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Your Time Is Now
High Availability in the Access

Samer Theodossy – Sr. Technical Leader
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BRKCRS-3438
High Availability in the Access
Session Overview and Objectives

High Availability has become part of the Cisco DNA and is being deployed on all levels of products

In this session, Our focus will be to learn about the High Availability feature of the Access switches; both Modular and Stackable. We will take a deep dive into the state machines of High Availability. Show the comparison between the Cisco Cat4500 and the new Cisco Cat3850 that is now deploying High Availability for the first time. Will show good design practices for both the Stackable and the Modular switches that will help us achieve better service availability.
Your Instructor today …

Samer Theodossy – Sr Technical Leader Enterprise Switching Group

I’m a Sr Technical Leader with the Enterprise Switching Software team at Cisco. I’ve been with Cisco for 18+ years. I have been intimately involved with the design and implementation of the systems and High Availability aspect of a lot of the platforms in Cisco. Well versed in the design of the SSO/NSF technology and its interworking and helped design the first ISSU solution at Cisco that has been commended with the Pioneer Award and best in class in the industry. Most recently I have been involved in the Cisco Cat3850 Architecture and integrated the High Availability Solution on this Access Product as well as on the Cisco Cat4500. I’m here to help you learn more about the High Availability architecture and how it works.

I have worked on a wide spectrum of Products in Cisco (BPX, MGX, 7600, 7500, 7300, 7200, Cat4500, C10K and the Cat3850) and Operating Systems (Classic IOS, IOS-XE).
Glossary

Switch

Active Switch

Standby Switch

Wireless Mobility Agent

Wireless Mobility Controller

Key Concept or Design

3x50 – 3650 or 3850 Switch

Reference slide that may not be presented in the session
HA Terms & Definitions

- **Route Processor Domain** – a set of SW processes (e.g. IOSd, WCM) that implement the centralized Active and Standby portions of the control plane

- **Line Card Domain** – a set of SW processes (e.g. FED, Platform Manager) that implement the distributed Line Card portions of the control plane

- **Election** – assigning roles or functions within the stack

- **RPR** – Route Process Redundancy. In RPR a redundant system elects an Active and Standby processor. The Active RP fully initializes and provides service. The Standby, however, suspends very early during initialization

- **RPR+** – Route Process Redundancy Plus. In RPR+ a redundant system elects an Active and Standby processor. The Active RP fully initializes and provides service. The Standby, will some state but not apply configuration until a switchover occurs.
HA Terms & Definitions

- **SSO** – Stateful Switchover refers to the implementation of IOS which allows applications and features to maintain state between an Active and Standby.
- **ISSU** – In Service Software Upgrade.
- **Active Switch** – supports the Active RP Domain, a LC Domain and Infra Domain.
- **Standby Switch** – supports the Standby RP Domain, a LC Domain and Infra Domain.
- **Member Switch** – supports a LC Domain and Infra Domain.
Agenda

• High Availability Overview and Evolution
  • High Availability Solution on the Campus Access
    • Stackable High Availability Solution
    • Modular High Availability Solution
  • Cisco IOS Application High Availability
  • High Availability Switchover Case Studies
• Summary/Q&A
Enterprise-Class Availability

Campus Systems Approach to High Availability
• Network-level redundancy
• System-level resiliency
• Enhanced management
• Human ear notices the difference in voice within 150–200 msec
  10 consecutive G711 packet loss
• Video loss is even more noticeable
• 200-msec end-to-end campus convergence

APPLICATIONS DRIVE REQUIREMENTS FOR HIGH AVAILABILITY NETWORKING
Cisco HA Evolution

No Redundancy
- No Redundant Units
- Failure on Supervisor causes reload
- Line Cards reload on failure

Redundancy with RPR
- Adding Redundant Units
- Failure on Active Sup causes Switchover
- Standby Unit is in STANDBY_COLD state
- Line Cards reload after switchover
- Startup Configuration Synchronized to Peer

Redundancy with RPR+
- Adding Redundant Units
- Failure on Active Sup causes Switchover
- Standby Unit is in STANDBY_WARM state
- Line Cards reload after switchover
- Startup Configuration Synchronized to Peer
- Running Configuration Synchronized to Peer and applied after switchover

Redundancy with SSO
- Adding Redundant Units
- Failure on Active Sup causes Switchover
- Standby Unit is in STANDBY_HOT state
- Line Cards Stay up after switchover
- Startup Configuration Synchronized to Peer
- Running Configuration Synchronized to Peer and applied.
### Cisco HA Evolution

