Introduction to Cisco IOS-XR
Next-Gen OS

DFW Cisco Users Group
Chris Williamson, Network Consulting Engineer
Agenda

- Under the Covers/Behind the Scenes
- Quickly over the hardware
- Installing the Software
- Making it go
- Making it go...faster!
Please keep in mind...

• Cell phones on stun
• Please keep side conversations to a minimum or outside
• Questions are encouraged, but please raise your hand
• We are time limited, speaker reserves the right to postpone questions
• I am not a developer
• I do not have all the answers
Network Engineer vs. Network Administrator

- What’s the difference?
- When do we assume each role?
- How does each role affect decision making?
- Key Question: What role do you assume more on a daily basis?
- Keep an eye out for the Engineer/Administrator meter
Router OS Evolution

- Monolithic Kernel
- Centralized Infrastructure
- Integrated Network stack
- Centralized applications
Router OS Evolution

- Micro Kernel
- Distributed Infrastructure
- Independent Network stack
- Distributed applications
IOS-XR Key Features

• Modular – Runtime SW upgrade/downgrade support
• Distributed – Scaleable with multichassis support
• Platform Independent – POSIX compliant
• Management Interface – Unified Data Model (SNMP/XML)
• High Availability – Hot Standby and Process Restart
• Security – Control, Data, and Management Plane
• Logical Router or Secure Domain Router – Router Partitioning
IOS XR Modular Packaged Software

• Upgrade specific packages/Composites
  • Across Entire system
  • Useful once a feature is qualified and you want to roll it without lot of cmd
  • Targeted Install to specific cards
    • Useful while a feature is being qualified
    • Reduces churn in the system to card boundary

• Point Fix for software faults
Distributed Control Plane

- Routing protocols and signaling protocols can run in one or more (D)RP
- Each (D)RP can have redundancy support with standby (D)RP
- Out of resources handling for proactive planning
Distributed Forwarding Infrastructure

- Single stage forwarding
- Single global Adjacency Information Base (AIB) distributed to all line cards
- Single global Interface Management DB distributed to all line cards
- Only Ingress FIB – forces forwarding features to be run in RP
Distributed Forwarding Infrastructure

- Two stage forwarding
- Each line card has independent AIB only for local interfaces
- Each line card has independent Interface DB for local interfaces
- Both Ingress and Egress FIB – allows forwarding features to be independently run in LCs
Process Restartability

- Used for small/contained faults (individual or small groups of process failures)
- Processes support restarting with dynamic state recovery
  - Mirrored State via checkpoint or synchronization with peer
- First line of defense
  - All Processes are restartable for fault recovery
- Certain processes are ‘mandatory’
  - Must always be running.
  - Failure of mandatory processes can cause RP failover
- Second line of defense
  - Card-level Redundancy is used when Process Restart fails-
Process Management

• Process
  • An executable portion of code run within its own memory space

• Threads
  • A process may contain one or more threads or a ‘sub-process’ e.g. OSPF process has a thread which handles ‘hellos’
  • A thread may only run when the parent process is allocated runtime by the system scheduler.

• Job ID (JID) and Process ID (PID)
  • Each process is allocated a Job ID# or JID when it is first run. Remains associated with the process even if the process is stopped & restarted - The PID changes if the process is stopped and restarted

• Thread ID# (TID)
  • If a process contains threads, each is assigned a TID# associated with the PID/JID.
Protected Process Memory Space

- Each process has a virtual memory space
  - Kernel/MMU maps virtual address to physical address (at page level)
- Threads share the memory space
- One process cannot corrupt another’s memory
  - Process can only access virtual space
  - In IOS – all processes shared same virtual space
- Communication between processes via controlled APIs
- Limited use of shared memory
Process Restart

Microkernel Architecture Enables Restart of Most Processes

- Microkernel includes minimal functionality
- Non-kernel processes can be restarted
- Critical to HA, ISSU, and MDR functions
- Restarting many processes can be tricky
  - Dependent processes may also need to restart
Process Restart

Monolithic
- IOS (7200, 12k (IOS))

Kernel
- BSD based routers

Microkernel
- IOS XR

Green areas cannot restart
Protection Against DDOS

- Layered Control Plane Protection
  - Uses multiple policers
  - DOS Filter using L2 Congestion Control Mode
  - Line rate ACL filtering
  - Control Plane Session Validation using Pre-filter mechanisms
  - Adjustable performance for trusted control plane session treatment
  - Multiple Queues to CPU
Local Packet Transport Protocol (LPTS)

- Enables delivery of data to distributed processes across the system hardware (RPs, DRPs)
- Used for ‘for_us’ packet prioritization and filtering
  - Sends ‘for us’ packets only to the nodes that want them
  - Uses HW policers to throttle “for us” traffic
- Applies to data plane traffic, not IPC

Interoffice Mail for Data Plane

LC/RP CPU guard
Local Packet Transport Protocol (LPTS)

- Integral Firewall protects Router Resources
  - Packet forwarding executed in HW - no impact on LC CPU
- Dynamic Adjustment
  - Flow types reflect both application type (OSPF, BGP, ...) and trust (established, configured or unknown peer)
  - Additional bandwidth allowed once neighbor up

Interoffice Mail for Data Plane

LC/RP CPU guard
Old (CoPP) vs. New (LPTS)

- Control-Plane Policing
  - Used to rate limit all ingress and egress packets from hitting CPU
  - Only 1 CPU to protect
  - Easy to configure
  - Easy to configure wrong!
    - Typically requires lots of lab testing prior to deployment
Old (CoPP) vs. New (LPTS)

- Why not keep CoPP on IOS-XR?
  - More than 1 CPU - Requires multiple policies in multiple directions!
  - Complexity increases orders of magnitude
- Local Packet Transport System
  - Preconfigured
  - Hidden configuration
  - You can change it***

*** Changing LPTS configuration is not endorsed by Cisco and should not be attempted without the assistance of Cisco Developers, Engineers, and Priests, prior consultation of all holy networking relics and manuals, should never be tested outside of a lab and a full radiation suit.
LPTS Stats

