---

## Configuring DER2

This section addresses the configuration required on the switch labeled DER2 in [Figure 4-2 on page 4-33](#), to route multiple services from that switch to the ARs. The configuration of DER2 is identical to that of DER1, with the exceptions noted below.

See [Configuring DNS Servers, page 4-2](#).



Note

A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

This section addresses the following:

- [Configuring QoS on DER2](#)
- [Establishing and Configuring Interfaces on DER2](#)
- [Configuring OSPF Routing for Video and Voice Traffic on DER2, page 4-57](#)
- [Configuring QinQ and Spanning Tree on DER2, page 4-57](#)



Note

For a complete configuration example, see [Appendix B, “Sample DER and AR Switch Configurations for the Hub-and-Spoke Topology.”](#)

## Configuring QoS on DER2

Proceed as in [Configuring QoS on DER1, page 4-36](#). The configurations are identical on both DERs.

## Establishing and Configuring Interfaces on DER2

Proceed as in [Establishing and Configuring Interfaces on DER1, page 4-39](#), but with the changes noted below:

- [Establishing VLANs for Services and Transport on DER2](#)
- [Establishing 10-GE Interfaces for Transport on DER2](#)

## Establishing VLANs for Services and Transport on DER2

Before the 1-GE interfaces can be configured, VLANs for the various services must be created. With the exception of the VLAN range for high-speed data (HSD), these are all Layer 3 VLANs. (See [Table 4-6 on page 4-34](#).)

Do the following to establish VLANs for services and transport on DER2.



Tip

For convenience in establishing these VLANs and others, you can establish all VLANs in global configuration mode first, then configure all the interfaces in interface configuration mode.

Step 1

Establish a VLAN and VLAN interface for management (including connectivity with DHCP, DNS, FTP, TFTP, Syslog, VoIP, and video servers).

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 11
name VLAN_11_Management
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan11
description Management VLAN (CNR - DNS, DHCP, etc)
ip address 10.1.11.1 255.255.255.0
no ip redirects
no ip unreachableables
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

- d. Establish a VLAN for unicast video aggregation.

```
vlan 61
name VLAN_61_Unicast_Video

interface Vlan61
description VoD server VLAN (Unicast Video)
ip address 10.1.61.1 255.255.255.0
no ip redirects
no ip unreachableables
load-interval 30
```

- e. Establish a VLAN for VoIP.

```
vlan 81
name VLAN_80_VoIP

interface Vlan81
description VoIP gateway VLAN
ip address 10.1.81.1 1 255.255.255.0
no ip redirects
no ip unreachableables
load-interval 30
```

**Step 2** Establish a VLAN for multicast video aggregation.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 70
name VLAN_70_Multicast_Video
```

- b. In interface configuration mode, create and configure the VLAN interfaces.

```
interface Vlan70
description Broadcast video source VLAN (Multicast Video)
ip address 10.1.70.1 255.255.255.0
no ip redirects
no ip unreachableables
```

- c. Change the PIM query interval from the default of 30 seconds.

```
ip pim query-interval 100 msec
```



**Note** It was determined in testing that convergence times improve if the PIM hello interval is less than one second. For more information about the **ip pim query-interval** command, see the following:

[http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3\\_i2gt.htm#wp1069550](http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123tcr/123tip3r/ip3_i2gt.htm#wp1069550)

- d. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast traffic.

```
ip pim sparse-mode
```

- e. Change the load interval from the default of 300.

```
load-interval 30
```

**Step 3** In global configuration mode, establish a range of VLANs for HSD. (No Layer 3 interface is required.)

```
vlan 1100-1111,1200-1211
```

**Step 4** Establish VLANs for transport. Proceed as in Step 4 of [Establishing VLANs for Services and Transport on DER1, page 4-39](#). The VLANs and interfaces are summarized below.

- a. Establish the VLANs and configure the interfaces as in Step 2.

#### Voice/Video to/From DER1

```
vlan 800
 name Video/Voice_To/From_DER1

interface Vlan800
 description Transport VLAN to/from DER2
 ip address 10.1.1.2 255.255.255.252
 ip pim query-interval 100 msec
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30
```

#### Voice/Video to/From AR1

```
vlan 824
 name Video/Voice_To/From_AR1

interface Vlan824
 description Transport VLAN to/from AR1
 ip address 10.1.1.25 255.255.255.252
 ip pim query-interval 100 msec
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30
```

**Voice/Video to/From AR2**

```

vlan 832
 name Video/Voice_To/From_AR2

interface Vlan832
 description Transport VLAN to/from AR2
 ip address 10.1.1.33 255.255.255.252
 ip pim query-interval 100 msec
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30

```

- b. Because the transport links are point-to-point, there is no risk of Layer 2 loops, so Spanning Tree Protocol (STP) can be disabled on these VLANs.

```
no spanning-tree vlan 800,824,832
```

- Step 5** In global configuration mode, establish a range of VLANs for HSD. (No Layer 3 interface is required.)