<table>
<thead>
<tr>
<th>No Redundancy</th>
<th>Redundancy with RPR</th>
<th>Redundancy with RPR+</th>
<th>ISSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Redundant Units</td>
<td>Adding Redundant Units</td>
<td>Adding Redundant Units</td>
<td>Running SSO Among different versions</td>
</tr>
<tr>
<td>Failure on Supervisor causes reload</td>
<td>Failure on Active Sup causes Switchover</td>
<td>Failure on Active Sup causes Switchover</td>
<td></td>
</tr>
<tr>
<td>Line Cards reload on failure</td>
<td>Standby Unit in STANDBY_WARM state</td>
<td>Standby Unit in STANDBY_HOT state</td>
<td></td>
</tr>
<tr>
<td>Startup Configuration Synchronized to Peer</td>
<td>Line Cards reload after switchover</td>
<td>Line Cards Stay up after switchover</td>
<td></td>
</tr>
<tr>
<td>Outage: 10s of Minutes</td>
<td>Outage: Several Minutes</td>
<td>Outage: Several Seconds</td>
<td>Outage: Order of msecs</td>
</tr>
</tbody>
</table>
Importance of High Availability for Access switches

Feature and Device rich layer
Agenda

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• High Availability Solution on the Campus Access
  • Stackable High Availability Solution
  • Modular High Availability Solution

• Cisco IOS Application High Availability

• High Availability Switchover Case Studies

• Summary/Q&A
Modular or Stackable?
What are your requirements?

• Modular Solution
  • Space Saving with density
  • Single Power Source
  • High Fabric Bandwidth
  • Costlier per port
  • Higher Availability

• Stackable Solution
  • More elements means less reliability
  • Less expensive per port
  • Easier to adapt to needs
  • Lower Bandwidth
**IOS XE Evolution**

- Modern IOS to enable multi-core CPU
- Easy customer migration
- While maintaining IOS functionality look and feel
- Allow hosted applications like Wireshark

---

**IOS**
- Features Components
  - Common Infrastructure / HA
  - Management Interface
  - Module Drivers
  - Kernel

**IOSd**
- Features Components

**HA**

**Hosted Apps**
- WCM
IOS XE Software Internals Overview

- Kernel
  - Driver Stubs
  - Generic Driver

- IOSd RP
  - Features PD
  - Platform Drivers
  - UADP ASIC Drivers
  - Low Level APIs

- Forwarding Engine Driver
  - Forwarding & Feature Mgr (FFM)

- Interface Manager

- Service Location

- Wireless Controller

- Stack Manager (3K)

- Packet Delivery Service

- External Transports (TCP/SCTP/UDP)

- HA

- Internal IPC

- Libraries/Utilities Services

- Consolidated Logging

- Licensing Services

- Comet Services

- Platform Manager

- System Manager

- Availability Framework
HA SSO Architecture

Feature State is synced between Active and Standby Unit

Feature States are inactive on Standby
HA Redundancy Evolution for Stacking

**Catalyst 3750-X – StackWise-Plus**
- Hybrid control-plane processing
- N:1 stateless control-plane redundancy
- Distributed L2/L3 Forwarding Redundancy
- Stateless L3 protocol Redundancy

**Catalyst 3850 – StackWise-480**
- Centralized control-plane processing
- 1+1 Stateful redundancy (SSO)
- Distributed L2/L3 Forwarding Redundancy
- IOS HA Framework alignment for L3 protocol
Stacking High Availability Evolution
Doing away with Master terminology

- One Master Unit
- Rest are Member Units

Catalyst 3750-X – StackWise-Plus

Catalyst 3850 – StackWise-480

- One Active and One Standby Unit
- Rest are Member Units
Catalyst 3x50 Stack similarity to Catalyst 6500

- Active and Standby units
- Run IOSd, WCM, etc. on Active/Standby
- Synchronize information
- Active programs Data plane for members
- Member switches act as Line cards—connected via the Stack Cable

- Active and Standby Supervisors
- Run IOS on Supervisors
- Synchronize information
- Active programs all DFCs
- DFCs run a subset of IOS for LCs
Catalyst 3x50 Stack Discovery
What’s the intent of Discovery

- Switches Boot
- Stack Interfaces brought online
- Infra and LC Domains boot in parallel
- Stack Discovery Protocol discovers Stack topology – broadcast, followed by neighbor cast
- In full ring, discovery exits after all members are found
- In half ring, system waits for 2 minutes
  - If the system is a standalone then it will not wait for 2 minutes and it will be bypassed
- Active Election begins after Discovery exits
Catalyst 3x50 Active Election