RP/0/2/CPU0:PE1# `show lpts pifib hardware police location 0/1/cpu0`

FT - Flow type ID; PPS - Packets per second configured rate

<table>
<thead>
<tr>
<th>FT Flow type</th>
<th>Rate (PPS)</th>
<th>Accept/Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 unconfigured-default</td>
<td>99</td>
<td>0/0</td>
</tr>
<tr>
<td>1 Fragment</td>
<td>1000</td>
<td>0/0</td>
</tr>
<tr>
<td>2 OSPF-mc-known</td>
<td>1500</td>
<td>0/0</td>
</tr>
<tr>
<td>3 OSPF-mc-default</td>
<td>250</td>
<td>0/0</td>
</tr>
<tr>
<td>4 OSPF-uc-known</td>
<td>2000</td>
<td>0/0</td>
</tr>
<tr>
<td>5 OSPF-uc-default</td>
<td>250</td>
<td>0/0</td>
</tr>
<tr>
<td>6 ISIS-known</td>
<td>1500</td>
<td>0/0</td>
</tr>
<tr>
<td>7 ISIS-default</td>
<td>250</td>
<td>0/0</td>
</tr>
<tr>
<td>8 BGP-known</td>
<td>2000</td>
<td>3511/0</td>
</tr>
</tbody>
</table>
LPTS: Dynamic Control Plane Protection

• DCoPP is an automatic, built in firewall for control plane traffic.
• Every Control and Management packet from the line card is rate limited in hardware to provide flood protect at RP
LPTS: Dynamic Control Plane Protection

LC 1 IFIB TCAM HW Entries

<table>
<thead>
<tr>
<th>Local</th>
<th>Port</th>
<th>Remote</th>
<th>Port</th>
<th>Rate</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
<td>ICMP</td>
<td>any</td>
<td>any</td>
<td>1000</td>
<td>Low</td>
</tr>
<tr>
<td>Any</td>
<td>179</td>
<td>any</td>
<td>any</td>
<td>100</td>
<td>Medium</td>
</tr>
<tr>
<td>202.4.48.1</td>
<td>179</td>
<td>202.4.48.99</td>
<td>any</td>
<td>1000</td>
<td>Medium</td>
</tr>
<tr>
<td>200.200.0.2</td>
<td>13232</td>
<td>200.200.0.1</td>
<td>646</td>
<td>100</td>
<td>Medium</td>
</tr>
</tbody>
</table>

LC 2 IFIB TCAM HW Entries...

router bgp
neighbor 202.4.48.99
ttl_security
...
! mpls ldp

TCP Handshake

BGP
LDP
SSH
SDR

What is a Secure Domain Router?

• Independent/isolated physical routing instance within a common (multi-) chassis
• Each RP & LC in chassis uniquely allocated to a specific LR
• Resource sharing between LRs is limited to fabric, power, cooling
• Acts as an independent router
  • Processors not shared – CPU resources not in contention
  • Memory not shared – Memory leaks can only affect that SDR
• Hardware Failures Isolated
• Think VDC
Resource Allocation for SDR Creation

- Route Processor[s] (RPs) and Line Card[s]
- Slot level granularity
- Configure and communicate via Admin Plane
- All routing apps run in LR Plane.
  - Can not communicate with processes outside their LR.

Control Plane Separation -> Data Plane Separation -> No inter-SDR communication (apart some exceptions) -> Simple -> fault isolation
Agenda

Under the Covers/Behind the Scenes

Quickly over the hardware
Installing the Software
Making it go
Making it go...faster!
# ASR 9K Chassis Overview

<table>
<thead>
<tr>
<th></th>
<th>ASR 9001 (Ironman)</th>
<th>ASR 9006</th>
<th>ASR 9010</th>
<th>ASR 9922 (Megatron)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max Capacity</strong></td>
<td>120Gbps</td>
<td>440G/slot</td>
<td>440G/slot</td>
<td>1.2T/slot 20 I/O slot</td>
</tr>
<tr>
<td>(bi-directional)</td>
<td></td>
<td>4 I/O slots</td>
<td>8 I/O slots</td>
<td></td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>2RU</td>
<td>10RU</td>
<td>21RU</td>
<td>44RU</td>
</tr>
<tr>
<td><strong>Max Power</strong></td>
<td>750W</td>
<td>6KW</td>
<td>9KW</td>
<td>24KW</td>
</tr>
<tr>
<td><strong>Air Flow</strong></td>
<td>Side to side</td>
<td>Side to back</td>
<td>Front to back</td>
<td>Front to back</td>
</tr>
<tr>
<td><strong>FCS</strong></td>
<td>Shipping</td>
<td>Shipping</td>
<td>Shipping</td>
<td>Shipping</td>
</tr>
</tbody>
</table>
Engage Maximum Engineering Mode!
Line Card Architecture Overview

Trident Line card

- PHY
- NP0
- NP1
- NP2
- NP3

CPU

B0

B1

FIA0

4x23 G

Switch Fabric

RSP0

Switch Fabric

RSP1

A9K-4T
Line Card Architecture Overview

Trident Line card

Typhoon Line card

A9K-4T

A9K-24x10G

3x 10G

3x 10GE SFP +

Switch Fabric

RSP 3

Switch Fabric

RSP0

Switch Fabric

RSP1

CPU

FIA0

FIA1

FIA2

FIA3

NP0

NP1

NP2

NP3

NP4

NP5

NP6

NP7

3x 10G

3x 10GE SFP +

3x 10GE SFP +

3x 10GE SFP +

3x 10G

3x 10G

3x 10G

3x 10G

3x 10G

8x 55 G

4x 23 G

32
Fabric Overview

- Physically separated from LC, Resides on RSP
- Logically separated from LC and RSP
  - All fabric ASICs run in active mode regardless of RSP Redundancy status
  - Extra fabric bandwidth and instant fabric switch over
  - If the FAB has been previously initiated then even with RP in rommon FABRIC IS ACTIVE!
Fabric Arbitration and Redundancy

  - One Arbitration ASIC (Arbiter) per RSP
  - Both Arbiters work in parallel – both answer to requests to transmit
  - FIAs follow active Arbiter, and switch to backup if needed
  - Arbiter switchover controlled by low level hardware signalling
Fabric Super-framing Mechanism

- Multiple unicast frames from/to same destinations aggregated into one super frame
- Super frame is created if there are frames waiting in the queue, up to 32 frames or when min threshold met, can be aggregated into one super frame
- Super frame only apply to unicast, not multicast
- Super-framing significantly improves total fabric throughput
Multicast Optimization

- MGID - Multicast Group Identifier
  - Unique ID assigned to a multicast group
  - Used by FIA/Bridge to determine replication requirements per multicast group
- Multicast traffic is replicated on a hop-by-hop basis
- Other details outside our scope for this evening
Agenda

Under the Covers/Behind the Scenes
Quickly over the hardware
**Installing the Software**
Making it go
Making it go...faster!
Software Install Terminology

- Software does not use old Cisco IOS terminology
  - Broken down into PIEs, Packages, SMUs
- Only the mini package is required
Software Maintenance Upgrade – SMU