```
vlan 1100-1111,1200-1211
```

---

**Establishing 10-GE Interfaces for Transport on DER2**

Do the following to establish 10-GE interfaces for transport on DER2.

- Step 1** Proceed as in [Establishing 10-GE Interfaces for Transport on DER1, page 4-44](#), but with the exceptions noted in Step 2.
- Step 2** Make the following changes in interface numbers.

**Video/VoIP Transport to/from DER1**

```

interface TenGigabitEthernet7/4
 description Transport to/from DER1 (TenGig7/4)
 ip address 10.1.1.2 255.255.255.252

 ip ospf network point-to-point
 ip ospf hello-interval 1

 load-interval 30

```

**Video/VoIP Transport to/from AR2**

```

interface TenGigabitEthernet7/1
 description Transport VLAN to/from AR2 (TenGig1/1)
 ip address 10.1.1.34 255.255.255.252

 ip pim sparse-mode
 ip pim query-interval 100 msec
 ip ospf network point-to-point
 ip ospf hello-interval 1
 load-interval 30

 carrier-delay msec 0
 dampening 5 1000 2000 20 restart 16000

```

## Establishing 1-GE Interfaces for Servers and Management on DER2

- Step 1** Make the following changes in the VLAN number as shown below. The remainder of the configuration is as for DER1.

### CNR Server

```
interface GigabitEthernet2/1
 description CNR ingress/egress (DHCP, DNS, TFTP, SysLog)
 no ip address

 switchport
 switchport mode access
 switchport access vlan 11

 load-interval 30

 no cdp enable

 spanning-tree portfast
 spanning-tree bpduguard enable

 service-policy input setDSCP
```

### Cisco Network Registrar (CNR)—Primary Server

```
interface GigabitEthernet2/1
 description CNR ingress/egress (DHCP, DNS, TFTP, SysLog)
 switchport
 switchport access vlan 11
```

### Kasenna VoD Pump Management Port (Eth0)

```
interface GigabitEthernet2/3
 description VoD Pump ingress/egress
 switchport
 switchport access vlan 61
```

### Kasenna VoD Pump (HPN0)

```
interface GigabitEthernet2/4
 description VoD Pump (HPN0) ingress/egress
 switchport
 switchport access vlan 61
```

### Kasenna VoD Pump (HPN1)

```
interface GigabitEthernet2/5
 description VoD Pump (HPN1) ingress/egress
 switchport
 switchport access vlan 61
```

### Broadcast Server (Multicast)

```
interface GigabitEthernet2/6
 description Broadcast Video ingress/egress
 switchport
 switchport access vlan 70
```

**VoIP—SIP Proxy Server**

```
interface GigabitEthernet2/7
description SIP Proxy Server ingress/egress
switchport
switchport access vlan 81
```

---

**Establishing 10-GE Interfaces for Transport on DER2**

- Step 1** Proceed as in [Establishing 10-GE Interfaces for Transport on DER1, page 4-19](#), but with the following changes in interface and IP address as noted below.

**10-GE Interface to/from AR1**

```
interface TenGigabitEthernet7/4
description Transport to/from AR1 (TenGig7/4)
ip address 10.1.1.2 255.255.255.252

load-interval 30

carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000

ip pim sparse-mode
ip pim query-interval 100 msec

ip ospf network point-to-point
ip ospf hello-interval 1
```

**10-GE Interface to/from AR2**

```
interface TenGigabitEthernet7/1
description Transport to/from AR2 (TenGig1/3)
dampening 5 1000 2000 20 restart 16000
ip address 10.1.1.34 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
carrier-delay msec 0
wrr-queue bandwidth 64 255 0 0 0 0 0
wrr-queue queue-limit 40 50 0 0 0 0 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
mls qos trust dscp
```

---

**Establishing Nx1-GE Interfaces for Transport on DER2**

Proceed as in [Establishing Nx1-GE Interfaces for Transport on DER1, page 4-47](#).



## Configuring OSPF Routing for Video and Voice Traffic on DER2

Do the following to configure OSPF routing for video and voice traffic on DER2.

- 
- Step 1** Proceed as in [Configuring OSPF Routing for Video and Voice Traffic on DER2, page 4-57](#), but with the following exceptions.
- Step 2** Define the OSPF routing process for video traffic for the following router ID.
- ```
router ospf 100
  router-id 10.1.1.2
  log-adjacency-changes
```
- Step 3** Apply the **passive-interface** statements to these aggregation VLANs.
- ```
passive-interface Vlan11
passive-interface Vlan61
passive-interface Vlan70
passive-interface Vlan81
```
- Step 4** Advertise these networks in the first OSPF routing process.
- ```
network 10.1.1.0 0.0.0.3 area 0
network 10.1.1.32 0.0.0.3 area 0
network 10.1.11.0 0.0.1.255 area 0
network 10.1.61.0 0.0.0.255 area 0
network 10.1.70.0 0.0.0.255 area 0
network 10.1.81.0 0.0.0.255 area 0
```
- Step 5** To support load sharing, set the maximum number of parallel routes the IP routing protocol supports (installs in a routing table).
- ```
maximum-paths 8
```
- 

## Configuring QinQ and Spanning Tree on DER2

Refer to [Configuring QinQ and Spanning Tree on DER1, page 4-50](#).

Do the following to in global configuration mode to configure QinQ and spanning tree on DER2. Configuring DER2 is essentially the symmetrical opposite of what was done on DER1.

- 
- Step 1** Create the HSD VLAN ranges for AR1 and AR2, respectively.
- ```
vlan 1100-1111,1200-1211
```
- Step 2** Enable QinQ tunneling.
- ```
vlan dot1q tag native
```
- Step 3** Disable MAC address learning globally for the HSD VLANs.
- ```
no mac-address-table learning vlan 1100,1200-1211
```
- Step 4** Configure RSTP.
- ```
spanning-tree mode rapid-pvst
```
-

## Configuring AR1

This section addresses the configuration required on the switch labeled AR1 in [Figure 4-2 on page 4-33](#), to route multiple services from AR1 to DER1 and DER2.

See [Configuring DNS Servers, page 4-2](#).



Note

A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

This section addresses the following:

- [Configuring QoS on AR1](#)
- [Establishing and Configuring Interfaces on AR1](#)
- [Configuring OSPF Routing for Video and Voice Traffic on AR1](#)
- [Configuring QinQ and Spanning Tree on AR1](#)



Note

For a complete configuration example, see [Appendix B, “Sample DER and AR Switch Configurations for the Hub-and-Spoke Topology.”](#)

## Configuring QoS on AR1

See [Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series, page 4-11](#). This section presents the following topics:

- [Configuring Marking and Classification on AR1](#)
- [Configuring Mapping on AR1](#)

### Configuring Marking and Classification on AR1

Do the following to enable marking and classification on AR1.

**Step 1** Enable QoS in global configuration mode.

