



# Implementing and Configuring the Solution

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## Overview

This chapter addresses the two fundamental Ethernet/IP architectures:

- [Switch in the Dhub, page 3-1](#)
- [No Switch in the Dhub, page 3-15](#)

In addition, resources for implementing the optical architecture are provided below:

- [Implementing Optics, page 3-17](#)
- [Implementing the Cisco uMG9820 QAM Gateway, page 3-18](#)

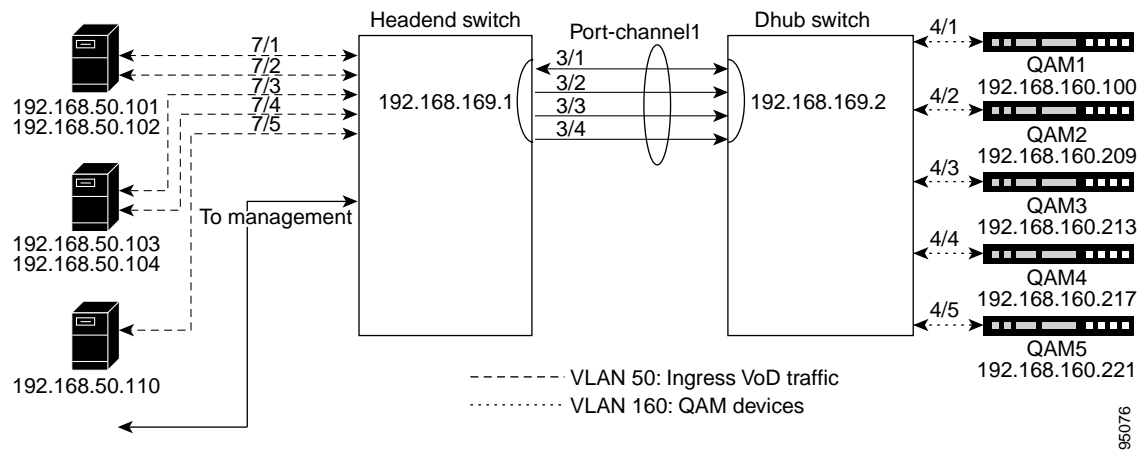
## Switch in the Dhub

This section addresses the following topics:

- [Configuring the Headend: Cisco Catalyst Switches \(Basic Configuration\)](#)
- [Configuring the Dhub: Cisco Catalyst Switches](#)
- [Establishing Multiple EtherChannels](#)
- [Establishing Subtended Dhubs](#)

For background, see [Switch in the Dhub, page 2-1](#). [Figure 3-1](#) illustrates an example network architecture for the switch-in-Dhub scenario. Extrapolate to add additional servers and switches.

Figure 3-1 Example Network Architecture: Switch in Dhub



## Configuring the Headend: Cisco Catalyst Switches (Basic Configuration)

This section illustrates the nondefault provisioning that is required to establish payload channels between a Cisco Catalyst switch and the VoD servers and QAMs where a switch is used in the Dhub. Switch defaults are not discussed here, but are available in [Appendix A, “Switch in Dhub: Sample Configurations for Cisco Catalyst 4500 Series Switches.”](#)



### Note

For switch-related documentation, see Cisco 4000 Family Switches at the following URL:

<http://www.cisco.com/univercd/cc/td/doc/product/lan/cat4000/index.htm>

The following topics are illustrated:

- [Establishing Quality of Service \(QoS\)](#)
- [Enabling OSPF](#)
- [Enabling Load Balancing](#)
- [Establishing Interfaces on the Headend Switch](#)
- [Using and Monitoring HSRP](#)
- [Example Configuration on a Headend Switch](#)

## Establishing Quality of Service (QoS)

For background, see [QoS, page 2-6](#). Cisco recommends that you tag all video traffic so that it is queued properly and efficiently. The following procedure illustrates the key interrelated components of establishing QoS for video.

**Step 1** Establish QoS. This is a global command.

```
qos
```

**Step 2** Establish a video class. This requires an access list.

```
class-map match-all class_video
  match access-group name acl_video
```

The extended access-list name **acl\_video** is arbitrary. The option **match-all** ensures that all statements in the list are matched.

**Step 3** Establish an extended access list.

```
ip access-list extended acl_video
  remark Identify video traffic (UDP ports 257-33023).
  permit udp any any range 257 33023
```

Above port 256, ranges will vary, depending upon the installation.



**Note** The Harmonic NSG QAM device uses the 2-byte UDP port number to specify the output QAM and program number for an incoming video stream. One of the leftmost eight bits is turned on to specify one of the eight output QAMs. The least-significant bit (LSB) for QAM 1, and the most-significant bit (MSB) is for QAM 8. The rightmost eight bits specify the output program number (range is 1–255). Thus, the access list will use the valid NSG UDP port range to identify video streams (range is 257–33023).

**Step 4** Establish a policy map. This exploits the Type of Service (TOS) bits in the video IP packet. You will need to establish Differentiated Services Code Point (DSCP) values.

```
policy-map setDSCP <---This value is arbitrary, and is applied to service-policy on a VLAN
  description Mark all video traffic with DSCP of EF
  class class_video
    set ip dscp 46
```

The parameter setDSCP is arbitrary, and provides an association set by the **service-policy** command, in the VLAN(s) for video traffic. The value 46 turns on the EF (Expedited Forwarding) flag.

