Chapter 4: EtherChannel and HSRP

CCNA Routing and Switching
Scaling Networks
Chapter 4 - Sections & Objectives

4.1 Link Aggregation Concepts
- Explain link aggregation operation in a switched LAN environment.
- Describe link aggregation.
- Describe EtherChannel technology.

4.2 Link Aggregation Configuration
- Implement link aggregation to improve performance on high-traffic switch links.
- Configure link aggregation.
- Troubleshoot a link aggregation implementation.

4.3 First Hop Redundancy Protocols (Read Only)
- Implement HSRP
  - Explain the purpose and operation of first hop redundancy protocols.
  - Explain how HSRP operates.
4.1 Link Aggregation Concepts
It is possible to combine the number of physical links between switches to increase the overall speed of switch-to-switch communication.

- STP will block redundant links to prevent routing loops.
Advantages of EtherChannel

- Most configuration tasks can be done on the EtherChannel interface instead of on each individual port.
- EtherChannel relies on existing switch ports.
- Load balancing takes place between links that are part of the same EtherChannel.
- EtherChannel creates an aggregation that is seen as one logical link.
- EtherChannel provides redundancy because the overall link is seen as one logical connection.
EtherChannel Operation
Implementation Restrictions

- EtherChannel groups multiple physical ports into one or more logical EtherChannel links.
- EtherChannel Restrictions
  - **Interface types cannot be mixed.** (Fast Ethernet + Gigabit Ethernet cannot be grouped.)
  - Provides full-duplex bandwidth up to 800 Mbps (Fast EtherChannel) or 8 Gbps (Gigabit EtherChannel)
  - Cisco IOS Switch can support 6 EtherChannels.
  - Created between two switches or a server and switch.
  - If one side is configured as trunk, the other side must be a trunk within same native VLAN.
  - Each EtherChannel has a logical port channel interface and changes to a channel affects its physical interfaces.
EtherChannel Operation

Port Aggregation Protocol

- EtherChannels can be formed by using PAgP or LACP protocol
- PAgP ("Pag-P") Cisco-proprietary protocol

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>Channel Establishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>On</td>
<td>On</td>
<td>Yes</td>
</tr>
<tr>
<td>Auto/Desirable</td>
<td>Desirable</td>
<td>Yes</td>
</tr>
<tr>
<td>On/Auto/Desirable</td>
<td>Not Configured</td>
<td>No</td>
</tr>
<tr>
<td>On</td>
<td>Desirable</td>
<td>No</td>
</tr>
<tr>
<td>Auto/On</td>
<td>Auto</td>
<td>No</td>
</tr>
</tbody>
</table>
EtherChannel Operation

Link Aggregation Control Protocol

- LACP multivendor environment

LACP modes:
- On: Channel member without negotiation (no protocol).
- Active: Actively asking if the other side can or will participate.
- Passive: Passively waiting for the other side.

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<tr>
<td>Active/Passive</td>
<td>Active</td>
<td>Yes</td>
</tr>
<tr>
<td>On/Active/Passive</td>
<td>Not Configured</td>
<td>No</td>
</tr>
<tr>
<td>On</td>
<td>Active</td>
<td>No</td>
</tr>
<tr>
<td>Passive/On</td>
<td>Passive</td>
<td>No</td>
</tr>
</tbody>
</table>
4.2 Link Aggregation Configuration
### Configuring EtherChannel

#### Configuration Guidelines

- **Configuration Settings Match on Both Switches**
  - Same speed and duplex mode.
  - All interfaces in a bundle must be assigned to the same VLAN, or configured as a trunk.
  - Trunk must support same range of VLANs.
Configuring EtherChannel

Configuration Guidelines (Cont.)

- If Configuration Settings Do Not Match

- EtherChannel not formed between S1 and S2

Note: When changing settings, configure them in port channel interface configuration mode. The configuration applied to the port channel interface also affects the individual interfaces.
Configuring EtherChannel

This configuration creates EtherChannel with LACP and configures trunking.