```
mls qos
```

**Step 2** Create access lists to identify the different service types in the network.

```
ip access-list extended acl_VoD_and_SIP_signaling
 permit ip any host 10.1.10.10
 permit ip any 10.1.60.0 0.0.0.255
 permit ip any 10.1.61.0 0.0.0.255
 permit ip any 10.1.80.0 0.0.0.255
 permit ip any 10.1.81.0 0.0.0.255
```

```
ip access-list extended acl_VoIP
 permit udp any any range 16384 32767
 permit udp any range 16384 32767 any
```

**Step 3** Create class maps for the access lists created in Step 2.

```
class-map match-all class_VoIP
 match access-group name acl_VoIP
class-map match-all class_VoD_and_SIP_signaling
 match access-group name acl_VoD_and_SIP_signaling
```

**Step 4** Create a policy map to set the DSCP values of the different classes created in Step 3.

```
policy-map setDSCP
 description Mark DSCP values for ingress traffic
 class class_VoIP
 set dscp ef
 class class_VoD_and_SIP_signaling
 set dscp cs3
```

**Step 5** Apply the policy map from Step 4 to the ingress interfaces, using the following command.

```
service-policy input setDSCP
```



**Note**

Specific interface examples of this and other interface commands are shown in the interface provisioning sections.

**Step 6** To maintain the DSCP marking applied at the network ingress interface, configure all noningress transport interfaces to trust the incoming DSCP markings.

```
mls qos trust dscp
```

## Configuring Mapping on AR1

To configure mapping on AR1, proceed as in [Configuring Mapping on DER1, page 4-38](#).

## Establishing and Configuring Interfaces on AR1

Refer to [Figure 4-2 on page 4-33](#).

This section addresses the following:

- [Configuring IP Unnumbered for Video and VoIP Services on AR1](#)
- [Establishing VLANs for Services on AR1](#)
- [Establishing 10-GE Interfaces for Transport on AR1](#)
- [Establishing 1-GE Interfaces to a DSLAM on AR1](#)



**Note**

10-GE interfaces are configured on AR1, but port channels are not.

## Configuring IP Unnumbered for Video and VoIP Services on AR1

Service mapping on each DSLAM is achieved by using VLANs, with a single VLAN allocated to video and VoIP services represented as N:1. High-speed data (HSD) traffic requires a single VLAN per subscriber, notated as 1:1. VLANs are not bridged on the AR; in other words, a VLAN defined on the AR does not span multiple DSLAMs on that AR. Consequently, IP unnumbered is used to reduce the operational overhead associated with assigning unique IP subnets per DSLAM. With IP unnumbered we can reduce operational overhead on the AR by assigning one /16 subnet to a service for all DSLAMs aggregated by an AR. With the exception of HSD, all interfaces are Layer 3 subinterfaces. The 1:1 requirement for HSD service increases the number of VLANs required in the services provider's network. To reduce the number of required VLANs, QinQ is used. (See [Table 4-6 on page 4-34](#).)



### Note

For additional details, see [Establishing VLANs for Services and Transport on DER1, page 4-39](#).

- Step 1** In global configuration mode, configure IP unnumbered by establishing two loopback interfaces, one for video services and one VoIP services.

```
interface Loopback0
 description Address block for Video Services on AR1
 ip address 10.10.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

```
interface Loopback1
 description Address block for VoIP services on AR1
 ip address 10.20.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

- Step 2** In global configuration mode, configure IP unnumbered to use “connected” host routes.

```
ip dhcp route connected
```

## Establishing VLANs for Services on AR1

Before 1-GE interfaces and 10-GE trunks can be configured, VLANs for the various services must be created. With the exception of the VLAN range for high-speed data (HSD), these are all Layer 3 VLANs. (Refer to [Table 4-6 on page 4-34](#).)

Do the following to establish VLANs for services on AR1.

- Step 1** In global configuration mode, establish a range of VLANs for high-speed data (HSD). (No Layer 3 interface is required.)

```
vlan 1100-1111
```

- Step 2** Establish a range of VLANs for video at the edge.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 100-111
```

- b. In interface configuration mode, create and configure the range of VLAN interfaces.

```
interface range Vlan100-111
 description Video edge VLAN on DSLAM
 no ip redirects
 no ip unreachable
```

- c. Enable PIM sparse mode. This is the aggregation VLAN range for video traffic to the DSLAMs.

```
ip pim sparse-mode
```

- d. To ensure consistently fast PIM convergence times, statically join the aggregation VLAN range 100 through 111 for video at the AR to the multicast groups.

```
ip igmp static-group 232.1.1.1 source ssm-map
ip igmp static-group 232.1.1.2 source ssm-map
ip igmp static-group 232.1.1.3 source ssm-map
ip igmp static-group 232.1.1.4 source ssm-map
ip igmp static-group 232.1.1.5 source ssm-map
ip igmp static-group 232.1.1.6 source ssm-map
ip igmp static-group 232.1.1.7 source ssm-map
ip igmp static-group 232.1.1.8 source ssm-map
ip igmp static-group 232.1.1.9 source ssm-map
ip igmp static-group 232.1.1.10 source ssm-map
```