The following helps explain the DSCP values and Tx-Queue (transmit queue) mappings, and illustrates how **policy-map** changes the ToS bits for all incoming packets that are in **class\_video**. The DSCP bits are the first 6 bits, and the last two (the ECT and CE bits) are ignored.

The incoming video packets from the VoD servers have a DSCP of 7, mapped from hex to binary as follows:

```
!
! Type of service = 1C
!  0 0 0 . . . . . = routine
!  . . . 1 . . . . = low delay
!  . . . . 1 . . . = high throughput
!  . . . . . 1 . . = high reliability
!  . . . . . . 0 . = ECT bit - transport protocol will ignore the CE bit
!  . . . . . . . 0 = CE bit - no congestion
!
```

The following policy-map changes the DSCP to 46.

```
!
! Type of service = B8
!  1 0 1 . . . . . = Critic/ECP
!  . . . 1 . . . . = low delay
!  . . . . 1 . . . = high throughput
!  . . . . . 0 . . = normal reliability
!  . . . . . . 0 . = ECT bit - transport protocol will ignore the CE bit
!  . . . . . . . 0 = CE bit - no congestion
!
```

Here is the default DSCP mapping. The **policy-map** changes the video packets from the DSCP value of 7, which maps to Tx-Queue 1, to a DSCP value of 46, which maps to Tx-Queue 3. Use the command **show qos maps** to view the mapping table and confirm this:

```
! Headend#show qos maps
! DSCP-TxQueue Mapping Table (dscp = d1d2)
! d1 : d2  0  1  2  3  4  5  6  7  8  9
! -----
!  0 :    01 01 01 01 01 01 01 01 01 01
!  1 :    01 01 01 01 01 01 02 02 02 02
!  2 :    02 02 02 02 02 02 02 02 02 02
!  3 :    02 02 03 03 03 03 03 03 03 03
!  4 :    03 03 03 03 03 03 03 03 04 04
!  5 :    04 04 04 04 04 04 04 04 04 04
!  6 :    04 04 04 04
```

## Enabling OSPF

Enable OSPF, as in the following example.

```
router ospf 100
 log-adjacency-changes
 passive-interface Vlan50
 network 1.1.1.0 0.0.0.255 area 0
 network 192.168.0.0 0.0.255.255 area 0
 distribute-list 1 in Port-channel1
 distribute-list 2 in Port-channel2
 distribute-list 3 in Port-channel3
 distribute-list 4 in Port-channel4
 distribute-list 4 in Port-channel5
```

OSPF will advertise all the headend switch interfaces to the DHubs. This includes the GRE tunnel endpoints (loopbacks) and the VoD server VLAN. The **distribute-list** commands are used to block alternative routes to DHub QAM VLANs from being added to the routing table. In other words, the only path to VLAN160 on DHub A should be through Port-channel1.

Area 0, the default, represents a backbone.

## Enabling Load Balancing

Both Layer 3 and EtherChannel load balancing should be used on the headend switch. Default hashing algorithms XOR the source and destination IP addresses. In the VoD application, this produces a small set to be distributed across multiple equal-cost paths. To increase this set and achieve a better distribution, Cisco recommends that you include the Layer 4 destination ports in the hashing algorithm.

### Layer 3 Load Balancing

For Layer 3 (CEF IP) load balancing, the Layer 4 ports are included with the following command:

```
ip cef load-sharing algorithm include-ports destination
```

### EtherChannel Load Balancing

For EtherChannel load balancing, the Layer 4 ports are used with the following command:

```
port-channel load-balance dst-port
```



Note See [Load-Balancing Strategies, page 2-4](#).

## Establishing Interfaces on the Headend Switch

Traffic is segregated naturally through the assignment of interfaces. Corresponding interfaces must also be configured on any Dhubs in the switch-in-Dhub scenario. Interfaces are assigned to VLANs on the switch.

The following interface-related topics are illustrated, in the general order in which they would be applied:

- [Establishing a VLAN and Addresses for VoD Server Traffic to the Switch](#)
- [Establishing the GE Interfaces to the VoD Servers](#)
- [Establishing GE Interfaces from the Headend Switch to the Dhub Switch](#)
- [Establishing an Asymmetric EtherChannel to the Dhub Switch](#)
- [Establishing Tunnels to a Dhub Switch \(Optional\)](#)
- [Establishing Interfaces for Management \(Optional\)](#)

### Establishing a VLAN and Addresses for VoD Server Traffic to the Switch

The following illustrates the establishment of a VLAN and range of IP addresses for video traffic to the switch. (See [Figure 3-1 on page 3-2](#).) Addressing will vary for multiple servers in disparate networks.

**Step 1** First assign a VLAN, then assign an address range to the VLAN.

```
interface Vlan50
description VoD Servers
ip address 192.168.50.2 255.255.255.0
no ip redirects
no ip unreachable
```



Note The last two commands above prevent the switch from returning ICMP notification messages to servers if a destination IP address is unreachable or has an erroneous destination.

**Step 2** Establish a service policy for the VLAN. The following applies values set by the parameter policy-map for TOS. See [Establishing Quality of Service \(QoS\), page 3-2](#).

```
service-policy input setDSCP <---Applies values set by policy-map
```

**Step 3** Establish virtual addresses.

```
standby 50 ip 192.168.50.1 <---See Note below
```



Note The line above establishes a virtual IP and MAC address for the VoD VLAN. By convention, the virtual IP address is the first host address in the subnet; the physical interfaces or SVIs (switch VLAN interfaces) are subsequent host addresses.