Rules of Active Election:

- The switch whose member has the higher user configurable priority 1–15

- The switch member that has the lowest MAC address
Show switch with SSO

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>Active</td>
<td>2037.06cf.0e80</td>
<td>10</td>
<td>V01</td>
<td>Ready</td>
</tr>
<tr>
<td>2</td>
<td>Standby</td>
<td>2037.06cf.3380</td>
<td>8</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>3</td>
<td>Member</td>
<td>2037.06cf.1400</td>
<td>6</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06cf.3000</td>
<td>4</td>
<td>V00</td>
<td>Ready</td>
</tr>
</tbody>
</table>

* Indicates which member is providing the "stack Identity" (aka "stack MAC")

Stack Mac follows Active initially

Active
Standby
Member
Show switch detail output

Switch# show switch detail
Switch/Stack Mac Address : 2037.06cf.0e80

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>H/W</th>
<th>Current</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>Active</td>
<td>2037.06cf.0e80</td>
<td>10</td>
<td>V01</td>
<td>Ready</td>
<td></td>
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<td>2</td>
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<td>6</td>
<td>V00</td>
<td>Ready</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06cf.3000</td>
<td>4</td>
<td>V00</td>
<td>Ready</td>
<td></td>
</tr>
</tbody>
</table>

Stack Port Status

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Neighbors Port 1</th>
<th>Neighbors Port 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OK</td>
<td>OK</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>OK</td>
<td>OK</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>OK</td>
<td>OK</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Catalyst 3x50 – HA State Machine

- Active starts RP Domain
  (IOSd, WCM, etc.) locally
- Programs hardware on all LC Domains
- **Traffic starts once hardware is programmed**
- Starts 2min Timer to elect Standby in parallel
- Active elects Standby
- Standby starts RP Domain locally
- Starts Bulk Sync with Active RP
- Standby reaches “Standby Hot”
Switch# show redundancy states

my state = 13 -ACTIVE
peer state = 8 -STANDBY HOT
  Mode = Duplex
  Unit ID = 1

Redundancy Mode (Operational) = SSO
Redundancy Mode (Configured) = SSO
  Redundancy State = SSO
  Manual Swact = enabled

Communications = Up
  client count = 76
  client_notification_TMR = 360000 milliseconds
  keep_alive TMR = 9000 milliseconds
  keep_alive count = 0
  keep_alive threshold = 9
  RF debug mask = 0
Show Redundancy Command Output…

Switch#sh redundancy
Redundant System Information :
-----------------------------
Available system uptime = 29 weeks, 2 days, 11 hours, 47 minutes
Switchovers system experienced = 2
   Standby failures = 0
Last switchover reason = user_forced

   Hardware Mode = Duplex
Configured Redundancy Mode = SSO
Operating Redundancy Mode = SSO
Maintenance Mode = Disabled
   Communications = Up

Current Processor Information :
-------------------------------
   Active Location = slot 1
Current Software state = ACTIVE
   Uptime in current state = 1 week, 4 days, 22 hours, 38 minutes
   Image Version = Cisco IOS Software, IOS-XE Software, Catalyst L3 Switch Software (CAT3K_CAA-UNIVERSALK9-M), Version 03.03.03E RELEASE SOFTWARE (fc1)

Peer Processor Information :
----------------------------
   Standby Location = slot 2
Current Software state = STANDBY HOT
   Uptime in current state = 1 week, 4 days, 22 hours, 34 minutes
   Image Version = Cisco IOS Software, IOS-XE Software, Catalyst L3 Switch Software (CAT3K_CAA-UNIVERSALK9-M), Version 03.03.03E RELEASE SOFTWARE (fc1)
Show Redundancy Command Output…

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  Current Software state = STANDBY HOT
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  Image Version = Cisco IOS Software, IOS-XE Software, Catalyst L3 Switch Software (CAT3K_CAA-UNIVERSALK9-M), Version 03.03.03E RELEASE SOFTWARE (fc1)
Best Practices for Stackables
Define Stack Roles with minimal Downtime

Simplify Network Operations

• Power up the first Switch that you want to make it as Active

• Configure Priority of the switch (1-15) – 1 by default – the higher the better

• Power up the second member that you want to make as Standby

• Configure Priority less than the Active

• Power up the rest of the members

• Configure Priorities on those units

```
C3850#switch 1 priority 15
C3850#switch 2 priority 14
C3850#switch 3 priority 13
C3850#switch 4 priority 12
```
Stacking Convergence