• Provides timely temporary point fixes for urgent issues for a given package version
• Fix integrated into the subsequent IOS XR maintenance release.
• Implementation changes only. No interface changes (no changes to CLI, APIs, IPC etc.) or new feature content
• Ideally not traffic impacting (Hitless, non traffic impacting)
• SMU is named by release and bug ID - Examples - hfr-rout-3.2.2.CSCei63263.pie
PIE: Package Installation Envelope

- PIEs are a delivery mechanism for packages
  - Used to deliver
    - Major release – New functionality (3.8, 3.9, 4.0..)
    - Maintenance release – SW fixes (3.8.1, 3.8.2....)
    - SMU – Fix for a specific bug
  - Includes authentication info
  - Installed from IOS XR admin mode
PIE Installation Concepts

- PIE install used once system is operational
- Packages can be added or upgraded
- System performs sanity checks
- 3 phase install
  - Add – Copy package and unpack
  - Activate – Restart processes/nodes with new code
  - Commit – Lock activated packages through reload
- The mini does not have the following functionality:
  - MPLS, Multicast, Security & Manageability through XML/CWI
- PIEs are installed from Admin mode
- Following actions can be performed on PIEs:
  - Add / Remove
  - Activate / De-activate
PIE Installation Process

- `admin install add tftp://172.21.116.8/c12k-mcast.pie-3.2.85.3l`
  - Copies Image to Disk, Verifies, and Unpacks
- `admin install activate disk0:c12k-mcast-3.2.85`
  - Begins Executing New Software
- `admin install commit`
  - Locks In Activated Software Across Reload
- `admin install deactivate disk0:c12k-rp-mgbl-3.2.85`
  - Deactivates package
  - Package features no longer available
  - Package still installed
  - Package can be reactivated
Agenda

Under the Covers/Behind the Scenes
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New User Modes

• IOS Modes
  • User, Exec, Config

• IOS XR Modes
  • Exec, Config, Admin

RP/0/RSP0/CPU0:b4-ebh-9010-04#admin
RP/0/RSP0/CPU0:b4-ebh-9010-04 (admin)#
RP/0/RSP0/CPU0:b4-ebh-9010-04 (admin)#conf t
RP/0/RSP0/CPU0:b4-ebh-9010-04 (admin-config)#

• Where “sensitive” configuration goes
  • AAA, usernames, fabric, environment, diagnostics, HW
# IOS-XR and IOS Config Differences

<table>
<thead>
<tr>
<th>IOS-XR</th>
<th>IOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration changes do NOT take place after &lt;CR&gt;</td>
<td>Configurations take place immediately after &lt;CR&gt;</td>
</tr>
<tr>
<td>Configuration changes must be ‘committed’ before they take effect</td>
<td>No commit</td>
</tr>
<tr>
<td>Allows you to verify your configuration before applying it</td>
<td>No verification required</td>
</tr>
<tr>
<td>Two stage configuration model</td>
<td>Not available</td>
</tr>
<tr>
<td>Configuration rollback</td>
<td>Not available</td>
</tr>
<tr>
<td>Provision to pre-configure</td>
<td>Not available</td>
</tr>
<tr>
<td>New config plane – Admin mode</td>
<td>Not available</td>
</tr>
<tr>
<td>Feature centric</td>
<td>Interface centric</td>
</tr>
</tbody>
</table>
IOS-XR and IOS Config Differences

- IOS-XR configuration is held in binary form which is quicker to parse and process
  - ‘show running-configuration’ is just an ASCII representation of the binary data extracted from all nodes in the system

- No concept of a startup config
  - If one copies the running to “startup”, a backup config with the name “startup” is created

- Running or “active” config can not be modified directly.

- Instead, user config first enters a staging area (first stage)
- Must be explicitly promoted to be part of active config (second stage).
IOS-XR CLI: New CLI Format

• New CLI reflects the HW position in the system
  • Introduces the Hierarchical location scheme
  • Each linecard has three-level identification: Shelf/Slot/CPU#
  • Interfaces have the Shelf/Slot/Bay/Interface scheme

• CRS-1 can scale 72 linecard chassis with a potential of 1296 linecard & RP slots
  • Location identifiers use R/S/M/I (R/S/M/P) format
    • R = Rack (applicable in multi-chassis systems)
    • S = Slot (physical slot the module is in)
    • M = module (0 for ‘fixed’ PLIMs, n for SPAs)
    • I = Interface (or P for Port)

• Protocol referenced by address family type – v4/v6
• Backward compatible command-set with IOS
### IOS-XR CLI: New CLI Format

```
RP/0/0/CPU0:Router-1#show ipv4 interface brief
```

<table>
<thead>
<tr>
<th>Interface</th>
<th>IP-Address</th>
<th>Status</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>MgmtEth0/0/CPU0/0</td>
<td>10.23.1.69</td>
<td>Up</td>
<td>Up</td>
</tr>
<tr>
<td>MgmtEth0/0/CPU0/1</td>
<td>unassigned</td>
<td>Shutdown</td>
<td>Down</td>
</tr>
<tr>
<td>MgmtEth0/0/CPU0/2</td>
<td>unassigned</td>
<td>Shutdown</td>
<td>Down</td>
</tr>
<tr>
<td>GigabitEthernet0/2/0/0</td>
<td>100.12.1.1</td>
<td>Up</td>
<td>Up</td>
</tr>
</tbody>
</table>
IOS XR – Curing fear of commitment

RP/0/RSP0/CPU0:9010-04#show run int TenGigE0/0/0/7
Mon Mar 31 22:45:04.711 EDT
interface TenGigE0/0/0/7
    shutdown
RP/0/RSP0/CPU0:9010-04#term mon
RP/0/RSP0/CPU0:9010-04#conf ?
    exclusive  Configure exclusively from this terminal
    terminal   Configure from the terminal
    <cr>
RP/0/RSP0/CPU0:9010-04#conf t
RP/0/RSP0/CPU0:9010-04(config)#interface TenGigE0/0/0/7
RP/0/RSP0/CPU0:9010-04(config-if)#ip address ?