- e. Change the ARP timeout from the default.

```
arp timeout 250
```

**Step 3** Establish a range of VLANs for VoIP at the edge.

- a. In global configuration mode, add the range of VLANs to the VLAN database.

```
vlan 200-211
```

- b. In interface configuration mode, create and configure the range of VLAN interfaces.

```
interface range Vlan200-211
 description VoIP edge VLAN on DSLAM
 no ip redirects
 no ip unreachable
```

- c. Change the load interval from the default of 300 for VLAN range.

```
load-interval 30
```

**Step 4** Establish VLANs for transport. The first is to and from DER1.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 808
name VLAN_808_Video_VoIP_to/from_DER1
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan808
 description Transport to/from DER1 (TenGig7/1)
 ip address 10.1.1.10 255.255.255.252
```

- c. Enable PIM sparse mode. This is the ingress port for broadcast video traffic, which is multicast traffic.

```
ip pim sparse-mode
```

- d. Configure OSPF on the transport VLAN interface.

```
ip ospf network point-to-point
```

```
ip ospf hello-interval 1
```

- e. Change the load interval from the default of 300.

```
load-interval 30
```

- f. Repeat Step 4a through Step 4d, as appropriate, to establish a VLAN for video/VoIP transport to and from DER2.

```
vlan 824
name VLAN_824_Video_VoIP_to/from_DER2

interface Vlan824
description Transport to/from DER2 (TenGig7/1)
ip address 10.1.1.26 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
```

## Establishing 10-GE Interfaces for Transport on AR1

The 10-GE trunk interfaces provide the transport from AR1 to DER1 and DER2.



### Note

For additional details, see [Establishing 10-GE Interfaces for Transport on DER1, page 4-44](#).

Do the following to establish 10-GE interfaces for transport on AR1.

- Step 1** Establish an interface to and from DER1.

- a. Establish the interface to and from DER1, configure the trunk for 802.1q encapsulation, and assign it to VLANs 808 and 1100 through 1111. (Refer to [Table 4-6 on page 4-34](#).)

```
interface TenGigabitEthernet1/1
description Transport to/from DER1 (TenGig7/1)
switchport
switchport trunk encapsulation dot1q
switchport trunk allowed vlan 808, 1100-1111
switchport mode trunk
dampening 5 1000 2000 20 restart 16000
no ip address
load-interval 30
carrier-delay msec 0
```

- b. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1, page 4-44](#).

```
wrr-queue bandwidth 64 255 0 0 0 0 0
wrr-queue queue-limit 40 50 0 0 0 0 0
wrr-queue threshold 2 80 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
mls qos trust dscp
```

**Step 2** Establish an interface to and from DER2.

- a. Repeat Step 1, as appropriate, to establish an interface to and from DER2 and assign it to VLANs 824 and 1100 through 1111.

```
interface TenGigabitEthernet1/3
 description Transport to/from DER2 (TenGig7/1)
 switchport
 switchport trunk encapsulation dot1q
 switchport trunk allowed vlan 824, 1100-1111
 switchport mode trunk
 dampening 5 1000 2000 20 restart 16000
 no ip address
 load-interval 30
 carrier-delay msec 0
```

- b. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1, page 4-44](#).

```
wrr-queue bandwidth 64 255 0 0 0 0 0
wrr-queue queue-limit 40 50 0 0 0 0 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
mls qos trust dscp
```

**Establishing 1-GE Interfaces to a DSLAM on AR1**

Two 1-GE interfaces are connected to and from each DSLAM. DSLAMs have two uplinks that are configured as IEEE 802.1q trunks. The first DSLAM uplink carries two VLANs, one video VLAN and one VoIP VLAN. The second DSLAM uplink carries one HSD VLAN per subscriber. QinQ is used with HSD to reduce the number of VLANs required in the service provider's network. (See [Common Task: Configuring QinQ and Spanning Tree, page 4-35](#).) Each QinQ tunnel (one per DSLAM) is terminated upstream on a BRAS that is connected to a DER (in our case, DER1).

Do the following to establish 1-GE interfaces to a DSLAM on AR1.

**Step 1** Establish an interface to DSLAM1 uplink 1.

- a. Establish the interface and assign it to VLANs 100 and 200.

```
interface GigabitEthernet2/1
 description GigE trunk for video and VoIP to/from DSLAM uplink GigE
 switchport
 switchport trunk encapsulation dot1q
 switchport trunk allowed vlan 100,200
 switchport mode trunk
 no ip address
 wrr-queue bandwidth 64 255 0
 wrr-queue queue-limit 40 50 0
 wrr-queue threshold 2 80 100 100 100 100 100 100
 wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
 wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
 no wrr-queue random-detect 2
 wrr-queue cos-map 1 1 0 1
 wrr-queue cos-map 2 2 3 4 6 7
```

- b. Change the load interval from the default of 300.

```
load-interval 30
```

- c. Change the ARP timeout from the default.

```
arp timeout 250
```




---

**Note** The default timeout for an entry in the ARP cache is 4 hours. The default timeout for an entry in the MAC address table is only 5 minutes. Because video traffic is mostly unidirectional, the MAC address table may not be refreshed within the 5-minute timeout. This causes video traffic to be flooded until the destination MAC address is found. To prevent this, reduce the ARP cache timeout to 250 seconds. This forces the switch to re-ARP for the entries in the ARP cache before the entries in the MAC address table time out, avoiding the disruptive behavior.

---

- d. Disable Cisco Discovery Protocol (CDP) on the interface.

