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**Welcome
To
Network for you
MAC and CEF**



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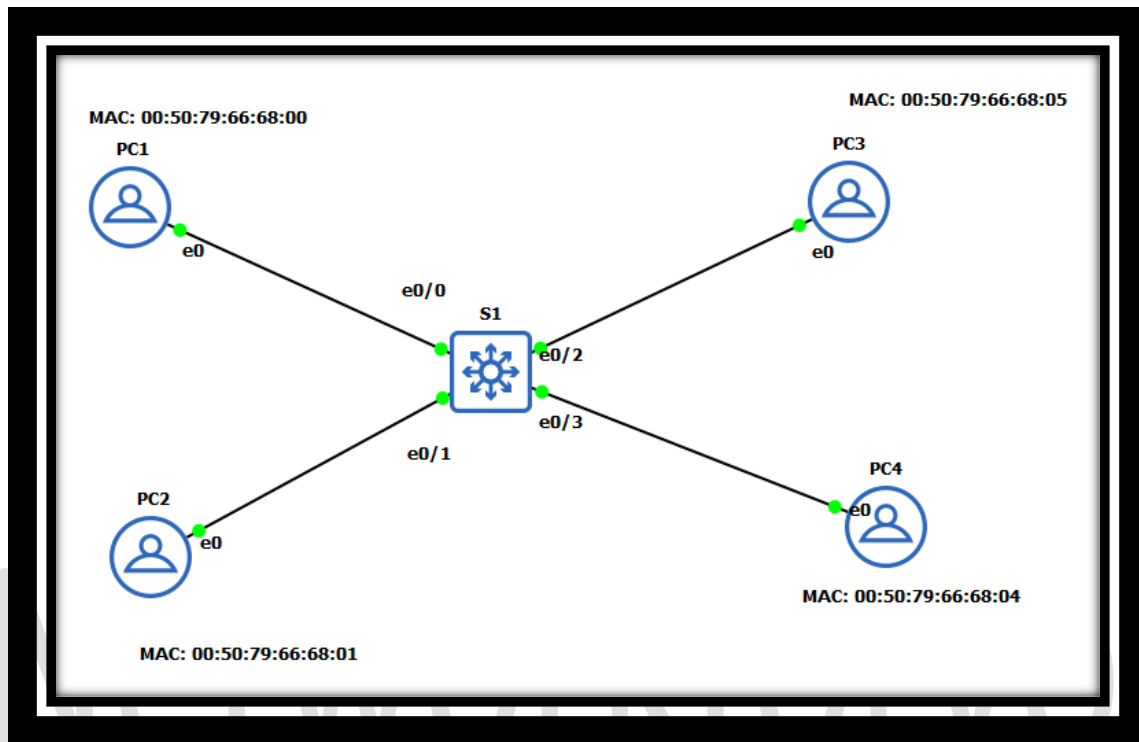
MAC Address Table:

- MAC stands for Media Access Control.
- Each network card has a unique identifier called **Media Access Control Address**.
- This address is used in LANs for Communication between devices on same network.
- Devices that want to communicate need to know each **other MAC address**.
- **Use process called ARP to find out the MAC address of another device in LAN.**
- Switches work base on **MAC address or Hardware address or Physical address**
- MAC (Media Access Control address used for layer 2 Datalink layer communication.
- It is 48 Bits Address called MAC address
- MAC has two parts, OUI (Organization Unique Identifier) and Serial Number.
- MAC address is total **48 Bits, 24 Bits for OUI and 24 Bits for Company Serial Number.**
- MAC address also called **Hardware, Physical, Fixed and Burn address**
- Switch manages and use MAC address table to forward traffic from one interface to another.
- MAC address table is combination of VLAN ID, MAC address, Address Type and Port number.
- MAC address table is of two type Dynamic address and Static address table.
- Dynamic MAC address table is a table where Switch learns dynamically.
- Dynamic MAC address is that the switch learns and After it age time flash out if they are not communicating.
- Static MAC address is the address that manually we can assign. And for Static MAC address there is no age time and it will not remove when we restart our device.
- If switch received frame and destination MAC address is not there then it flooded to all ports.
- When the destination replies then switch adds that source MAC address to the table.
- CISCO Switches default aging time is **300 seconds or five mints**, we can be modifying.
- Aging timer is used to remove inactive Media Access Control addresses from the table
- Aging time help to remove inactive MAC address from the MAC table.
- **Content Addressable Memory (CAM) table is a system memory construct used by Ethernet switch logic which stores information such as MAC addresses available on physical ports with their associated VLAN Parameters.**
- **The CAM table, or content addressable memory table, is present in all switches for layer 2 switching.**
- **TCAM (ternary content-addressable memory) is a specialized type of high-speed memory that searches its entire contents in a single clock cycle.**