Multi-Layer Access

- Active unit with uplink failure introduces two failures
  - Active control plane
  - Uplink interface
- When the Active fails, the Standby will take over.
- Upstream, HSRP / GLBP will detect link down, and D2 will start answering to the virtual MAC 0000.0c07.ac00
- Downstream traffic is re-routed to D2 via L3 link
Stacking Convergence

Multi-Layer Access

- Active unit Failure (without uplink)
- When the Active fails, the Standby will take over
- No HSRP/GLBP failover, while the new Active being elected, MAC address of HSRP/GLBP still used by the rest of the stack for data forwarding
- No downstream re-route convergence
Catalyst 3x50 StackWise

Routed Access

- CLI “stack-mac persistent timer 0” enables MAC consistency –
  - This is the default value for 3850
  - This is a change from the existing stacking model
  - New Active inherits the MAC address of the previous Active
  - No MAC changes for end hosts and adjacent routers, significantly improves upstream recovery

- Caution –
  - Do not re-introduce the 3x50 elsewhere in order to avoid duplicate MAC in your network
Changing Stack Mac on 3x50 Stack

- By default the timer value is set to indefinite (0)
  - System continues to keep selected stack mac after switchover
  - Avoids Protocol flapping
- How to change it
  - A new command introduced

```
3850-1#stack-mac update force
```

```
3850-1#show switch

Switch/Stack Mac Address : 2037.06cf.3380
Mac persistency wait time: Indefinite

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>Member</td>
<td>0000.0000.0000</td>
<td>10</td>
<td>V01</td>
<td>Removed</td>
</tr>
<tr>
<td>2</td>
<td>Active</td>
<td>2037.06cf.3380</td>
<td>8</td>
<td>V00</td>
<td>Ready</td>
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</table>
```
Catalyst 3850 solution for Manufacturing

Manufacturing Plant – Eastern Europe

Business Issues faced

• Port-channel not configured on the switch led to lot of mac moves
• High CPU utilization on the Active switch

Solution Highlights

• Correct Port channel configuration
• Used Redundancy to switchover Active to Standby unit
• Collecting Data and taking unit out of service
• Minimal impact to other devices in network.
Key Recommendations for Stacking

• Run the stack in full ring mode to get full bandwidth

• Configure the Active switch priority and Standby switch priority
  • Predetermine which switch is the Active and Standby which will become the Active should the Active fail
  • Simplifies operations

• Configure Active and Standby unit without uplinks if possible
  • If deploying a stack of 4 or more switches keep the Active and Standby switches without uplinks, this will simplify the convergence and reduce the outage time

• Do Not change the stack-mac timer value
  • By default the value is 0 (indefinite)
  • Avoids protocol flapping
  • There is a command to change the stack-mac when needed
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  • Cisco IOS Application High Availability
  • High Availability Switchover Case Studies
  • Summary/Q&A
Catalyst 4500 High Availability (Modular)

- There are two dedicated supervisors
- Switch Boots Up
- Reads registers on backplane to determine the inserted card types
- Active Election begins after Discovery exits
- Active Supervisor asserts mastership in the HW
- Other Supervisor will become Standby
Catalyst 4500 High Availability State Machine

- Active starts its software processes
- Standby starts its software processes
- **Active Programs the local Sup HW**
- Standby Start Bulk sync with Active RP
- Standby Reaches “Standby Hot”
- **Standby Programs the local Sup HW**
switch#sh redundancy
Redundant System Information :
-----------------------------
Available system uptime = 3 years, 42 weeks, 4 days, 10 hours, 26 minutes
Switchovers system experienced = 0
  Standby failures = 0
  Last switchover reason = not known

  Hardware Mode = Duplex
  Configured Redundancy Mode = SSO
  Operating Redundancy Mode = SSO
  Maintenance Mode = Disabled
  Communications = Up

Current Processor Information :
-----------------------------
Active Location = slot 7
Current Software state = ACTIVE
Uptime in current state = 3 years, 42 weeks, 4 days, 10 hours, 26 minutes

Peer Processor Information :
-----------------------------
Standby Location = slot 8
Current Software state = STANDBY HOT
Uptime in current state = 3 years, 42 weeks, 4 days, 6 hours, 26 minutes
In Service Software Upgrades
Supported by the Catalyst 4500
Streamlined Process to Perform Software Upgrades/Downgrades

1. ISSU Loadversion
2. ISSU Runversion
3. ISSU Acceptversion (Optional)
4. ISSU Commitversion
In-Service Software Upgrade – IOS