```
no cdp enable
```

- e. Enable PortFast on the interface to bypass the listening and learning states in Spanning Tree Protocol (STP). This allows the interface to move immediately from the blocking state to the forwarding state, rather than waiting for STP to converge.

```
spanning-tree portfast
```

- f. Configure the switch to disable any interface that is configured for PortFast and receives a Bridge Protocol Data Unit (BPDU).

```
spanning-tree bpduguard enable
```




---

**Note** This guards against a user accidentally connecting a switch to a switchport that is intended for a VoD server or other host. The switchport is disabled and the user must investigate why the port is down. If this command is not used and such an accidental connection were to happen, STP could reconverge and block other connections in the switch.

---

- g. Apply the “setDSCP” service policy to mark DSCP values in the inbound IP packets.

```
service-policy input setDSCP
```

## Step 2 Establish an interface to DSLAM1 uplink 2.

- a. Establish the interface and assign it to VLAN 1100.

```
interface GigabitEthernet2/2
description GigE QinQ port for HSD to/from DSLAM uplink GigE
switchport
no ip address
wrr-queue bandwidth 64 255 0
wrr-queue queue-limit 40 50 0
wrr-queue threshold 2 80 100 100 100 100 100 100
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```




---

**Note** No QoS policy is required on the HSD interface, so all HSD packets are rewritten to the default DSCP value, 0.

---



- b. Change the load interval from the default of 300.  

```
load-interval 30
```
- c. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1](#), page 4-44.
- d. Disable Cisco Discovery Protocol (CDP) on the interface.  

```
no cdp enable
```
- e. Set the Service Provider outer VLAN tag, or S-TAG, for the HSD VLANs. Assign one tag from the range of VLANs listed in [Table 4-7 on page 4-35](#).  

```
switchport access vlan 1100
```
- f. Set the port mode to QinQ (dot1q tunnel).  

```
switchport mode dot1q-tunnel
```

## Configuring OSPF Routing for Video and Voice Traffic on AR1

Do the following to configure OSPF for video and voice traffic on AR1.

- Step 1** Define an OSPF routing process to route video traffic.

```
router ospf 100
router-id 10.1.1.3
log-adjacency-changes
```

- Step 2** Modify various timer parameters.

- a. Use the following command to enable OSPF SPF throttling, modifying the timers, and provide fast convergence: **timers throttle spf** *spf-start spf-hold spf-max-wait*  

```
timers throttle spf 10 100 1000
```
- b. Use the following command to set the rate-limiting values for OSPF link-state advertisement (LSA) generation: **timers throttle lsa all** *start-interval hold-interval max-interval*  

```
timers throttle lsa all 1 10 1000
```
- c. Use the following command to control the minimum interval for accepting the same LSA: **timers lsa arrival** *milliseconds*  

```
timers lsa arrival 100
```

If an instance of the same LSA arrives sooner than the interval that is set, the LSA is dropped.

- Step 3** Use the following command to set incremental SPF updates for LSA type 1 and LSA type 2 within an area. Enabling iSPF can minimize the effect of SPF changes within an area to only those routers where the change is relevant, thus reducing the time spent calculating SPF.

```
ispf
```

- Step 4** Advertise the networks in the first OSPF routing process.

```
network 10.1.1.8 0.0.0.3 area 0
network 10.1.1.24 0.0.0.3 area 0
network 10.10.0.0 0.0.255.255 area 0
network 10.20.0.0 0.0.255.255 area 0
```

- Step 5** To support load sharing, set the maximum number of parallel routes the IP routing protocol supports (installs in a routing table).

```
maximum-paths 8
```

---

## Configuring QinQ and Spanning Tree on AR1

See [Common Task: Configuring QinQ and Spanning Tree, page 4-35](#).

Do the following in global configuration mode to configure QinQ and spanning tree parameters on AR1.

---

- Step 1** Create the HSD VLAN ranges.

```
vlan 1100-1111,1200-1211
```

- Step 2** Enable QinQ tunneling.

```
vlan dot1q tag native
```

- Step 3** Configure RSTP.

```
spanning-tree mode rapid-pvst
```

---

## Configuring AR2

This section addresses the configuration required on the switch labeled AR2 in [Figure 4-2 on page 4-33](#), to route multiple services from AR2 to DER1 and DER2.

See [Configuring DNS Servers, page 4-2](#).



Note

A Cisco Catalyst 6509 can also be used, as it uses the same supervisor engine, line cards, and Cisco IOS code as the Cisco 7609 router.

This section addresses the following:

- [Configuring QoS on AR2](#)
- [Establishing and Configuring Interfaces on AR2](#)
- [Configuring OSPF Routing for Video and Voice Traffic on AR2](#)
- [Configuring QinQ and Spanning Tree on AR2](#)



Note

For a complete configuration example, see [Appendix B, “Sample DER and AR Switch Configurations for the Hub-and-Spoke Topology.”](#)

## Configuring QoS on AR2

See [Overview of QoS on a Cisco 7600 Series and Cisco Catalyst 6500 Series, page 4-11](#). This section presents the following topics:

- [Configuring Marking and Classification on AR2](#)
- [Configuring Mapping on AR1](#)

### Configuring Marking and Classification on AR2

Do the following to enable marking and classification on AR2.