- Step 1: Specify the interfaces that compose the EtherChannel group.
- Step 2: Create the port channel interface with the `channel-group` command in active mode. (Channel group number needs to be selected.)
- Step 3: Change Layer 2 settings in port channel interface configuration mode.

```plaintext
S1(config)# interface range FastEthernet0/1-2
S1(config-if-range)# channel-group 1 mode active
Creating a port-channel interface Port-channel 1
S1(config-if-range)# interface port-channel 1
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk allowed vlan 1,2,20
```
Verifying and Troubleshooting EtherChannel

**Verifying EtherChannel**

```
S1# show interfaces port-channel 1
Port-channel1 is up, line protocol is up (connected)
    Hardware is EtherChannel, address is 0cd9.96e8.8a02 (bia 0cd9.96e8.8a02)
    MTU 1500 bytes, BW 200000 Kbit/sec, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
    Encapsulation ARPA, loopback not set
    <Output omitted>
```

Verifies the interface status.

```
S1# show EtherChannel summary
Flags:  D - down      P - bundled in port-channel
        I - stand-alone s - suspended
        H - Not-standby (LACP only)
        M - Layer3  S - Layer2
        U - in use   f - failed to allocate aggregator
        * - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

Number of channel-groups in use: 1
Number of aggregators: 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Port-channel</th>
<th>Protocol</th>
<th>Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Po1(SU)</td>
<td>LACP</td>
<td>Fa0/1(P)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fa0/2(P)</td>
</tr>
</tbody>
</table>
```

Displays a one-line summary per channel group.
SU indicates in use.
Verifying and Troubleshooting EtherChannel

Verifying EtherChannel (Cont.)

S1# show etherchannel port-channel
Channel-group listing:
-----------------------------

Group: 1
--------
Port-channels in the group:
-----------------------------

Port-channel: Po1 (Primary Aggregator)

---------
Age of the Port-channel = 0d:06h:23m:49s
Logical slot/port = 2/1  Number of ports = 2
HotStandBy port = null
Port state = Port-channel Ag-Inuse
Protocol = LACP
Port security = Disabled

Ports in the Port-channel:

<table>
<thead>
<tr>
<th>Index</th>
<th>Load</th>
<th>Port</th>
<th>EC state</th>
<th>No of bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>55</td>
<td>Fa0/1</td>
<td>Active</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>Fa0/2</td>
<td>Active</td>
<td>4</td>
</tr>
</tbody>
</table>

Time since last port bundled: 0d:05h:52m:59s  Fa0/2
Time since last port Un-bundled: 0d:05h:53m:05s  Fa0/2

Displays port channel information.
Verifying and Troubleshooting EtherChannel

Verifying EtherChannel (Cont.)

```
S1# show interfaces f0/1 etherchannel
Port state = Up  Matr Assoc In-Bndl
Channel group = 1  Mode = Active  Gcchange = -
Port-channel = Pol  GC = -  Pseudo port-channel = Pol
Port index = 0  Load = 0x00  Protocol = LACP

Flags:  S - Device is sending Slow LACPDU's  F - Device is sending fast LACPDU's.
         A - Device is in active mode.  P - Device is in passive mode.

Local information:
Port Flags State Priority Key Key Number State
Fa0/1   SA  bnd1  32768  0x1   0x1  0x102  0x3D

Partner's information:

LACP port
Port Flags Priority Dev ID Age Admin Oper Port Port
Fa0/1   SA  32768 0cd9.96d2.4000 13s 0x0 0x1 0x102 0x3D

Age of the port in the current state: 0d:06h:06m:51s
```

Displays role of particular interface in an EtherChannel.
Verifying and Troubleshooting EtherChannel

Troubleshooting EtherChannel

- All interfaces within EtherChannel must have the same:
  - speed
  - duplex mode
  - native and allowed VLANs on trunk (Ports with different native VLANs cannot form an EtherChannel.)
  - assigned to same VLAN
Verifying and Troubleshooting EtherChannel

Troubleshooting EtherChannel (Cont.)