Be sure to include a group number on this and all standby commands. Otherwise, the group number defaults to 0, resulting in improper operation.

## Establishing the GE Interfaces to the VoD Servers

Refer to [Figure 3-1 on page 3-2](#). The following establishes GE interfaces for the video traffic to the VoD servers, interfaces GigabitEthernet7/1, GigabitEthernet7/5, GigabitEthernet7/9, GigabitEthernet7/13, and GigabitEthernet7/17, assigning them to VLAN 50.



### Note

Slot 7 holds a 24-port linecard that supports 10/100/1000 Mbps over copper. While the optical ports on the switch support only 1000 Mbps, the copper ports have to be set explicitly to this rate.



### Caution

When using VoD servers that have copper GE interfaces, be sure to space the VoD server connections appropriately. On a 24-port 10/100/1000 Mbps linecard, use one VoD server connection for every four ports on the linecard. On a 14-port 1000 Mbps linecard, use one server connection for every four copper GE ports, and one for each optical GE port.

```
interface GigabitEthernet7/1
  description VODserver1 GigE0
  switchport access vlan 50
  switchport mode access
  load-interval 30
  duplex full
  speed 1000 <---See Note above
!
interface GigabitEthernet7/5
  description VODserver1 GigE1
  switchport access vlan 50
  load-interval 30
  speed 1000
!
interface GigabitEthernet7/9
  description VODserver2 GigE0
  switchport access vlan 50
  load-interval 30
  speed 1000
!
interface GigabitEthernet7/13
  description VODserver2 GigE1
  switchport access vlan 50
  load-interval 30
  speed 1000
!
interface GigabitEthernet7/17
  description VODserver3 GigE0
  switchport access vlan 50
  load-interval 30
  speed 1000
```

## Establishing GE Interfaces from the Headend Switch to the Dhub Switch

Refer to [Figure 3-1 on page 3-2](#). The following illustrates the establishment of interfaces GigabitEthernet3/1, GigabitEthernet3/2, GigabitEthernet3/3, and GigabitEthernet3/4. GigabitEthernet3/1 is bidirectional, with all others being unidirectional. Corresponding channels will need to be established on the Dhub switch. Once you establish the interfaces, assign them to an EtherChannel as described in [Establishing an Asymmetric EtherChannel to the Dhub Switch, page 3-8](#).

**Caution**

When adding send-only links to EtherChannels that are already carrying video traffic, be sure to configure the receive-side switch and all physical connections before configuring the send-side switch. See [Preventing Lost Traffic: Adding Send-Only GE Links to Operational EtherChannels, page 5-12](#).

```
interface GigabitEthernet3/1
  description Bidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  tx-queue 3 <---See first Note below
    priority high
  channel-group 1 mode on <---See second Note below
!
```



**Note** There are 64 DSCP (Differentiated Services Code Point) values, which are mapped to four queues on the switch. This ensures that traffic marked EF (video), which is mapped to queue 3, has a higher priority than traffic mapped to the other three queues.



**Note** The command **channel-group** binds the interface to Port-channel1.

```
interface GigabitEthernet3/2
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  tx-queue 3
    priority high
  unidirectional send-only <---See Note below
  channel-group 1 mode on
!
```



**Note** This forces the GE port up with transmit-only capabilities. This relieves the CPU and improves throughput.

```
interface GigabitEthernet3/3
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  tx-queue 3
    priority high
  unidirectional send-only
  channel-group 1 mode on
!
```

```
interface GigabitEthernet3/4
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  tx-queue 3
    priority high
  unidirectional send-only
  channel-group 1 mode on
```

For the corresponding configuration on the Dhub switch, see [Establishing GE Interfaces from the Dhub Switch to the Headend Switch, page 3-11](#).

### Establishing an Asymmetric EtherChannel to the Dhub Switch

Once the GE interfaces are configured, they can be assigned to an EtherChannel. The switch-in-Dhub scenario requires the establishment of an asymmetric EtherChannel between the switches, as illustrated below. Refer to [Figure 3-1 on page 3-2](#).

```
interface Port-channel1
  description asymmetric EtherChannel to DHub_A
  ip address 192.168.169.1 255.255.255.252
  load-interval 30
```

The **load-interval** is the measurement interval for interface statistics. (The default **load-interval** is 300.)

For the corresponding configuration on the Dhub switch, see [Establishing an Asymmetric EtherChannel from the Dhub Switch to the Headend Switch, page 3-11](#).

### Establishing Tunnels to a Dhub Switch (Optional)

As noted in [Ethernet Topology, page 2-1](#), with this UDLR application tunnels provide the mechanism for creating a return path for a unidirectional interface or EtherChannel. Create loopback interfaces on the headend and Dhub switches to serve as endpoints for the UDLR tunnel. Loopback interfaces (rather than physical interfaces) are used as endpoints of the tunnel, because loopback interfaces never go down, and each tunnel requires its own unique set of endpoints. In this example, the return path for a unidirectional EtherChannel (Port-channel2) will be configured, beginning at the headend switch. For the corresponding configuration on the Dhub switch, see [Establishing Tunnels to a Headend Switch \(Optional\), page 3-12](#).