ISSU Overview

- ISSU provides a mechanism to perform software upgrades and downgrades without taking the switch out of service

- Leverages the capabilities of NSF and SSO to allow the switch to forward traffic during Supervisor IOS upgrade (or downgrade)

- Key technology is the ISSU Infrastructure
  - Allows SSO between different versions
In-Service Software Upgrade – IOS

ISSU Stages

- ISSU upgrade is a 4 step process
- Possible to rollback (abort) up until you complete the 4<sup>th</sup> step (commit to final state)
- Leverages NSF/SSO to implement Supervisor transition
- Requires that the two images are compatible for upgrade / downgrade processing
Best Practices for Modular
Uplinks on the Catalyst 4500

- Two redundant 10 Gig uplinks active between the supervisors and actively forwarding at the same time.
- The Active Sup controls all the uplinks on both itself and the Standby unit.
- Two wire speed 10 Gig uplinks are active all the time even if one of the units fail.
- **Recommendation** – Connect uplinks on different Supervisors.

![Uplinks Diagram]
Power Supply Redundancy on the Catalyst 4500

- Has two power supply bays that can be run in redundant or combined mode.

- Power Supply configuration modes

  - **Redundant Mode:** second power supply is online and provides $\frac{1}{2}$ system power

  - **Combined Mode:** supervisor engines manages the combined power budget of both units
    - Only used for powering POE devices that require more power than the 1 supply can provide
Power Supply Redundancy on the Catalyst 4500

- Has two power supply bays that can be run in redundant or combined mode.
- **Power Supply configuration modes**
  - **Redundant Mode**: second power supply is online and provides ½ system power
  - **Combined Mode**: supervisor engines manages the combined power budget of both units.
    - Only used for powering POE devices that require more power than the 1 supply can provide.

```
Cat4500(config)#power redundancy-mode redundant
Cat4500#show power supplies
Power supplies needed by system: 1
```

```
Cat4500(config)#power redundancy-mode combined
Cat4500#show power supplies
Power supplies needed by system: 2
```
Catalyst 4500 Solution for Healthcare
Large sized Hospital in Europe

Business and Technology Drivers
• Deliver easy and secure access to patient records
• Maintain high level of safety within a critical environment
• High resiliency solution with Supervisor Redundancy and ISSU

Solution Highlights
• Deployed Virtual Desktops and 97 Catalyst 4500E with UPOE
• 13,500 wired client

Case Study
Panel Discussion
Key Recommendations for Modular

- Redundant Supervisors for better Availability

- Split the Uplinks between the Active and Standby units in a redundant system
  - All uplinks are Actively forwarding traffic
  - Active Supervisor will control all uplinks even if the other unit is failed

- Power Redundancy
  - Default is redundant Power mode
  - Choose the combined mode for running POE devices requiring more power than 1 supply can provide
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Stateful Switchover Mode – IOS
SSO-Aware and SSO-Compliant IOS Applications

SSO-Aware Applications
Forwarding Information Base
IEEE 802.1x
PAgP / LACP
…and more

SSO-Compliant Applications
Routing Protocols
NetFlow
Cisco Discovery Protocol
…and more

Redundancy Facility
Checkpointing Facility
Cisco IOS

Active Unit
Standby Hot Unit

SSO-Aware Applications
Forwarding Information Base
IEEE 802.1x
PAgP / LACP
…and more

SSO-Compliant Applications
Routing Protocols
NetFlow
Cisco Discovery Protocol
…and more
SSO Compliant Redundancy Clients – examples

Switch#sh redundancy clients

Group ID = 1
clientID = 20002 clientSeq = 4 EICORE HA Client
clientID = 24001 clientSeq = 28 Table Manager Client
clientID = 20010 clientSeq = 31 SNMP SA HA Client
clientID = 20007 clientSeq = 34 Installer HA Client
clientID = 29 clientSeq = 60 Redundancy Mode
clientID = 139 clientSeq = 61 IfIndex
clientID = 3300 clientSeq = 62 Persistent Var
clientID = 25 clientSeq = 68 CHKPT RF
clientID = 20005 clientSeq = 74 IIF-shim

Switch#sh redundancy slaves

Group ID = 1
Slave/Process ID = 6175 Slave Name = [installer]
Slave/Process ID = 6177 Slave Name = [eicored]
Slave/Process ID = 6198 Slave Name = [snmp_subagent]
Slave/Process ID = 12981 Slave Name = [wcm]
Slave/Process ID = 12982 Slave Name = [table_mgr]
Slave/Process ID = 12985 Slave Name = [iosd]