Output indicates that the EtherChannel is down (SD).

```
S1# show etherchannel summary
Flags:  D - down   P - bundled in port-channel
        I - stand-alone  S - suspended
        H - Hot-standby (LACP only)
        L - Layer3  S - Layer2
        U - in use  f - failed to allocate aggregator
        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

Number of channel-groups in use: 1
Number of aggregators:   1

Group  Port-channel  Protocol  Ports
--------+-------------------+------------+
1      Po1(SD)  - Fa0/1(D)  Fa0/2(D)
```
Verifying and Troubleshooting EtherChannel

Troubleshooting EtherChannel (Cont.)

Incompatible PAgP modes configured on S1 and S2.

```
S1# show run | begin interface port-channel
interface Port-channel1
  switchport mode trunk
  !
  interface FastEthernet0/1
  switchport mode trunk
  channel-group 1 mode on
  !
  interface FastEthernet0/2
  switchport mode trunk
  channel-group 1 mode on
  
  <Output omitted>
S2# show run | begin interface port-channel
interface Port-channel1
  switchport mode trunk
  !
  interface FastEthernet0/1
  switchport mode trunk
  channel-group 1 mode desirable
  !
  interface FastEthernet0/2
  switchport mode trunk
  channel-group 1 mode desirable
  
  <Output omitted>
```
Verifying and Troubleshooting EtherChannel

Troubleshooting EtherChannel (Cont.)

S1(config)# no interface port-channel 1
S1(config)# interface range Fa0/1 - 2
S1(config-if-range)# channel-group 1 mode desirable
Creating a port-channel interface Port-channel 1

S1(config-if-range)# no shutdown
S1(config-if-range)# interface port-channel 1
S1(config-if)# switchport mode trunk
S1(config-if)# end
S1# show etherchannel summary

Flags:  D - down  P - bundled in port-channel
        I - stand-alone  S - suspended
        H - Hot-standby (LACP only)
        R - Layer3  S - Layer2
        U - in use  f - failed to allocate aggregator

M - not in use, minimum links not met
u - unsuitable for bonding
w - waiting to be aggregated
d - default port

Number of channel-groups in use: 1
Number of aggregators: 1

Group  Port-channel  Protocol  Ports
----------+-----------------+----------+
         +-----------------+----------+
1  Po1(SU)    PAgP    Fa0/1(P)  Fa0/2(P)

PAgP mode on the EtherChannel is changed to desirable and the EtherChannel becomes active.
4.3 First Hop Redundancy Protocols (Read Only)
Concept of First Hop Redundancy Protocols

Default Gateway Limitations

- A mechanism is needed to provide alternate default gateways in switched networks where two or more routers are connected to the same VLANs.
  
  - Note: In the graphic, a multilayer switch is acting as the default gateway and used for routing.
  
  - In a switched network, each client receives only one default gateway.
  
  - There is no way to use a secondary gateway, even if a second path exists to carry packets off the local segment.
  
  - In the figure, R1 is responsible for routing packets from PC1. If R1 becomes unavailable, R2 can route packets that would have gone through R1.
  
  - End devices are typically configured with a single IP address for a default gateway.
  
  - If that default gateway IP address cannot be reached, the local device is unable to send packets off the local network.
Concept of First Hop Redundancy Protocols

Router Redundancy

- To prevent a single point of failure at the default gateway, implement a virtual router.
  - Present the illusion of a single router to the hosts on the LAN.
  - By sharing an IP address and a MAC address, two or more routers can act as a single virtual router.
  - IPv4 address of the virtual router is configured as the default gateway for the workstations on a specific IPv4 segment.
  - ARP resolution returns the MAC address of the virtual router.
  - Physical router that forwards traffic is transparent to the host devices.

- A redundancy protocol provides the mechanism for determining which router should take the active role in forwarding traffic.
- Ability of a network to dynamically recover from the failure of a device acting as a default gateway is known as first-hop redundancy.
Steps for Router Failover

- When the active router fails, the redundancy protocol transitions the standby router to the new active router role.