Tunnels are used in the following scenarios:

- [Establishing Multiple EtherChannels, page 3-14](#)
- [Establishing Subtended Dhubs, page 3-14](#)

To establish a tunnel from the headend switch to a Dhub switch:

---

**Step 1** Create a loopback interface for each tunnel. (For numbering recommendations, see Tip below.)

```
interface Loopback2
  description Endpoint of Tunnel2
  ip address 1.1.1.5 255.255.255.255
```

You must create a corresponding destination address to communicate to the same loopback on the Dhub switch, as shown in Step 2.



**Tip**

Loopback1 is not used as Port-channel1 is asymmetrical and does not need a tunnel. For convenience in provisioning and following configurations, it is useful to match the numbers for loopback, tunnel, and Port-channel.

---

**Step 2** Create the tunnel interface:

```
interface Tunnel2
  description Return Path for Unidirectional EtherChannel to DHub_B
  no ip address
  tunnel source 1.1.1.5
  tunnel destination 2.2.2.6
  tunnel udld receive-only Port-channel2
```



You also must create Tunnel2 on the Dhub switch. See [Establishing Tunnels to a Headend Switch \(Optional\)](#), page 3-12.



**Note** UDLR tunnels are configured as **receive-only** on the headend switch, and as **send-only** on the Dhub switch.

**Step 3** Repeat Step 1 and Step 2 with unique tunnel IDs and IP addresses for each tunnel configured between the headend and the Dhubs. There can be multiple GE interfaces or EtherChannels between the headend and a single Dhub.

**Step 4** Configure an OSPF network statement on the headend switch.

```
router ospf 100 network 1.1.1.0 0.0.0.255 area 0
```



**Note** Because loopback interfaces are configured on both the headend and Dhub switches for use as tunnel endpoints, the Dhub switches need to know how to route to the tunnel endpoints on the headend switch. However, the headend switch does not need to know how to route to the endpoints of the Dhub switches, because packets travel only from the Dhub to the headend. You must therefore include the tunnel endpoints in a network statement under the OSPF process.

### Establishing Interfaces for Management (Optional)

If your installation supports a management application, simply assign Layer 3 addresses to dedicated northbound and southbound management channels.

### Using and Monitoring HSRP

If redundant switches are used, it is important to monitor the status of the failover protocol. You should also use this command to determine the virtual MAC address that should be configured on VoD servers that do not support ARP.



**Note** Redundancy is discussed in detail in [Chapter 4, “Providing Redundancy and Reliability.”](#)

The following example illustrates the result of a **show standby** command:

```
Headend#show standby
Vlan50 - Group 50
Local state is Active, priority 100

    Hello time 3 sec, holdtime 10 sec

    Next hello sent in 0.346
Virtual IP address is 192.168.50.1 configured
Active router is local
Standby router is unknown
Virtual mac address is 0000.0c07.ac32
2 state changes, last state change 3d22h
IP redundancy name is "hsrp-V150-50" (default)
```

## Example Configuration on a Headend Switch

For a complete example configuration of a headend switch connected to a single Dhub switch over a single EtherChannel, see [Single EtherChannel: Headend Switch to Dhub Switch, page A-1](#).

## Configuring the Dhub: Cisco Catalyst Switches

In the switch-in-Dhub architecture, the configuration on the Dhub switch is considerably simpler. Simply maintain the correspondences and VLANs that were established at the headend. This section addresses the following topics:

- [Establishing QoS](#)
- [Enabling OSPF](#)
- [Enabling Load Balancing](#)
- [Establishing Interfaces on the Dhub Switch](#)
- [Manually Configuring the ARP and MAC Address Tables on the Dhub Switch \(Optional\)](#)

### Establishing QoS

No configuration is required on Dhub switches to perform QoS. For issues that pertain to the headend switch, see [QoS, page 2-6](#).

### Enabling OSPF

Cisco recommends that you enable OSPF routing on the switch, to advertise to the headend switch the route to the QAM VLAN, as well as to receive routes from the headend switch. Here we set the PID to 100, the same as in [Enabling OSPF, page 3-4](#).

```
router ospf 100
 log-adjacency-changes
 passive-interface Vlan160 <---See Note below
 network 192.168.0.0 0.0.255.255 area 0
```




---

**Note** The QAM devices do not need to participate in OSPF messaging.

---

### Enabling Load Balancing

No configuration is required on the Dhub switch to perform load balancing. For issues that pertain to the headend switch, see [Load-Balancing Strategies, page 2-4](#).

### Establishing Interfaces on the Dhub Switch

The interfaces established on the Dhub switch must naturally correspond to those on the headend switch. Below we illustrate the following:

- [Establishing a VLAN and Addresses for Video Traffic to the QAM Devices](#)
- [Establishing GE Interfaces from the Dhub Switch to the Headend Switch](#)
- [Establishing an Asymmetric EtherChannel from the Dhub Switch to the Headend Switch](#)

## Establishing a VLAN and Addresses for Video Traffic to the QAM Devices

The following illustrates the establishment of a VLAN and range of IP addresses for video traffic to the QAM devices. Refer to [Figure 3-1 on page 3-2](#).

```
interface Vlan160
  description QAM Devices
  ip address 192.168.160.1 255.255.255.0
  no ip redirects
  no ip unreachable
```



### Note

The last two commands above prevent the switch from returning ICMP notification messages to servers if a destination IP address is unreachable or has an erroneous destination.