**Step 1** Enable QoS in global configuration mode.

```
mls qos
```

**Step 2** Create access lists to identify the different service types in the network.

```
ip access-list extended acl_VoD_and_SIP_signaling
 permit tcp 10.1.60.0 0.0.0.255 any
 permit tcp 10.1.61.0 0.0.0.255 any
 permit tcp 10.1.80.0 0.0.0.255 any
 permit tcp 10.1.81.0 0.0.0.255 any
```

```
ip access-list extended acl_VoIP
 permit udp any any range 16384 32767
 permit udp any range 16384 32767 any
```

**Step 3** Create class maps for the access lists created in Step 2.

```
class-map match-all class_VoIP
 match access-group name acl_VoIP
class-map match-all class_VoD_and_SIP_signaling
 match access-group name acl_VoD_and_SIP_signaling
```

**Step 4** Create a policy map to set the DSCP values of the different classes created in Step 3.

```
policy-map setDSCP
 description Mark DSCP values for ingress traffic
 class class_VoIP
 set dscp ef
 class class_VoD_and_SIP_signaling
 set dscp cs3
```

**Step 5** Apply the policy map from Step 4 to the ingress interfaces using the following command.

```
service-policy input setDSCP
```



**Note**

Specific interface examples of this and other interface commands are shown in the interface provisioning sections.

**Step 6** To maintain the DSCP marking applied at the network ingress interface, configure all noningress transport interfaces to trust the incoming DSCP markings.

```
mls qos trust dscp
```

## Configuring Mapping on AR2

To configure mapping on AR2, proceed as in [Configuring Mapping on AR1, page 4-59](#).

## Establishing and Configuring Interfaces on AR2

Refer to [Figure 4-2 on page 4-33](#).

This section addresses the following:

- [Configuring IP Unnumbered for Video and VoIP Services on AR2](#)
- [Establishing VLANs for Services on AR2](#)
- [Establishing Nx1-GE Interfaces for Transport on AR2](#)
- [Establishing 1-GE Interfaces to a DSLAM on AR2](#)



**Note**

Port channels are configured on AR2, but 10-GE interfaces are not.

## Configuring IP Unnumbered for Video and VoIP Services on AR2

For background, see [Configuring IP Unnumbered for Video and VoIP Services on AR1, page 4-60](#).

Do the following to configure IP unnumbered for video and VoIP services on AR2.

**Step 1** In global configuration mode, configure IP unnumbered by establishing two loopback interfaces, one for video services and one for VoIP services.

```
interface Loopback0
 description Address block for Video Services on AR2
 ip address 10.11.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

```
interface Loopback1
 description Address block for VoIP services on AR2
 ip address 10.21.0.1 255.255.0.0
 ip ospf network point-to-point
 load-interval 30
```

- Step 2** In global configuration mode, configure IP unnumbered to use “connected” host routes.

```
ip dhcp route connected
```

---

## Establishing VLANs for Services on AR2

Before 1-GE interfaces and 10-GE trunks can be configured, VLANs for the various services must be created. With the exception of the high-speed data (HSD) VLAN range, these are all Layer 3 VLANs. (Refer to [Table 4-6 on page 4-34](#).)

Do the following to establish VLANs for services on AR2.

- Step 1** In global configuration mode, establish a range of VLANs for HSD. (No Layer 3 interface is required.)

```
vlan 1200-1211
```

- Step 2** Establish a range of VLANs for video at the edge.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 100-111
```

- b. In interface configuration mode, create and configure the VLAN interfaces for video services.

```
interface range Vlan100-111
 description Video edge VLAN on DSLAM
 no ip redirects
 no ip unreachablees
```

- c. Enable PIM sparse mode. This is the aggregation VLAN range for video traffic to the DSLAMs.

```
ip pim sparse-mode
```

- d. To ensure consistently fast PIM convergence times, statically join the aggregation VLAN range 100 through 111 for video at the AR to the multicast groups.

```
ip igmp static-group 232.1.1.1 source ssm-map
ip igmp static-group 232.1.1.2 source ssm-map
ip igmp static-group 232.1.1.3 source ssm-map
ip igmp static-group 232.1.1.4 source ssm-map
ip igmp static-group 232.1.1.5 source ssm-map
ip igmp static-group 232.1.1.6 source ssm-map
ip igmp static-group 232.1.1.7 source ssm-map
ip igmp static-group 232.1.1.8 source ssm-map
ip igmp static-group 232.1.1.9 source ssm-map
ip igmp static-group 232.1.1.10 source ssm-map
```

- e. Change the ARP timeout from the default.

```
arp timeout 250
```

- Step 3** Establish a range of VLANs for VoIP at the edge.

- a. In global configuration mode, add the range of VLANs to the VLAN database.

```
vlan 200-211
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface range Vlan200-211
description VoIP edge VLAN on DSLAM
no ip redirects
no ip unreachable
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

**Step 4** Establish VLANs for video and VoIP transport. The first is to and from DER1.

- a. In global configuration mode, add the VLAN to the VLAN database.

```
vlan 816
name VLAN_816_Video_VoIP_to/from_DER1
```

- b. In interface configuration mode, create and configure the VLAN interface.

```
interface Vlan816
description Transport to/from DER1 (TenGig7/1)
ip address 10.1.1.18 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
```

- c. Configure OSPF on the transport VLAN interface.

```
ip ospf network point-to-point
ip ospf hello-interval 1
```

- d. Change the load interval from the default of 300.

```
load-interval 30
```

- e. Repeat Step 4a through Step 4d, as appropriate, to establish a VLAN for video and VoIP transport to and from DER2.