Some processes have more than one HA client

Security Applications | Other Applications
--- | ---
Bonjour | Bonjour
Net flow | Net flow
Wireless | Wireless
Multicast | Multicast
ARP | ARP
LLDP | LLDP
IPv6 | IPv6
L2 Multicast | L2 Multicast
L3 Multicast | L3 Multicast
Port Security | Port Security
PAGP | PAGP
IP routing NSF | IP routing NSF
CTs | CTS
STP | STP
BRKCRS | BRKCRS
-3438 | -3438
Wireless High Availability

- Converged access brings in the support of Wireless and Wired applications together on the same system.
- The High Availability is extended to the Wireless application as well.
- Let’s now examine the state maintained by the MC within a stack, and see what redundancy we provide for this …
Wireless HA – Tunnel SSO

Tunnel State is synced between Active and Standby Member in stack

Tunnel States are inactive on Standby Member
SSO by itself Does Not Provide Redundancy for the Routing Protocols
Graceful Restart, Non-Stop Forwarding and Non-Stop Routing

- Non-Stop Forwarding was developed by Cisco to maintain traffic forwarding by a router experiencing a control plane switchover event. The router will essentially synchronize its Forwarding Information Base between an Active and Standby Route Processor as well as signal to its routing neighbors to continue forwarding traffic while routing topology information is exchanged.

- The IETF developed standards based implementations similar to Cisco NSF.

- The IETF implementations use different terminology including the terms “Graceful Restart” to describe the signaling used between the routers.

- Graceful Restart (GR) and Non-Stop Forwarding (NSF) are terms often used interchangeably.

- Graceful Restart/Non-Stop Forwarding as well as Non-Stop Routing (NSR) all allow for the forwarding of data packets to continue along known routes while the routing protocol information is being restored (in the case of Graceful Restart) or refreshed (in the case of Non Stop Routing) following a processor switchover.

- Each routing protocol has its own unique implementation and signaling mechanisms.
Routing Protocol Redundancy With NSF

### Active Supervisor Engine Slot 1

<table>
<thead>
<tr>
<th>EIGRP RIB</th>
<th>Prefix</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0.0.0</td>
<td>10.1.1.1</td>
<td></td>
</tr>
<tr>
<td>10.1.0.0</td>
<td>10.1.1.1</td>
<td></td>
</tr>
<tr>
<td>10.20.0.0</td>
<td>10.1.1.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OSPF RIB</th>
<th>Prefix</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0</td>
<td>192.168.0.1</td>
<td></td>
</tr>
<tr>
<td>192.168.55..</td>
<td>192.168.55.1</td>
<td></td>
</tr>
<tr>
<td>192.168.32.0</td>
<td>192.168.32.1</td>
<td></td>
</tr>
</tbody>
</table>

### ARP Table

<table>
<thead>
<tr>
<th>IP</th>
<th>MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.1.1</td>
<td>aa8bbcc:ddee32</td>
</tr>
<tr>
<td>10.1.1.2</td>
<td>aabb32:d34e43</td>
</tr>
<tr>
<td>10.20.1.1</td>
<td>aa25cc:ddee8</td>
</tr>
</tbody>
</table>

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</tr>
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<td>aa25cc:ddee8</td>
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</tbody>
</table>

### Standby Supervisor Engine Slot 2

<table>
<thead>
<tr>
<th>OSPF RIB</th>
<th>Prefix</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.0</td>
<td>192.168.0.1</td>
<td></td>
</tr>
<tr>
<td>192.168.55..</td>
<td>192.168.55.1</td>
<td></td>
</tr>
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</table>

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**SSO Redundancy Facility**

**Checkpoint Facility**
### Routing Protocol Redundancy With NSF

#### Active Supervisor Engine Slot 1

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<thead>
<tr>
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</thead>
<tbody>
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</tr>
<tr>
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<td>10.1.1.1</td>
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<td>adbb32:d34e43</td>
</tr>
<tr>
<td>10.20.1.1</td>
<td>aa25cc:ddee8</td>
</tr>
</tbody>
</table>

#### OSPF RIB

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.0.0</td>
<td>aa25cc:ddee8</td>
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</tr>
<tr>
<td>192.168.0.0</td>
<td>aa25cc:ddee8</td>
</tr>
</tbody>
</table>

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#### Standby Supervisor Engine Slot 2

#### EIGRP RIB

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Next Hop</th>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### OSPF RIB

<table>
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<tr>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
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<td>192.168.0.0</td>
<td>aa25cc:ddee8</td>
</tr>
</tbody>
</table>