## Establishing GE Interfaces from the Dhub Switch to the Headend Switch

Below we establish Gigabit Ethernet interfaces GigabitEthernet3/1, GigabitEthernet3/2, GigabitEthernet3/3, and GigabitEthernet3/4. Interface GigabitEthernet3/1 is bidirectional, with all others being unidirectional. (Refer to [Figure 3-1 on page 3-2](#).) This corresponds to [Establishing GE Interfaces from the Headend Switch to the Dhub Switch, page 3-6](#). Once you establish the interfaces, assign them to an EtherChannel as described in [Establishing an Asymmetric EtherChannel from the Dhub Switch to the Headend Switch, page 3-11](#).

```
interface GigabitEthernet3/1
  description Bidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  channel-group 1 mode on
!
interface GigabitEthernet3/2
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  unidirectional receive-only
  channel-group 1 mode on
!
interface GigabitEthernet3/3
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  unidirectional receive-only
  channel-group 1 mode on
!
interface GigabitEthernet3/4
  description Unidirectional Link of EtherChannel
  no switchport
  no ip address
  load-interval 30
  unidirectional receive-only
  channel-group 1 mode on
```

## Establishing an Asymmetric EtherChannel from the Dhub Switch to the Headend Switch

Once GE interfaces have been configured, they can be aggregated in an EtherChannel. The switch interface used is the same as that on the headend switch. (Refer to [Figure 3-1 on page 3-2](#).) This corresponds to [Establishing an Asymmetric EtherChannel to the Dhub Switch, page 3-8](#).

**Note**

To accommodate additional traffic, see [Load-Balancing Strategies, page 2-4](#). See also [Establishing Multiple EtherChannels, page 3-14](#).

See [Establishing an Asymmetric EtherChannel to the Dhub Switch, page 3-8](#).

```
interface Port-channel1
  description asymmetric EtherChannel from Headend
  ip address 192.168.169.2 255.255.255.252
  load-interval 30
```

The **load-interval** is the measurement interval for interface statistics. The default **load-interval** is 300.

### Establishing Tunnels to a Headend Switch (Optional)

See [Establishing Tunnels to a Dhub Switch \(Optional\), page 3-8](#). This configuration on the Dhub switch must correspond to that established on the headend switch.

To establish a tunnel from the Dhub switch to the headend switch:

- Step 1** Create a loopback interface for each tunnel, corresponding to what is established on the headend switch..

```
interface Loopback2
  description Endpoint of Tunnel2
  ip address 2.2.2.6 255.255.255.255
```

A corresponding destination address, as illustrated below, will need to be created for communicating to the same loopback on the headend switch.

- Step 2** Create the tunnel interface:

```
interface Tunnel2
  description Return Path for Unidirectional EtherChannel to Dhub_B
  no ip address
  tunnel source 2.2.2.6
  tunnel destination 1.1.1.5
  tunnel udlr send-only Port-channel2
  tunnel udlr address-resolution
```

This corresponds to Tunnel2 on the headend switch.

**Note**

UDLR tunnels are configured as **send-only** on the Dhub switch, and as **receive-only** on the headend switch. The command **tunnel udlr address-resolution** enables Dhub\_B to send ARP responses for Port-channel2 through Tunnel2 to the headend switch.

- Step 3** Repeat Step 1 and Step 2 with unique tunnel IDs and IP addresses for each tunnel configured between the Dhub and the headend. There can be multiple GE interfaces or EtherChannels between the headend and a single Dhub.

## Manually Configuring the ARP and MAC Address Tables on the Dhub Switch (Optional)

Where the tables must be populated manually, the following lines illustrate the correspondence that will have to be entered, through a text editor, into the configuration file. (See [Manual Population of ARP and Bridging Tables on the Dhub Switch, page 2-14](#).) The addresses of the QAM devices being supported are shown in [Figure 3-1 on page 3-2](#).

### ARP Example

The following lines will find their MAC address correspondence in [MAC Address Table Example](#), below:

```
arp 192.168.160.100 0020.a300.92aa ARPA
arp 192.168.160.209 000b.4627.0001 ARPA
arp 192.168.160.213 000b.4627.0002 ARPA
arp 192.168.160.217 000b.4627.0003 ARPA
arp 192.168.160.221 000b.4627.0004 ARPA
```

### MAC Address Table Example

The following lines correspond to the ARP lines in [ARP Example](#), above:

```
mac-address-table static 0020.a300.92aa vlan 160 interface GigabitEthernet4/1
mac-address-table static 000b.4627.0001 vlan 160 interface GigabitEthernet4/2
mac-address-table static 000b.4627.0002 vlan 160 interface GigabitEthernet4/3
mac-address-table static 000b.4627.0003 vlan 160 interface GigabitEthernet4/4
mac-address-table static 000b.4627.0004 vlan 160 interface GigabitEthernet4/5
```

## Connecting to QAM Devices

The following example illustrates the assigning of interfaces in the Dhub switch to the QAM devices, in a single VLAN.

```
interface GigabitEthernet4/1
description QAM1
switchport access vlan 160
switchport mode access
load-interval 30
speed nonegotiate
!
interface GigabitEthernet4/2
description QAM2
switchport access vlan 160
switchport mode access
load-interval 30
!
interface GigabitEthernet4/3
description QAM3
switchport access vlan 160
switchport mode access
load-interval 30
```