% Invalid input detected at '^' marker.
RP/0/RSP0/CPU0:9010-04(config-if)#ipv4 address 1.1.1.1?
A.B.C.D/prefix
RP/0/RSP0/CPU0:9010-04(config-if)#ipv4 address 1.1.1.1/31
RP/0/RSP0/CPU0:9010-04(config-if)#show config

Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
!
end

Hint: ipv4 netmask-format bit-count
IOS XR – Curing fear of commitment

RP/0/RSP0/CPU0:9010-04(config-if)#show run int te 0/0/0/7
Mon Mar 31 22:50:09.901 EDT
interface TenGigE0/0/0/7
  shutdown
RP/0/RSP0/CPU0:9010-04(config-if)#show config
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
!
end
RP/0/RSP0/CPU0:9010-04(config-if)#no shut
RP/0/RSP0/CPU0:9010-04(config-if)#show config
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
  no shutdown
IOS XR - Curing fear of commitment

RP/0/RSP0/CPU0:9010-04(config-if)#commit ?
  best-effort   Commit the configuration changes via best-effort operation
  comment      Assign a comment to this commit
  confirmed    Rollback this commit unless there is a confirming commit
  force        Override the memory checks
  label        Assign a label to this commit
  replace      Replace the contents of running configuration
  save-running Save running configuration to a file
  <cr>         Commit the configuration changes to running

RP/0/RSP0/CPU0:9010-04(config-if)#commit
LC/0/0/CPU0:Mar 31 22:53:19.074 EDT: ifm[199]: %PKT_INFRA-LINK-3-UPDOWN : Interface
TenGigE0/0/0/7, changed state to Down
protocol on Interface TenGigE0/0/0/7, changed state to Down
RP/0/RSP0/CPU0:Mar 31 22:53:19.394 EDT: config[65898]: %MGBL-CONFIG-6-DB_COMMIT:
Configuration committed by user 'chrisw3'. Use 'show configuration commit changes
1000000143' to view the changes.
RP/0/RSP0/CPU0:9010-04(config-if)#show config
Building configuration...
!! IOS XR Configuration 4.2.1
end

RP/0/RSP0/CPU0:9010-04(config-if)#show run int te 0/0/0/7
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
RP/0/RSP0/CPU0:9010-04(config-if)#show config commit changes last 1
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
  no shutdown
IOS XR – Curing fear of commitment

RP/0/RSP0/CPU0:9010-04(config)#load commit changes last 1
Building configuration...
Loading.
113 bytes parsed in 1 sec (112)bytes/sec
RP/0/RSP0/CPU0:9010-04(config)#sho config
Mon Mar 31 22:57:44.671 EDT
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
  ipv4 address 1.1.1.1 255.255.255.254
  no shutdown
!
end

RP/0/RSP0/CPU0:9010-04(config)#abort
RP/0/RSP0/CPU0:Mar 31 22:58:44.933 EDT: config[65898]: %MGBL-SYS-5-CONFIG_I: Configured from console by chrisw3 on vty2 (9.0.1.88)
RP/0/RSP0/CPU0:9010-04#
### IOS XR – Curing fear of commitment

```
RP/0/RSP0/CPU0:9010-04#show config commit list
Tue Apr 1 23:16:26.666 EDT

<table>
<thead>
<tr>
<th>SNo</th>
<th>Label/ID</th>
<th>User</th>
<th>Line</th>
<th>Client</th>
<th>Time Stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000000147</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Tue Apr 1 14:05:46 2014</td>
</tr>
<tr>
<td>2</td>
<td>1000000146</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Tue Apr 1 13:56:48 2014</td>
</tr>
<tr>
<td>3</td>
<td>1000000145</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Tue Apr 1 13:38:33 2014</td>
</tr>
<tr>
<td>4</td>
<td>1000000144</td>
<td>chrisw3</td>
<td>vty2:node0_RSP0_CP</td>
<td>Rollback</td>
<td>Mon Mar 31 23:02:44 2014</td>
</tr>
<tr>
<td>5</td>
<td>1000000143</td>
<td>chrisw3</td>
<td>vty2:node0_RSP0_CP</td>
<td>CLI</td>
<td>Mon Mar 31 22:53:19 2014</td>
</tr>
<tr>
<td>6</td>
<td>1000000142</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Mon Mar 31 22:01:48 2014</td>
</tr>
<tr>
<td>7</td>
<td>1000000141</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Mon Mar 31 21:46:34 2014</td>
</tr>
<tr>
<td>8</td>
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<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Mon Mar 31 21:45:45 2014</td>
</tr>
<tr>
<td>9</td>
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<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Thu Mar 27 11:56:39 2014</td>
</tr>
<tr>
<td>10</td>
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<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Thu Mar 27 11:54:38 2014</td>
</tr>
<tr>
<td>11</td>
<td>1000000137</td>
<td>cisco</td>
<td>vty0:node0_RSP0_CP</td>
<td>CLI</td>
<td>Wed Mar 26 22:36:52 2014</td>
</tr>
</tbody>
</table>
```

<snip>
IOS XR – Curing fear of commitment

RP/0/RSP0/CPU0:9010-04#show configuration rollback changes last 1
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
   no ipv4 address 1.1.1.1 255.255.255.254
   shutdown
RP/0/RSP0/CPU0:9010-04#rollback configuration last 1
Loading Rollback Changes.
Loaded Rollback Changes in 1 sec
Committing.LC/0/0/CPU0:Mar 31 23:02:44.219 EDT: ifmgr[199]: %PKT_INFRA-LINK-5-CHANGED : Interface TenGigE0/0/0/7, changed state to Administratively Down

2 items committed in 1 sec (1)items/sec
Updating.RP/0/RSP0/CPU0:Mar 31 23:02:45.348 EDT: config_rollback[65601]: %MGBL-CONFIG-6-DB_COMMIT : Configuration committed by user 'chrisw3'. Use 'show configuration commit changes 1000000144' to view the changes.

Updated Commit database in 1 sec
Configuration successfully rolled back 1 commits.
IOS-XR CLI: Two Stage Config Model

User establishes config session

- Adds/deletes/modifies configuration; these changes:
  - Are entered in the staging area
  - Are validated for syntax & authorized
  - Can be reviewed and modified

Promotes the changes to active configuration; these changes:
- Are verified for semantic correctness
- Are check-pointed on the router
IOS XR – Failure to Commit

RP/0/RSP0/CPU0:9010-04#conf t
RP/0/RSP0/CPU0:9010-04(config)#interface te 0/0/0/7 l2transport
RP/0/RSP0/CPU0:9010-04(config-if-12)#exit
RP/0/RSP0/CPU0:9010-04(config-if)#ipv4 address 1.1.1.1/31
RP/0/RSP0/CPU0:9010-04(config-if)#show config
Building configuration...
!! IOS XR Configuration 4.2.1
interface TenGigE0/0/0/7
ipv4 address 1.1.1.1 255.255.255.254
l2transport
!
!
end
RP/0/RSP0/CPU0:9010-04(config-if)#commit
% Failed to commit one or more configuration items during a pseudo-atomic operation. All changes made have been reverted. Please issue 'show configuration failed' from this session to view the errors
IOS XR – Failure to Commit

RP/0/RSP0/CPU0:b4-ebh-9010-04(config-if)#show config fail
Mon Mar 31 23:14:09.478 EDT
!! SEMANTIC ERRORS: This configuration was rejected by
!! the system due to semantic errors. The individual
!! errors with each failed configuration command can be
!! found below.