- These are the steps that take place when the active router fails:
  1. The standby router stops seeing hello messages from the forwarding router.
  2. The standby router assumes the role of the forwarding router.
  3. Because the new forwarding router assumes both the IPv4 and MAC addresses of the virtual router, the host devices see no disruption in service.
Concept of First Hop Redundancy Protocols

First Hop Redundancy Protocols

- **Hot Standby Router Protocol (HSRP)** - A Cisco-proprietary FHRP designed to allow for transparent failover of a first-hop IPv4 device.
  - Active device is the device that is used for routing packets.
  - Standby device is the device that takes over when the active device fails.
  - Function of the HSRP standby router is to monitor the operational status of the HSRP group and to quickly assume packet-forwarding responsibility if the active router fails.

- **HSRP for IPv6** - Cisco-proprietary FHRP providing the same functionality of HSRP, but in an IPv6 environment.

- HSRP defines a group of routers - one active and one standby.
- Virtual IP and MAC addresses are shared between the two routers.
- To verify HSRP state, use the `show standby` command.
- HSRP is Cisco proprietary.
- VRRP is a standard protocol.
First Hop Redundancy Protocols (Cont.)

- **Virtual Router Redundancy Protocol version 2** - A nonproprietary protocol that dynamically assigns responsibility for one or more virtual routers to the VRRP routers on an IPv4 LAN.
  - One router is elected as the virtual router master, with the other routers acting as backups, in case the virtual router master fails.

- **VRRPv3** - Capability to support IPv4 and IPv6.

- **Gateway Load Balancing Protocol (GLBP)** - Cisco-proprietary FHRP that protects data traffic from a failed router or circuit allowing load balancing between a group of redundant routers.

- **GLBP for IPv6** - Cisco-proprietary FHRP providing the same functionality of GLBP.
HSRP Operations

HSRP Overview

- One of the routers is selected by HSRP to be the active router and default gateway.
- Other router will become the standby router.
- If active router fails, standby assumes the role of active router and default gateway.
- Hosts are configured with single default gateway VIRTUAL address that is recognizable by both the active and standby routers.
HSRP Operations

HSRP Priority and Preemption

- Role of active and standby routers determined by election process.
- By default, the router with the numerically highest IPv4 address is elected as the active router.
- Control HSRP election with priority and do not use highest address.

HSRP Priority

- Used to determine active router.
- Default HSRP priority is 100.
- Range is 0 to 255 and router with highest priority will become active.
- Use the `standby priority interface` command.

HSRP Preemption

- Preemption - ability of HSRP router to trigger the re-election process.
- To force a new HSRP election process, preemption must be enabled using `standby preempt interface`.
- A router that comes online with the a higher priority will become the active router.
**HSRP Operations**

**HSRP States and Timers**

<table>
<thead>
<tr>
<th>State</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>This state is entered through a configuration change or when an interface first becomes available.</td>
</tr>
<tr>
<td>Learn</td>
<td>The router has not determined the virtual IP address and has not yet seen a hello message from the active router. In this state, the router waits to hear from the active router.</td>
</tr>
<tr>
<td>Listen</td>
<td>The router knows the virtual IP address, but the router is neither the active router nor the standby router. It listens for hello messages from those routers.</td>
</tr>
<tr>
<td>Speak</td>
<td>The router sends periodic hello messages and actively participates in the election of the active and/or standby router.</td>
</tr>
<tr>
<td>Standby</td>
<td>The router is a candidate to become the next active router and sends periodic hello messages.</td>
</tr>
<tr>
<td>Active</td>
<td>The router currently forwards packets that are sent to the group virtual MAC address. The router sends periodic hello messages.</td>
</tr>
</tbody>
</table>

- The active and standby HSRP routers send hello packets to the HSRP group multicast address every 3 seconds, by default. The standby router will become active if it does not receive a hello message from the active router after 10 seconds.
- You can lower these timer settings to speed up the failover or preemption. However, to avoid increased CPU usage and unnecessary standby state changes, do not set the hello timer below 1 second or the hold timer below 4 seconds.
4.4 Chapter Summary
Chapter 4: EtherChannel and HSRP

- EtherChannel and how to encompass both the PAgP-based and the LACP-based link aggregation methods
- EtherChannel technologies and the various means available to implement them
- The configuration, verification, and troubleshooting of EtherChannel