```
vlan 832
name VLAN_832_Video_VoIP_to/from_DER2
```

```
interface Vlan832
description Transport to/from DER2 (TenGig7/1)
ip address 10.1.1.34 255.255.255.252
ip pim query-interval 100 msec
ip pim sparse-mode
ip ospf network point-to-point
ip ospf hello-interval 1
load-interval 30
```

## Establishing Nx1-GE Interfaces for Transport on AR2

Do the following to establish Nx1-GE interfaces on AR2. (See [Table 4-6 on page 4-34](#).)

**Step 1** Proceed as in [Establishing Nx1-GE Interfaces for Transport on DER1, page 4-47](#).

**Step 2** Establish a 1-GE interface to and from DER1.

a. Establish the interface.

```
interface GigabitEthernet1/5
 description Transport to/from DER1 (GigE1/1)
 switchport
 switchport mode trunk
 no ip address
 no keepalive
```

b. Configure the trunk for 802.1q encapsulation.

```
switchport trunk encapsulation dot1q
```

c. Assign the trunk to VLAN 816 and VLAN range 1200–1211.

```
switchport trunk allowed vlan 816,1200-1211
```

d. Change the load interval from the default of 300.

```
load-interval 30
```

e. Configure interface link detect options, such as **carrier-delay**, to reduce the time to detect a link failure, and **dampening** to minimize the effects of flapping links.



**Note** The **restart** command option is applied on start up to reduce the possibility of routing “black holes” during startup (where upper layers converge before lower layers do).

```
carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000
```

**Step 3** Establish a 1-GE interface to and from DER2.

a. Establish the interface.

```
interface GigabitEthernet1/5
 description Transport to/from DER2 (GigE1/1)
 switchport
 switchport mode trunk
 no ip address
 no keepalive
```

b. Configure the trunk for 802.1q encapsulation.

```
switchport trunk encapsulation dot1q
```

c. Assign the trunk to VLAN 832 and VLAN range 1200–1211.

```
switchport trunk allowed vlan 832,1200-1211
```

d. Change the load interval from the default of 300.

```
load-interval 30
```

e. Configure interface link detect options, such as **carrier-delay**, to reduce the time to detect a link failure, and **dampening** to minimize the effects of flapping links.



**Note** The **restart** command option is applied on start up to reduce the possibility of routing “black holes” during startup (where upper layers converge before lower layers do).

```
carrier-delay msec 0
dampening 5 1000 2000 20 restart 16000
```

**Step 4** Repeat Step 1 and Step 2 for additional 1-GE transport links as required.

**Step 5** Configure QoS on a 1-GE transport link.



**Note** The Nx1-GE transport links from the DER to the ARs require modifications to the transmit queues. There are eight transmit queues, but this solution uses only three.

- a. View the default CoS-to-Tx-Queue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0
1 2 1
2 1 2
2 2 3 4
3 1 6 7
4 1 5
```

- b. Configure the CoS-to-TxQueue mapping on the 10-GE transport interfaces. HSD (CoS = 0) remains in TxQueue1 and VoIP (CoS = 5) remains in TxQueue4. Video is separated into two classes, one class for broadcast video (CoS = 4) and one class for VoD video (CoS = 2). The other three CoS values are associated with TxQueue2.

```
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```



**Note** TxQueue2 has two thresholds: Threshold 1 = CoS 2 (default) and Threshold 2 = CoS 3, 4, 6, and 7.

- c. Verify the modified CoS-to-TxQueue mapping. The following information was extracted from the **show queueing interface** command.

```
queue thresh cos-map

1 1 0 1
2 1 2
2 2 3 4 6 7
4 1 5
```

- d. Configure the TxQueue thresholds.

TxQueue1 uses Weighted Random Early Drop (WRED) for queue-congestion management. Only HSD is queued in this queue, and when the amount of HSD in the queue reaches 75%, random packets are dropped in an attempt to keep the queue from reaching 100% utilization.

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100 100
```

TxQueue2 uses tail drop for queue congestion management. VoD is assigned to threshold 1 and is dropped once the queue reaches 80% utilization. VoD signaling, network signaling, and broadcast video are assigned to threshold 2 and are dropped once the queue reaches 100% utilization.



```
wrr-queue threshold 2 80 100 100 100 100 100 100
no wrr-queue random-detect 2
```

- e. Configure the bandwidth of the weighted queues.

The weighted queues need to be modified to handle our modified TxQueue mappings. The ratio between TxQueue2 and TxQueue1 is  $255/64 = 4$ , so TxQueue2 needs four times as much bandwidth as TxQueue1. Therefore, TxQueue1 is allocated 20% of the bandwidth on the interface, and TxQueue2 is allocated 80% of the bandwidth.

```
wrr-queue bandwidth 64 255 0
```

- f. Configure the size of the weighted queues.

Each line card has a limited amount of buffer for the transmit queues. For this interface, 40% of the buffer is allocated for TxQueue1, and 50% of the buffer is allocated for TxQueue2.

```
wrr-queue queue-limit 40 50 0
```

- g. Configure this interface (and all noningress transport interfaces) to trust the incoming DSCP markings. (This maintains the DSCP marking applied at the network ingress interface.)

```
mls qos trust dscp
```

- Step 6** Repeat Step 5 for any additional 1-GE transport links.
- 

## Establishing 1-GE Interfaces to a DSLAM on AR2

Two 1-GE interfaces are connected to and from each DSLAM. DSLAMs have two uplinks that are configured as IEEE 802.1q trunks. The first DSLAM uplink carries two VLANs, one video VLAN and one VoIP VLAN. The second DSLAM uplink carries one HSD VLAN per subscriber. QinQ is used for HSD to reduce the number of VLANs required in the service provider's network. Each QinQ tunnel (one per DSLAM) is terminated upstream on a BRAS that is connected to a DER (in our case, to DER1).