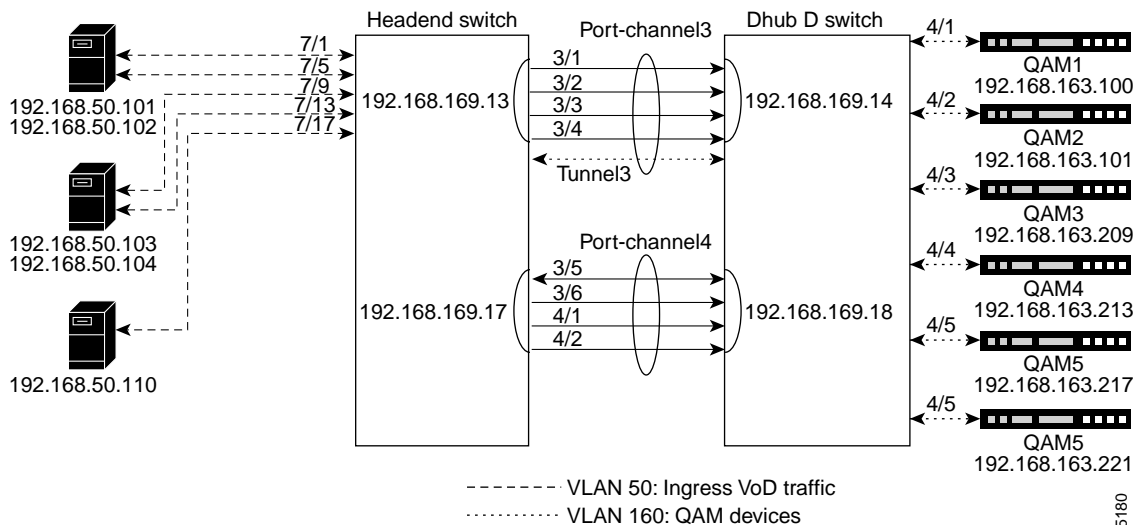
## Example Configuration on Dhub Switch

For a complete example configuration of a Dhub switch connected to a single headend switch over a single EtherChannel, see [Single EtherChannel: Dhub Switch to Headend Switch, page A-5](#).

## Establishing Multiple EtherChannels

When more than one EtherChannel interface is used between a headend and a Dhub switch, one EtherChannel will need to be asymmetric, to support bidirectional control traffic. The return path for the second EtherChannel uses UDLR over the bidirectional path on the asymmetric EtherChannel, and is established as discussed in [Establishing Tunnels to a Dhub Switch \(Optional\)](#), page 3-8. See [Figure 3-2](#) on page 3-14. See also [Load-Balancing Strategies](#), page 2-4.

**Figure 3-2** Switch in Dhub: Multiple EtherChannels



Configuration is as in [Configuring the Headend: Cisco Catalyst Switches \(Basic Configuration\)](#), page 3-2, and [Configuring the Dhub: Cisco Catalyst Switches](#), page 3-10, but with the following differences:

- A tunnel is configured on the headend switch.
  - The tunnel source is configured as a loopback interface on the headend switch.
  - The tunnel destination is configured with the same loopback interface on the Dhub switch.
  - The tunnel is associated with the receive port of an EtherChannel.
- A tunnel is configured on the Dhub switch.
  - The tunnel source is configured as a loopback interface on the Dhub switch.
  - The tunnel destination is configured with the same loopback interface on the Dhub switch.
  - The tunnel is associated with the send port of the same EtherChannel selected above.

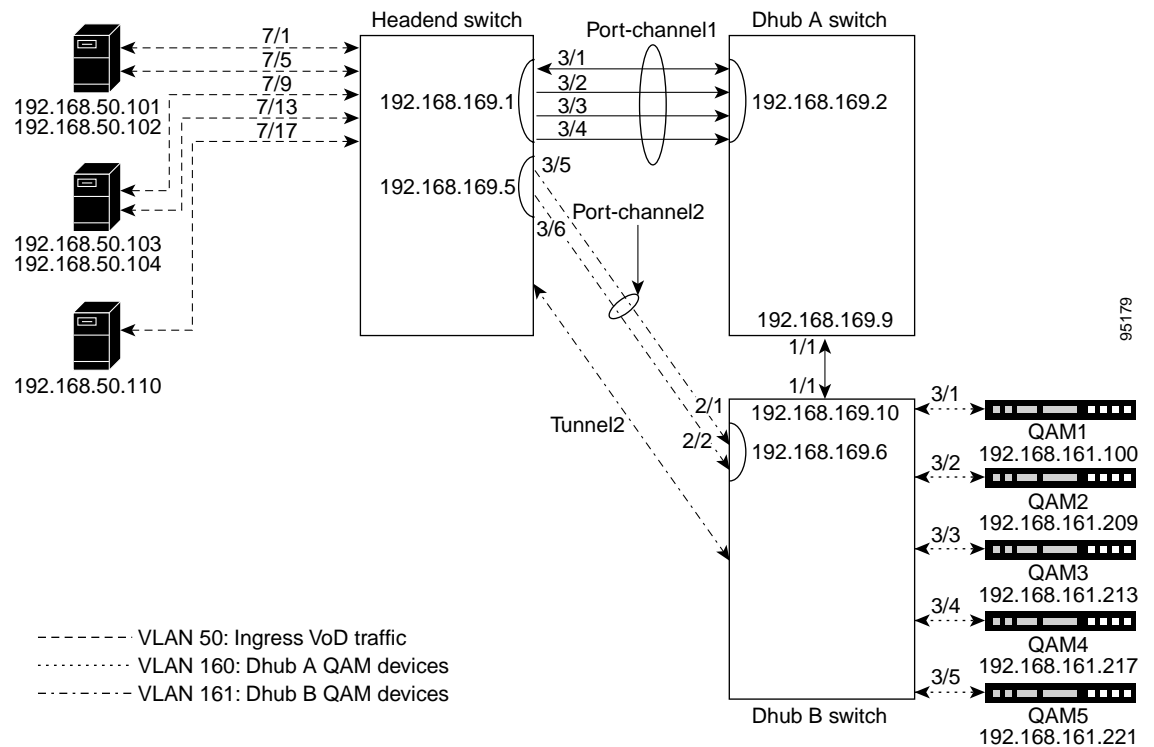
For example configurations of the headend and Dhub switch, see the following:

- [Multiple EtherChannels: Headend Switch to Dhub Switch](#), page A-8
- [Multiple EtherChannels: Dhub Switch to Headend Switch](#), page A-12

## Establishing Subtended Dhubs

With subtended Dhubs (see [Subtended Dhubs](#), page 2-7), a unidirectional EtherChannel from one Dhub switch is returned through another Dhub switch. See [Figure 3-3](#).

Figure 3-3 Switch in Dhub: Subtended Control Path



Configuration is as in [Configuring the Headend: Cisco Catalyst Switches \(Basic Configuration\)](#), page 3-2, and [Configuring the Dhub: Cisco Catalyst Switches](#), page 3-10, but with the following differences:

- A tunnel is configured on the headend switch.
  - The source is configured as a loopback interface on the headend switch.
  - The destination is configured with the same loopback interface on the Dhub switch.
  - The tunnel is associated with the receive port of an EtherChannel.
- A tunnel is configured on the Dhub switch.
  - The source is configured as a loopback interface on the Dhub switch.
  - The destination is configured with the same loopback interface on the Dhub switch.
  - The tunnel is associated with the send port of the same EtherChannel selected above.
  - The tunnel is configured to send ARP replies.

For example configurations of the headend and Dhub switch, see the following:

- [Subtended Control Path: Headend Switch to Two Dhubs](#), page A-15
- [Subtended Control Path: Dhub A to Headend Switch](#), page A-19
- [Subtended Control Path: Dhub B to Headend Switch](#), page A-22

## No Switch in the Dhub

For background, see [No Switch in the Dhub](#), page 2-11. This section addresses the following topics:

- Establishing a Single VLAN
- Establishing a Split VLAN
- Establishing Multiple VLANs

For sample configurations that illustrate the above, see [Appendix B, “No Switch in Dhub: Sample Configurations for Cisco Catalyst 4500 Series Switches.”](#)

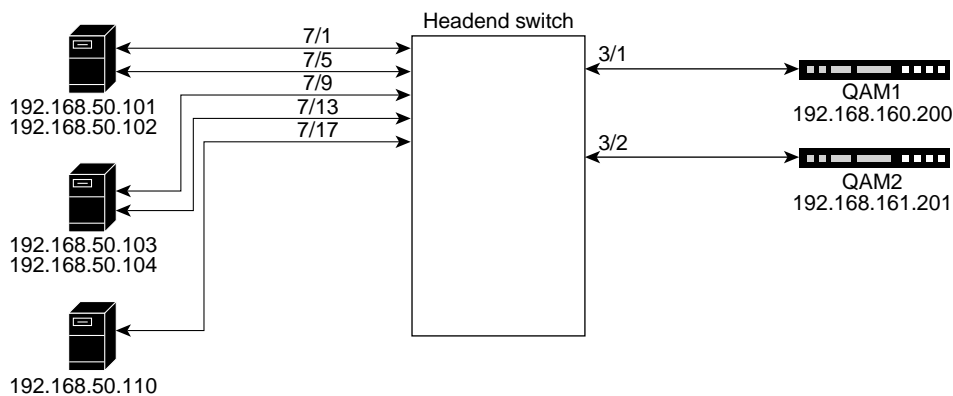

**Note**

For all of the following VLAN examples, ARP and bridging tables are populated manually, as discussed in [Manually Configuring the ARP and MAC Address Tables on the Dhub Switch \(Optional\)](#), page 3-13.

## Establishing a Single VLAN

[Figure 3-4](#) illustrates the implementation of a single VLAN, the simplest case. Here all ports are members of the same VLAN. For a sample switch configuration, see [Single VLAN](#), page B-1.

*Figure 3-4 No Switch in Dhub: Single VLAN*



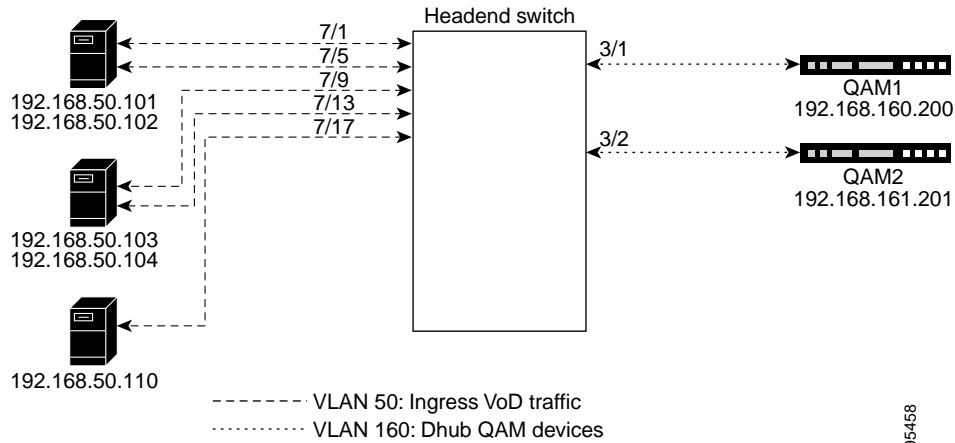
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## Establishing a Split VLAN

[Figure 3-5](#) illustrates the implementation of a split VLAN, where one VLAN is reserved for ingress VoD traffic (source ports) and another for the QAM devices (destination ports). For a sample switch configuration, see [Split VLAN](#), page B-4.