---

**SSO Redundancy Facility**

**Checkpoint Facility**

---

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Routing Protocol Redundancy With NSF

GR/NSF Signaling per protocol
Synchronization per protocol

Standy Supervisor Engine Slot 2

<table>
<thead>
<tr>
<th>EIGRP RIB</th>
<th>OSPF RIB</th>
<th>ARP Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefix</td>
<td>Next Hop</td>
<td>IP</td>
</tr>
<tr>
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<td>10.1.1.1</td>
<td>10.1.1.1</td>
</tr>
<tr>
<td>10.1.0.0</td>
<td>10.1.1.1</td>
<td>aabbcc:ddee32</td>
</tr>
<tr>
<td>10.20.0.0</td>
<td>10.1.1.1</td>
<td>10.1.1.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>FIB Table</th>
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<tbody>
<tr>
<td>Prefix</td>
</tr>
<tr>
<td>10.1.1.1</td>
</tr>
<tr>
<td>10.1.1.2</td>
</tr>
<tr>
<td>192.168.0.0</td>
</tr>
</tbody>
</table>
Non Stop Forwarding Router Roles

• Non-Stop Forwarding, NSF, allows a router to continue forwarding data along routes that are already known, while the routing protocol information is being restored

• NSF Aware router or NSF Helper router*
  • A router running NSF-compatible software, capable of assisting a neighbor router perform an NSF restart

• NSF Capable router
  • A router configured to perform an NSF restart, therefore able to rebuild routing information from neighbor NSF-aware or NSF capable router

* NSF Helper - This term is used in IETF terminology
Non-Stop Routing (NSR)

- Cisco IOS Non-Stop Routing preserves the state information (prefixes and related data) in the Routing Information Base across Supervisor Engine (Route Processor) switchover events.
  - Helpful in environments where peer routers are not managed by the same entity or are not capable of supporting NSF awareness
  - Consider that Non-Stop Routing does consume more control plane resources, such as memory and CPU compute cycles, compared to NSF
Routing Protocol Redundancy With NSR

No additional signaling required to maintain topology
• High Availability Overview and Evolution
• High Availability Solution on the Campus Access
  • Stackable High Availability Solution
  • Modular High Availability Solution
• Cisco IOS Application High Availability
  • High Availability Switchover Case Studies
• Summary/Q&A
Stack Switchover Example

3850-1# show redundancy states

my state = 13 - **ACTIVE**
peer state = 8 - **STANDBY HOT**
Mode = Duplex
Unit ID = 1
Stack Switchover Example

3850-1# show redundancy states

3850-1# show switch detail

Switch/Stack Mac Address: 2037.06cf.0e80

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>Active</td>
<td>2037.06cf.0e80</td>
<td>10</td>
<td>V01</td>
<td>Ready</td>
</tr>
<tr>
<td>2</td>
<td>Standby</td>
<td>2037.06cf.3380</td>
<td>8</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>3</td>
<td>Member</td>
<td>2037.06cf.1400</td>
<td>6</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06cf.3000</td>
<td>4</td>
<td>V00</td>
<td>Ready</td>
</tr>
</tbody>
</table>

Stack Port Status

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Neighbors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OK</td>
<td>OK</td>
<td>2, 4</td>
</tr>
<tr>
<td>2</td>
<td>OK</td>
<td>OK</td>
<td>3, 1</td>
</tr>
<tr>
<td>3</td>
<td>OK</td>
<td>OK</td>
<td>4, 2</td>
</tr>
<tr>
<td>4</td>
<td>OK</td>
<td>OK</td>
<td>1, 3</td>
</tr>
</tbody>
</table>
Stack Switchover Example

1. Active Unit Goes Down
Stack Switchover Example

1. Active Unit Goes Down
2. Standby Unit Becomes the new Active

3850-2# show redundancy states

my state = 13 - ACTIVE
peer state = 1 - DISABLED
Mode = Simplex
Unit ID = 2
Stack Switchover Example

1. Active Unit Goes Down
2. Standby Unit Becomes the new Active

```
3850-1# show switch detail
Switch/Stack Mac Address : 2037.06cf.0e80

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>Member</td>
<td>0000.0000.0000</td>
<td>10</td>
<td>V01</td>
<td>Removed</td>
</tr>
<tr>
<td>2</td>
<td>Active</td>
<td>2037.06cf.3380</td>
<td>8</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>3</td>
<td>Member</td>
<td>2037.06cf.1400</td>
<td>6</td>
<td>V00</td>
<td>Ready</td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06cf.3000</td>
<td>4</td>
<td>V00</td>
<td>Ready</td>
</tr>
</tbody>
</table>
```

```
Stack Port Status
Switch# | Port 1 | Port 2 | Neighbors
---------|--------|--------|------------
2        | OK     | DOWN  | 3          | None      |
3        | OK     | OK    | 4          | 2         |
4        | DOWN   | OK    | None       | 3         |
```
Stack Switchover Example