interface TenGigE0/0/0/7
  l2transport
!!% Subsystem(2599), Code(11): errno 0x45139600: Cannot configure an interface as L2 when
L3 configuration exists
Agenda

Under the Covers/Behind the Scenes
Quickly over the hardware
Installing the Software
Making it go
Making it go...faster!
Think Hierarchically
OSPF Configuration and CLI Comparison

**IOS**

```
router ospf 99
  router-id 1.1.1.1
  log-adjacency-changes
  network 201.0.0.0 0.0.0.255 area 0
!
Interface Gigabitethernet2/0/0
  ip address 201.1.1.2 255.255.255.0
  ip ospf cost 20
```

**IOS XR**

```
router ospf 99
  router-id 1.1.1.1
  area 0
    interface GigabitEthernet0/2/0/0
      cost 20
    !
    interface FastEthernet0/6/2/0
      cost 20
```
router ospf 1
router-id 192.168.11.2
bdf minimum-interval 100
bdf fast-detect
bdf multiplier 3
authentication message-digest
message-digest-key 1 md5 encrypted 104D000A0618
network point-to-point
passive enable
area 0.0.0.0
  interface Bundle-Ether4000.4001
    passive disable
!
area 10.4.124.0
authentication null
interface GigabitEthernet0/6/0/0.1260
  passive disable
  mtu-ignore enable
!
interface Multilink0/4/0/0/222641
  passive disable
  mtu-ignore enable

Items at the top apply to all configurations below
OSPF Configuration and CLI Comparison

```
router ospf 1
  router-id 192.168.11.2
  bfd minimum-interval 100
  bfd fast-detect
  bfd multiplier 3
  authentication message-digest
  message-digest-key 1 md5 encrypted 104D000A0618
  network point-to-point
  passive enable
  area 0.0.0.0
    interface Bundle-Ether4000.4001
      passive disable
  !
  area 10.4.124.0
  authentication null
  interface GigabitEthernet0/6/0/0.1260
    passive disable
    mtu-ignore enable
  !
  interface Multilink0/4/0/0/222641
    passive disable
    mtu-ignore enable
```

Individual interfaces inherit all above properties, except when defined.
OSPF Configuration and CLI Comparison

```
routing ospf 1
  router-id 192.168.11.2
  bfd minimum-interval 100
  bfd fast-detect
  bfd multiplier 3
  authentication message-digest message-digest-key 1 md5 encrypted 104D000A0618
  network point-to-point passive enable
  area 0.0.0.0
    interface Bundle-Ether4000.4001 passive disable
  
  area 10.4.124.0 authentication null
    interface GigabitEthernet0/6/0/0.1260 passive disable mtu-ignore enable
  
  interface Multilink0/4/0/0/222641 passive disable mtu-ignore enable
```
router ospf 1
  router-id 192.168.11.2
  bfd minimum-interval 100
  bfd fast-detect
  bfd multiplier 3
  authentication message-digest
  message-digest-key 1 md5 encrypted 104D000A0618
  network point-to-point
  passive enable
  area 0.0.0.0
    interface Bundle-Ether4000.4001
      passive disable

area 10.4.124.0
  authentication null
  interface GigabitEthernet0/6/0/0.1260
    passive disable
    mtu-ignore enable
  !
  interface Multilink0/4/0/0/222641
    passive disable
    mtu-ignore enable

Configurations can be nested within subsections
OSPF Configuration and CLI Comparison

router ospf 1
router-id 192.168.11.2
bfd minimum-interval 100
bfd fast-detect
bfd multiplier 3
authentication message-digest
message-digest-key 1 md5 encrypted 104D000A0618
network point-to-point
passive enable
area 0.0.0.0
  interface Bundle-Ether4000.4001
    passive disable
!
area 10.4.124.0
  authentication null
  interface GigabitEthernet0/6/0/0.1260
    passive disable
    mtu-ignore enable
!
interface Multilink0/4/0/0/222641
  passive disable
  mtu-ignore enable

17 lines of IOS XR
Would require over 30 lines in IOS
BGP Configuration and CLI Comparison

**IOS**

```
router bgp 300
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 400
  neighbor 1.1.1.1 update-source Loopback0
!
  address-family ipv4
  neighbor 1.1.1.1 activate
  no auto-summary
  no synchronization
```
BGP: Show Commands

RP/0/1/CPU0:Router-5# sh bgp ipv4 unicast summary
BGP router identifier 2.2.2.2, local AS number 300
BGP generic scan interval 60 secs
BGP table state: Active
BGP main routing table version 101
BGP scan interval 60 secs
BGP is operating in STANDALONE mode.

<table>
<thead>
<tr>
<th>Process</th>
<th>RecvTblVer</th>
<th>bRIB/RIB</th>
<th>LabelVer</th>
<th>ImportVer</th>
<th>SendTblVer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker</td>
<td>101</td>
<td>101</td>
<td>101</td>
<td>101</td>
<td>101</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neighbor</th>
<th>Spk</th>
<th>AS</th>
<th>MsgRcvd</th>
<th>MsgSent</th>
<th>TblVer</th>
<th>InQ</th>
<th>OutQ</th>
<th>Up/Down</th>
<th>St/PfxRcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.1.1.2</td>
<td>0</td>
<td>400</td>
<td>2451</td>
<td>2453</td>
<td>101</td>
<td>0</td>
<td>0</td>
<td>00:24:33</td>
<td>100</td>
</tr>
</tbody>
</table>
BGP Timers

RP/0/2/CPU0:PE1#show bgp neighbor 20.20.1.2
BGP neighbor is 20.20.1.2
Remote AS 10, local AS 65518, external link
Remote router ID 28.28.28.1
  BGP state = Established, up for 00:00:20
  Last read 00:00:20, hold time is 180, keepalive interval is 60 seconds
  <snip>
  Sent 3 messages, 0 notifications, 0 in queue
  Minimum time between advertisement runs is 30 seconds
  Minimum time between advertisement runs is 0 seconds
For Address Family: IPv4 Unicast
  BGP neighbor version 1
  Update group: 0.2
  eBGP neighbor with no inbound or outbound policy; defaults to 'drop'

IOS Default
iBGP Adv: 5,1,0
eBGP Adv: 30 Sec

IOS-XR eBGP Adv.: 30Sec
IOS-XR iBGP Adv.: 0 Sec
Hmmm- No BGP Routes!!

```
RP/0/2/CPU0:PE1#show bgp summary

BGP router identifier 10.0.0.1, local AS number 65518

<snip>

<table>
<thead>
<tr>
<th>Neighbor</th>
<th>Spk</th>
<th>AS</th>
<th>MsgRcvd</th>
<th>MsgSent</th>
<th>TblVer</th>
<th>InQ</th>
<th>OutQ</th>
<th>Up/Down</th>
<th>St/PfxRcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0.0.10</td>
<td>0</td>
<td>65518</td>
<td>1397</td>
<td>1376</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>22:46:55</td>
<td>0</td>
</tr>
<tr>
<td>10.0.0.11</td>
<td>0</td>
<td>65518</td>
<td>1397</td>
<td>1376</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>22:46:54</td>
<td>0</td>
</tr>
<tr>
<td>20.20.1.2</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>00:00:11</td>
<td>0</td>
</tr>
</tbody>
</table>
```
Hmmm- No BGP Routes!!