Figure 3-5 No Switch in Dhub: Split VLAN

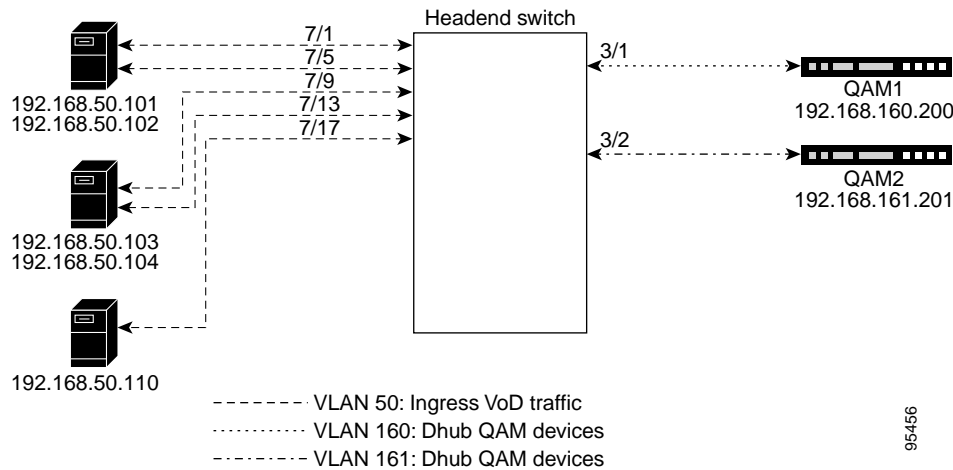


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## Establishing Multiple VLANs

Figure 3-6 illustrates the implementation of a VLAN for ingress VoD traffic as well as multiple VLANs to the QAM devices. Here, source ports are members of one VLAN, and destination ports are grouped (usually by region) into discrete VLANs. For a sample switch configuration, see Multiple VLANs, page B-7.

Figure 3-6 No Switch in Dhub: Multiple VLANs



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## Implementing Optics

The following discussions present a variety of options for implementing the various optics and supervisory channels for the Cisco Gigabit-Ethernet Optimized VoD Solution:

- [Implementing the Cisco ONS 15216 FlexLayer](#)
- [Implementing the Cisco 15216 OSC-1510](#)

## Implementing the Cisco ONS 15216 FlexLayer

The Cisco Gigabit-Ethernet Optimized VoD Solution uses the Cisco ONS 15216 FlexLayer solution to provide modular support for a variety of optical functions. A single chassis accommodates multiplex/demultiplex filters, combiner or splitter assemblies, and optical attenuators, providing for easy and cost-effective expansion.

**Note**

For more about features and the various modules, refer to “Data Sheet: Cisco ONS 15216 Metropolitan Dense Wavelength Division Multiplexing 100-GHz FlexLayer Filter Solution,” at the following URL:

[http://www.cisco.com/warp/public/cc/pd/olpl/metro/15200/prodlit/flexp\\_ds.htm](http://www.cisco.com/warp/public/cc/pd/olpl/metro/15200/prodlit/flexp_ds.htm)

To install and use the Cisco ONS 15216 FlexLayer and its various components, refer to *Cisco ONS 15216 FlexLayer User Guide, Release 1.0*, at the following URL:

<http://www.cisco.com/univercd/cc/td/doc/product/ong/15216/flxlyr10/>

## Implementing the Cisco 15216 OSC-1510

The Cisco ONS 15216 OSC-1510 can be used in the Cisco Gigabit-Ethernet Optimized VoD Solution to provide optical supervisory channel (OSC) communication to a site without the need for a OADM (optical add/drop multiplexer), EDFA (erbium-doped fiber amplifier), or multiplexing/demultiplexing at that site. This passive single-channel 100-GHz device allows you to add or drop a protected OSC wavelength in each direction at any point of a DWDM link. The dropped OSC channel is then sent to the receive GBIC port on the switch.

**Note**

For a description of the Cisco ONS 15216 OSC-1510 and installation instructions, refer to *Cisco ONS 15216 OSC-1510 User Guide* at the following URL:

<http://www.cisco.com/univercd/cc/td/doc/product/ong/15216/osc.htm>

Although that document refers to the Cisco Catalyst 2950 switch, the Cisco ONS 15216 OSC-1510 is compatible with the Cisco Catalyst 4500 series switches.

## Implementing the Cisco uMG9820 QAM Gateway

For information on preparing, installing, starting, and configuring the Cisco uMG9820 QAM Gateway, refer to the *Cisco uMG9820 QAM Gateway Installation and Configuration Guide*, at the following URL:

<http://www.cisco.com/univercd/cc/td/doc/product/cable/vod/umg9820/index.htm>