1. Active Unit Goes Down
2. Standby Unit Becomes the new Active
3. Starts 2min Timer to elect Standby
4. Active elects Standby
5. Standby starts RP Domain locally
6. Starts Bulk Sync with Active RP
7. Standby reaches “Standby Hot”
Stack Switchover Example

1. Active Unit Goes Down
2. Standby Unit Becomes the new Active
3. Starts 2min Timer to elect Standby
4. Active elects Standby
5. Standby starts RP Domain locally
6. Starts Bulk Sync with Active RP
7. `show redundancy states`

```
my state = 13 - ACTIVE
peer state = 8 - STANDBY HOT
Mode = Duplex
Unit ID = 2
```
Stack Switchover Example

1. Active Unit Goes Down
2. Standby Unit Becomes the new Active
3. Starts 2min Timer to elect Standby
4. Active elects Standby
5. Standby starts RP Domain locally
6. Starts Bulk Sync with Active RP
7. Standby reaches “Standby Hot”
8. Member rejoins the Stack
9. Active Programs hardware on all LCs
10. Traffic resumes
Stack Switchover Example

1. **Active Unit Goes Down**

   2. **Standby Unit Becomes the new Active**

   3. **Starts 2min Timer to elect Standby**

   4. **Active elects Standby**

   5. **Standby starts RP Domain locally**

   6. **Starts Bulk Sync with Active RP**

   7. **Standby reaches "Standby Hot"**

   8. **Member rejoins the Stack**

   9. **Active Programs hardware on all LCs**

   10. **Traffic resumes**

---

```
3850-1# show switch detail
Switch/Stack Mac Address : 2037.06cf.0e80

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<td>3</td>
<td>1</td>
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<tr>
<td>4</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
```
Catalyst 4500 Switchover Example

4500# show redundancy states

my state = 13 -ACTIVE
peer state = 8 -STANDBY HOT
Mode = Duplex
Unit ID = 7
Catalyst 4500 Switchover Example

1. Active Unit Goes Down
2. Standby Takes over as Active
Catalyst 4500 Switchover Example

1. Active Unit Goes Down
2. Standby Takes over as Active
3. Standby Unit Boot up
4. Standby Start Bulk sync with Active RP
5. Standby Reaches “Standby Hot”

```
4500# show redundancy states

my state = 13 -ACTIVE
peer state = 8 -STANDBY HOT
Mode = Duplex
Unit ID = 8
```
Agenda

• High Availability Overview and Evolution
• High Availability Solution on the Campus Access
  • Stackable High Availability Solution
  • Modular High Availability Solution
• Cisco IOS Application High Availability
• High Availability Switchover Case Studies

• Summary/Q&A
Summary

Importance of High Availability to the Access

• Feature rich and device rich deployments
• Single Points of Failures

Best Practices on Stacking (Campus)

• Connect the switches in full ring
• Configure the Active switch priority and Standby switch priority
• Configure Active and Standby unit without uplinks where possible
• Do Not change the stack-mac timer value

Best Practices on Modular (Campus)

• Run the system with Redundant Sups
• Split the Uplinks between the Active and Standby units in a redundant system
• Chose the right Power Redundancy Mode
Complete Your Online Session Evaluation

• Give us your feedback to be entered into a Daily Survey Drawing. A daily winner will receive a $750 Amazon gift card.

• Complete your session surveys through the Cisco Live mobile app or from the Session Catalog on CiscoLive.com/us.

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• Demos in the Cisco campus

• Walk-in Self-Paced Labs
  • Walk in Labs – LTRCRS-2010 – Converged Access Hands-On Lab

• Table Topics

• Meet the Engineer 1:1 meetings

• Related sessions
  • BRKARC-3438 - Cisco Catalyst 3850 and 3650 Series Switching Architecture
  • BRKCRS-3146 - Troubleshooting Cisco Catalyst 3650/3850 Series Switches
  • BRKARC-3445 – Cisco Catalyst 4500E Switch Architecture
  • BRKCRS-3143 - Troubleshooting Cisco Catalyst 4500 Series Switches
Thank you