RP/0/2/CPU0:PE1#

RP/0/2/CPU0:Jul  5 17:28:13.829 : bgp[123]: %ROUTING-BGP-5-ADJCHANGE : neighbor 20.20.1.2 Up

RP/0/2/CPU0:Jul  5 17:28:13.829 : bgp[123]: %ROUTING-BGP-4-NBR_NOPOLICY : No inbound IPv4 Unicast policy is configured for eBGP neighbor 20.20.1.2. **No IPv4 Unicast prefixes will be accepted from the neighbor until inbound policy is configured.**

RP/0/2/CPU0:Jul  5 17:28:13.829 : bgp[123]: %ROUTING-BGP-4-NBR_NOPOLICY : No outbound IPv4 Unicast policy is configured for eBGP neighbor 20.20.1.2. **No IPv4 Unicast prefixes will be sent to the neighbor until outbound policy is configured.**
RPL- Route Policy Language
RPL Motivation and Basic Building Blocks

• Scaling
  • Using route-maps could lead to 100k – 1M lines of configuration (e.g. 1000s of BGP peers).

• Modularity
  • Exploit modularity to reuse common portions of configuration.

• Parameterization
  • For elements which are not exact copies of each other we can add parameterization (think variables) to get further re-use.

• Improved Clarity
  • No Silently skipped statements.
RPL Motivation and Basic Building Blocks

Route Policy Language

Route Policies

Policy Sets

AS Path Sets

Community Sets

Ext. Comm. Sets

Prefix Sets
RPL Syntax: General Structure

- RPL is used in 2 steps:
  - Define the policy in configuration mode:
    ```plaintext
    route-policy <Policy Name>
    statement A
    statement B
    End-policy
    ```
  - Use the policy in BGP body:
    ```plaintext
    router bgp 99
    neighbor 2.2.2.2 remote-as 1
    address-family ipv4 unicast
    route-policy <policy Name> in/out
    ```
RPL – Conditional Statements – if and if- then-else

- An “if” statement uses a conditional expression to decide which actions or dispositions should be taken for the given route.

```plaintext
If as-path in as-path-set-1 then
  drop
endif
```
RPL - Conditional Statements – if and if- then-else

• The “if” statement also permits an “else” clause, which is executed if the expression is false.

```plaintext
if med eq 150 then
    set local-preference 10
elseif med eq 200 then
    set local-preference 60
else
    set local-preference 0
endif
```

• The statements within an if statement may themselves be if statements

```plaintext
if community matches-every(12:34,56:78) then
    if med eq 8 then
        drop
        endif
    set local-preference 100
endif
```
RPL: Boolean Expressions

• Boolean expressions evaluate as either true or false.
• Compound conditions by means of boolean operators: negation (not), conjunction (and), disjunction (or).

if med eq 42 and next-hop in (1.1.1.1) then
if med eq 10 and not destination in (10.1.3.0/24) or community is (56:78)
if med eq 10 and (not destination in (10.1.3.0/24)) or community is (56:78)
RPL: Hierarchical Policy

route-policy Inner
  set weight 100
end-policy
!
route-policy Outer
  apply Inner
    set community (2:666) additive
end-policy
Non-Stop Routing (NSR)
What about BGP Graceful Restart—GR?

• Requires software support/upgrade on all routers
• Requires the operators to manually tune various timers—if not correctly determined, GR may not come into effect
• Adds load on the peering routers which could cause instability
• NSF procedures add CPU load on neighbors/protocol peers
• Scalability is limited—extensive post switchover protocol activity (NSF/GR procedures)
• Not all vendors have implemented GR
Overview of Non-Stop Routing (NSR) Operation

- Process routes from peers and update DB independently
- Active mirrors best-path info before advertising to peers
- Active sends updates to peers
- Active synchronizes the send state information after mapping from the TCP and ACKs
Overview of Non-Stop Routing (NSR) Operation

1. Process routes from peers and update DB

- **ACTIVE RP**
  - route DB
  - BGP
  - RIB
  - LSD
  - TCP

- **STANDBY RP**
  - route DB
  - BGP
  - RIB
  - LSD
  - TCP
Overview of Non-Stop Routing (NSR) Operation

2. Active mirrors best-path info before advertising to peers
Overview of Non-Stop Routing (NSR) Operation

3. Active sends updates to peers
Overview of Non-Stop Routing (NSR) Operation

4. Active synchronizes the send state information after mapping from the TCP and ACKs
Overview of Non-Stop Routing (NSR) Operation

- Unlike Graceful Restart (GR)
  - NSR is a self-contained solution
  - Maintains the routing topology across HA events

- TCP Connection/Protocol Session Migration
  - Migrates from active RP to standby RP
  - Protocol Peers unaware of the switchover

- Does not depend on any protocol extensions
  - Relies on forwarding-plane’s NSF capability
Overview of Non-Stop Routing (NSR) Operation

- Restart Hidden from Neighbors/Protocol Peers.Rest of Network
  - Unaware that an OSPF/LDP/BGP process went through a restart
  - Minimal LSA/Route information re-flooded during NSR recovery
  - Overall CPU usage greatly reduced during NSR recovery
  - Improves reliability of the overall system
NSR Configuration and Verification

RP/0/0/CPU0:R2#show running-config router bgp
router bgp 1
    nsr
    bgp router-id 3.3.3.3
NSR Configuration and Verification

RP/0/0/CPU0:R2#show bgp summary
BGP router identifier 3.3.3.3, local AS number 1
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0xe0000000
BGP main routing table version 561
BGP scan interval 60 secs
BGP is operating in STANDALONE mode.