Do the following to establish 1-GE interfaces to a DSLAM on AR2.

---

- Step 1** Establish an interface to DSLAM1 uplink 1.

- a. Establish the interface and assign it to VLANs 100 and 200.

```
interface GigabitEthernet2/1
description GigE trunk for video and VoIP to/from DSLAM uplink GigE
switchport
switchport trunk encapsulation dot1q
switchport trunk allowed vlan 100,200
switchport mode trunk
no ip address
```

- b. Apply the "setDSCP" service policy to mark DSCP values in the inbound IP packets.

```
service-policy input setDSCP
```

- c. Change the load interval from the default of 300.

```
load-interval 30
```

- d. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1](#), page 4-44.

```
wrr-queue bandwidth 64 255 0
wrr-queue queue-limit 40 50 0
wrr-queue threshold 2 80 100 100 100 100 100 100
```

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```

- e. Disable Cisco Discovery Protocol (CDP) on the interface.

```
no cdp enable
```

- f. Enable PortFast on the interface to bypass the listening and learning states in Spanning Tree Protocol (STP). This allows the interface to move immediately from the blocking state to the forwarding state, rather than waiting for STP to converge.

```
spanning-tree portfast
```

- g. Configure the switch to disable any interface that is configured for PortFast and receives a Bridge Protocol Data Unit (BPDU).

```
spanning-tree bpduguard enable
```



**Note**

This guards against a user accidentally connecting a switch to a switchport that is intended for a VoD server or other host. The switchport is disabled and the user must investigate why the port is down. If this command is not used and such an accidental connection were to happen, STP could reconverge and block other connections in the switch.

- h. Apply the “setDSCP” service policy to mark DSCP values in the inbound IP packets.

```
service-policy input setDSCP
```

**Step 2** Establish an interface to DSLAM1 uplink 2.

- a. Establish the interface and assign it to VLAN 1100.

```
interface GigabitEthernet2/2
description GigE QinQ port for HSD to/from DSLAM uplink GigE
switchport
no ip address
```



**Note** No QoS policy is required on the HSD interface, so all HSD packets are rewritten to the default DSCP value, 0.

- b. Set the Service Provider outer VLAN tag, or S-TAG, for the HSD VLANs.

```
switchport access vlan 1200
```

- c. Set the port mode to QinQ (dot1q tunnel).

```
switchport mode dot1q-tunnel
```

- d. Change the load interval from the default of 300.

```
load-interval 30
```

- e. Proceed as in Step 2 of [Establishing 10-GE Interfaces for Transport on DER1, page 4-44](#).

```
wrr-queue bandwidth 64 255 0
wrr-queue queue-limit 40 50 0
wrr-queue threshold 2 80 100 100 100 100 100 100
```

```
wrr-queue random-detect min-threshold 1 75 100 100 100 100 100 100
wrr-queue random-detect max-threshold 1 100 100 100 100 100 100 100
no wrr-queue random-detect 2
wrr-queue cos-map 1 1 0 1
wrr-queue cos-map 2 2 3 4 6 7
```

- f. Disable Cisco Discovery Protocol (CDP) on the interface.

```
no cdp enable
```

## Configuring OSPF Routing for Video and Voice Traffic on AR2

Do the following to configure OSPF for video and voice traffic on AR2.

- Step 1** Define an OSPF routing process to route video traffic.

```
router ospf 100
router-id 10.1.1.4
log-adjacency-changes
```

- Step 2** Modify various timer parameters.

- a. Use the following command to enable OSPF SPF throttling, modifying the timers, and provide fast convergence: **timers throttle spf** *spf-start spf-hold spf-max-wait*

```
timers throttle spf 10 100 1000
```

- b. Use the following command to set the rate-limiting values for OSPF link-state advertisement (LSA) generation: **timers throttle lsa all** *start-interval hold-interval max-interval*

```
timers throttle lsa all 1 10 1000
```

- c. Use the following command to control the minimum interval for accepting the same LSA: **timers lsa arrival** *milliseconds*

```
timers lsa arrival 100
```

If an instance of the same LSA arrives sooner than the interval that is set, the LSA is dropped.

- Step 3** Use the following command to set incremental SPF updates for LSA type 1 and LSA type 2 within an area. Enabling iSPF can minimize the effect of SPF changes within an area to only those routers where the change is relevant, thus reducing the time spent calculating SPF.

```
ispf
```

- Step 4** Advertise the networks in the first OSPF routing process.

```
network 10.1.1.16 0.0.0.3 area 0
network 10.1.1.32 0.0.0.3 area 0
network 10.11.0.0 0.0.255.255 area 0
network 10.21.0.0 0.0.255.255 area 0
```

- Step 5** To support load sharing, set the maximum number of parallel routes the IP routing protocol supports (installs in a routing table).

```
maximum-paths 8
```

## Configuring QinQ and Spanning Tree on AR2

See [Common Task: Configuring QinQ and Spanning Tree, page 4-35](#).

Do the following in global configuration mode to configure QinQ and spanning tree parameters on AR2.

---

**Step 1** Create the HSD VLAN ranges.

```
vlan 1100-1111,1200-1211
```

**Step 2** Enable QinQ tunneling.

```
vlan dot1q tag native
```

**Step 3** Configure RSTP.

```
spanning-tree mode rapid-pvst
```

---