<table>
<thead>
<tr>
<th>Process</th>
<th>RecvTbl</th>
<th>VerbRIB/RIB</th>
<th>LabelVer</th>
<th>ImportVer</th>
<th>SendTbl</th>
<th>Ver</th>
<th>StandbyVer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker</td>
<td>561</td>
<td>561</td>
<td>561</td>
<td>561</td>
<td>561</td>
<td>561</td>
<td>561</td>
</tr>
</tbody>
</table>
IOS XR Multicast Forwarding Architecture
Multicast Routing Information Base (MRIB)

- A centralized database of mroutes and attributes
- A communication medium between protocols and forwarding, e.g.,
  - IGMP and PIM
  - MSDP and PIM
  - PIM and MFIB (Multicast forwarding Information Base)
- Does not contain internal protocol state, e.g., PIM timers
Cisco IOS vs IOS XR Multicast

IOS

ip multicast-routing distributed
ip pim rp-address A.B.C.D

Int pos2/0/0
  ip igmp version 3
  ip pim sparse-mode
Pos5/1/0
Cisco IOS vs IOS XR Multicast

IOS XR

multicast-routing address-family ipv4

   interface POS0/2/0/0
       enable
   !

router igmp

   interface POS0/2/0/0
       version 3
   !

router pim address-family ipv4

   rp-address A.B.C.D
   interface POS0/2/0/0
Process Management

• Basic command
  • show process

• Process restart-ability
  • process restart <process name | number> <option>

• Monitor commands:
  • monitor processes
  • monitor threads (or top)

• Troubleshooting commands:
  • show exception, exception
  • dumpcore
  • show context, clear context
  • process core
    • follow process
Show Process Command

```
RP/0/RP1/CPU0:equinox# show process snmpd
  Job Id: 288
  PID: 143532
  Executable path: /disk0/hfr-base-3.2.85/bin/snmpd
  Instance #: 1
  Version ID: 00.00.0000
  Respawn: ON
  Respawn count: 1
  Max. spawns per minute: 12
  Last started: Mon May 9 15:32:22 2005
  Process state: Run
  Package state: Normal
  Started on config: cfg/gl/snmp/admin/community/ww
    core: TEXT SHAREDMEM MAINMEM
    Max. core: 0
  startup_path: /pkg/startup/snmpd.startup
  Ready: 11.636s
  Process cpu time: 45.821 user, 5.058 kernel, 50.879 total

JID TID Stack pri state     HR:MM:SS:MSEC NAME
288 1  96K 10 Condvar  0:00:29:0500 snmpd
288 2  96K 10 Receive  0:00:00:0049 snmpd
```

Example of a process in normal ‘run’ state

SNMP Process contains 8 threads (not shown) which operate under a single JID
Monitor Process

**233 processes; 788 threads; 4663 channels, 5906 fds**

**CPU states:** 94.8% idle, 4.1% user, 1.0% kernel

**Memory:** 4096M total, 3599M avail, page size 4K

<table>
<thead>
<tr>
<th>JID</th>
<th>TIDS</th>
<th>Chans</th>
<th>FDs</th>
<th>Tmrs</th>
<th>MEM</th>
<th>HH:MM:SS</th>
<th>CPU</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>236</td>
<td>183</td>
<td>1</td>
<td>0</td>
<td>67:18:56</td>
<td>1.06%</td>
<td>procnto-600-smp-cisco...</td>
</tr>
<tr>
<td>256</td>
<td>5</td>
<td>39</td>
<td>21</td>
<td>4</td>
<td>292K</td>
<td>0:02:44</td>
<td>0.79%</td>
<td>packet</td>
</tr>
<tr>
<td>69</td>
<td>10</td>
<td>454</td>
<td>9</td>
<td>3</td>
<td>2M</td>
<td>0:33:07</td>
<td>0.62%</td>
<td>qnet</td>
</tr>
<tr>
<td>331</td>
<td>8</td>
<td>254</td>
<td>21</td>
<td>13</td>
<td>2M</td>
<td>0:15:20</td>
<td>0.52%</td>
<td>wdsysmon</td>
</tr>
<tr>
<td>55</td>
<td>11</td>
<td>23</td>
<td>15</td>
<td>6</td>
<td>36M</td>
<td>0:31:18</td>
<td>0.50%</td>
<td>eth_server</td>
</tr>
<tr>
<td>241</td>
<td>12</td>
<td>96</td>
<td>83</td>
<td>13</td>
<td>1M</td>
<td>0:04:54</td>
<td>0.37%</td>
<td>netio</td>
</tr>
<tr>
<td>171</td>
<td>15</td>
<td>97</td>
<td>44</td>
<td>9</td>
<td>2M</td>
<td>0:03:33</td>
<td>0.12%</td>
<td>gsp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>JID</th>
<th>TIDS</th>
<th>Chans</th>
<th>FDs</th>
<th>Tmrs</th>
<th>MEM</th>
<th>HH:MM:SS</th>
<th>CPU</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>11</td>
<td>23</td>
<td>15</td>
<td>6</td>
<td>36M</td>
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<td>0.00%</td>
<td>eth_server</td>
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<tr>
<td>155</td>
<td>1</td>
<td>7</td>
<td>18</td>
<td>4</td>
<td>12M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>fgid_server</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>11</td>
<td>16</td>
<td>3</td>
<td>11M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>fgid_aggregator</td>
</tr>
<tr>
<td>257</td>
<td>8</td>
<td>16</td>
<td>36</td>
<td>3</td>
<td>8M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>parser_server</td>
</tr>
<tr>
<td>65554</td>
<td>7</td>
<td>16</td>
<td>3</td>
<td>3</td>
<td>7M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>devb-ata</td>
</tr>
<tr>
<td>53</td>
<td>5</td>
<td>237</td>
<td>633</td>
<td>0</td>
<td>4M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>dllmgr</td>
</tr>
<tr>
<td>121</td>
<td>11</td>
<td>18</td>
<td>67</td>
<td>19</td>
<td>3M</td>
<td>0:00:00</td>
<td>0.00%</td>
<td>bgp</td>
</tr>
</tbody>
</table>
Monitor Process Command

- Command provide Unix ‘top’ like information
- Automatically updates every 10 seconds
- Can specify the location of the node that you wish to monitor, for example 0/RP0/CPU0 or 0/2/CPU0
  - `-t` sort on CPU time
  - `-m` sort on memory usage
- Similar usage for **monitor threads**
Trace Functionality

- Many major functions have ‘trace’ functionality to show the last actions it conducted
  - “always-on debug”
- Very useful if you can devote the time to understanding them
Trace Functionality

RP/0/RP1/CPU0:CRS1_1# sh cef trace tailf
4 unique entries (128 possible, 0 filtered) May 19 23:37:04.172
ipv4_fib/ipv4_fib_mgr_unique 0/RP1/CPU0 1# IP-CEF platform creates hash set to TRUE.
May 20 07:04:41.574 ipv4_fib/ipv4_fib_mgr_unique 0/RP1/CPU0 5# IP-CEF-Error: Doesn't own external adjacency for 1.1.1.100/32 path 0
May 20 07:04:41.574 ipv4_fib/ipv4_fib_mgr_unique 0/RP1/CPU0 5# IP-CEF-Error: Doesn't own external adjacency for 10.1.2.0/24 path 0
May 20 07:04:41.574 ipv4_fib/ipv4_fib_mgr_unique 0/RP1/CPU0 5# IP-CEF-Error: Doesn't own external adjacency for 10.1.3.0/24 path 0
102 wrapping entries (10240 possible, 0 filtered, 102 total)
May 19 23:37:04.174 ipv4_fib/ipv4_fib_mgr_low 0/RP1/CPU0 t1 IP-CEF-Event: Spawning CEF periodic thread
May 19 23:37:04.174 ipv4_fib/ipv4_fib_mgr_low 0/RP1/CPU0 t1 IP-CEF-Event: Spawning CEF main thread
May 19 23:37:04.199 ipv4_fib/ipv4_fib_mgr_low 0/RP1/CPU0 t3 IP-CEF-EA: Connected to IMP
May 19 23:37:04.207 ipv4_fib/ipv4_fib_mgr_hi 0/RP1/CPU0 t1 IP-CEF-Event: Connected to netio
May 19 23:37:04.218 ipv4_fib/ipv4_fib_mgr_errors 0/RP1/CPU0 t1 IP-FIB:fib_pfi_if_connect pfi_ifh_bind failed : 0x434e8c00, 'pfi-ifh' detected the 'warning' condition 'Failed to contact the IFH server'

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Monitor interface Command

```
RP/0/RP1/CPU0:CRS1_1# monitor interface all

CRS1_1  Monitor Time: 00:00:55  SysUptime: 16:35:50

<table>
<thead>
<tr>
<th>Interface</th>
<th>Encap</th>
<th>Input</th>
<th>Output</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pps</td>
<td>pps</td>
<td>Kbps</td>
<td>Kbps</td>
</tr>
<tr>
<td>MgmtEth0/RP0/CPU0/0</td>
<td>ARPA</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>MgmtEth0/RP1/CPU0/0</td>
<td>ARPA</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>POS0/4/0/0</td>
<td>HDLC</td>
<td>1230</td>
<td>0</td>
<td>542210</td>
<td>0</td>
</tr>
<tr>
<td>POS0/4/0/3</td>
<td>HDLC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>POS0/4/0/6</td>
<td>PPP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>POS0/4/0/7</td>
<td>HDLC</td>
<td>0</td>
<td>1230</td>
<td>0</td>
<td>542210</td>
</tr>
</tbody>
</table>
```

Quit='q', Freeze='f', Thaw='t', Clear='c', Next set='n', Prev set='p'
Online Manuals: man

- Integrated commands reference with various search options:

RP/0/RP1/CPU0:ios#**man keyword mpls**

Following Commands Matched for 'mpls'

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>COMMAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>is-is</td>
<td>mpls traffic-eng</td>
</tr>
<tr>
<td>is-is</td>
<td>mpls traffic-eng router-id (is-is)</td>
</tr>
<tr>
<td>is-is</td>
<td>show isis mpls traffic-eng adjacency-log</td>
</tr>
<tr>
<td>is-is</td>
<td>show isis mpls traffic-eng advertisements</td>
</tr>
<tr>
<td>is-is</td>
<td>show isis mpls traffic-eng tunnel</td>
</tr>
<tr>
<td>ospf</td>
<td>mpls traffic-eng area (ospf)</td>
</tr>
<tr>
<td>ospf</td>
<td>mpls traffic-eng router-id (ospf)</td>
</tr>
<tr>
<td>ospf</td>
<td>show ospf mpls traffic-eng</td>
</tr>
<tr>
<td>quality-of-service</td>
<td>match mpls experimental topmost</td>
</tr>
<tr>
<td>quality-of-service</td>
<td>set mpls experimental topmost</td>
</tr>
</tbody>
</table>

RP/0/RP1/CPU0:ios#**man command show cef ipv4**

COMMAND

`show cef ipv4`

DESCRIPTION

To display the IPv4 Cisco Express Forwarding (CEF) table, use the show cef ipv4 command in EXEC mode.

`show cef ipv4 [prefix [mask] | type instance] [detail] [location node-id]`
Expanded Pipe Capabilities

RP/0/RSP0/CPU0:b4-ebh-9010-04#show run | ?
  begin   Begin with the line that matches
  exclude Exclude lines that match
  file     Save the configuration
  include  Include lines that match
  utility  A set of common unix utilities
  <cr>     Shows current operating configuration

RP/0/RSP0/CPU0:b4-ebh-9010-04#show run | include ospf | ?
  begin   Begin with the line that matches
  exclude Exclude lines that match
  file     Save the configuration
  include  Include lines that match
  utility  A set of common unix utilities
  <cr>     Shows current operating configuration
Regex Capabilities

- Must use " "
- To interpret literal characters, use \\n
RP/0/RSP0/CPU0:b4-ebh-9010-04#show ipv4 interface brief | exclude "un|Mu|./\.|/..\.”
Util-lay-hee-hoo

RP/0/RSP0/CPU0:b4-ebh-9010-04#show run | utility ?
cut Cut out selected fields of each line of a file
egrep Extended regular expression grep
fgrep Fixed string expression grep
head Show set of lines/characters from the top of a file
less Fixed string pattern matching
more Paging Utility More
script Launch a script for post processing
sort Sort, merge, or sequence-check text files
tail Copy the last part of files
uniq Report or filter out repeated lines in a file
wc Counting lines/words/characters of a file
xargs Construct argument list(s) and invoke a program
Special Thanks to...

- DFW Cisco Users Group
- Xander Thuijs
  - Principle Engineer, ASR9000
- Mukhtiar Shaikh
- Beau Williamson
  - Proof Reader
Acronyms

- SDR – Secure Domain Router
- RPL – Route Policy Language
- SMU – Software Maintenance Unit
- LPTS – Local Packet Transport Protocol
- IMDB – In Memory Data Base
- DRP – Distributed Route Processor
- AIB – Adjacency Information Base
- IDB – Interface Data Base
- ISSU – In Service Software Upgrade
- IFIB – Internal Forwarding Information Base
- pIFIB – Pre-IFIB
- PIE – Package Installation Envelope
- IPFRR – IP Fast Reroute
- LFA – Loop Free Alternate
- NSR – Non-Stop Forwarding
- BCDL – Bulk Content Downloader
- dSDRSC – Designated SDR Shelf Controller
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