Commands for MAC address Table:

Command	Description
Mac address-table aging-time seconds	To Check Mac address table aging time.
Mac address-table static mac-address vlan vlan-id interface	To configure static Mac address on stitch.
No mac address-table static mac-address vlan vlan-id interface	To remove static Mac address from switch.
Sh mac address-table address	To check information about a specific mac address.
Sh mac address-table aging-time	To check time out values for the Mac address table.
Sh mac address-table count	To check the number of entries currently in the MAC address table
Sh mac address-table dynamic	To check dynamic MAC address table entries only.
Sh mac address-table interface (like e0/0)	To check Specifies Interface
Sh mac address-table Multicast	To check the multicast MAC address table entries only
Sh mac address-table static	To check the static MAC address table entries only
Sh mac address-table vlan #	To check the Vlan in mac table



Lab Example for this:

Let take some PC's and switch

Device Configuration PCs and Switch

```
PC1> ip 192.168.1.1/24
PC1> save

PC1> sh ip
NAME      : PC1[1]
IP/MASK   : 192.168.1.1/24
GATEWAY   : 0.0.0.0
DNS       :
MAC       : 00:50:79:66:68:00
LPORT     : 10010
```

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RHOST:PORT : 127.0.0.1:10011

MTU: : 1500

PC2> ip 192.168.1.2/24

PC2> sh ip

NAME : PC2[1]

IP/MASK : 192.168.1.2/24

GATEWAY : 0.0.0.0

DNS :

MAC : 00:50:79:66:68:01

LPORT : 10004

RHOST:PORT : 127.0.0.1:10005

MTU: : 1500

PC3> ip 192.168.1.3/24

PC3> sh ip

NAME : PC3[1]

IP/MASK : 192.168.1.3/24

GATEWAY : 0.0.0.0

DNS :

MAC : 00:50:79:66:68:05

LPORT : 10008

RHOST:PORT : 127.0.0.1:10009

MTU: : 1500

PC4> ip 192.168.1.4/24

PC4> sh ip

NAME : PC4[1]

IP/MASK : 192.168.1.4/24

GATEWAY : 0.0.0.0

DNS :

MAC : 00:50:79:66:68:04

LPORT : 10006

RHOST:PORT : 127.0.0.1:10007

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MTU: : 1500

S1#sh mac address-table dynamic
Mac Address Table

Vlan	Mac Address	Type	Ports
1	0050.7966.6800	DYNAMIC	Et0/0
1	0050.7966.6801	DYNAMIC	Et0/1
1	0050.7966.6804	DYNAMIC	Et0/3
1	0050.7966.6805	DYNAMIC	Et0/2

Total Mac Addresses for this criterion: 4

S1(config)#mac address-table static aaaa.aaaa.1111 vlan 1 interface e1/0

S1#sh mac address-table static
Mac Address Table

Vlan	Mac Address	Type	Ports
1	aaaa.aaaa.1111	STATIC	Et1/0

Total Mac Addresses for this criterion: 1

Process Switching:

- Process switching also called as **software switching or slow path**.
- Process switching is primary function of forwarding the packets to the destination.
- In process switching processor is inspecting every single packet to process before send to destination.
- **Process switching requires CPU to be personally involved with every forwarding decision.**
- The input process runs on general purpose CPU for processing incoming IP packets
- All packets examined by CPU and all forwarding decisions are made in software are very slow.
- Compare to Hardware switching, Software switching is slow.

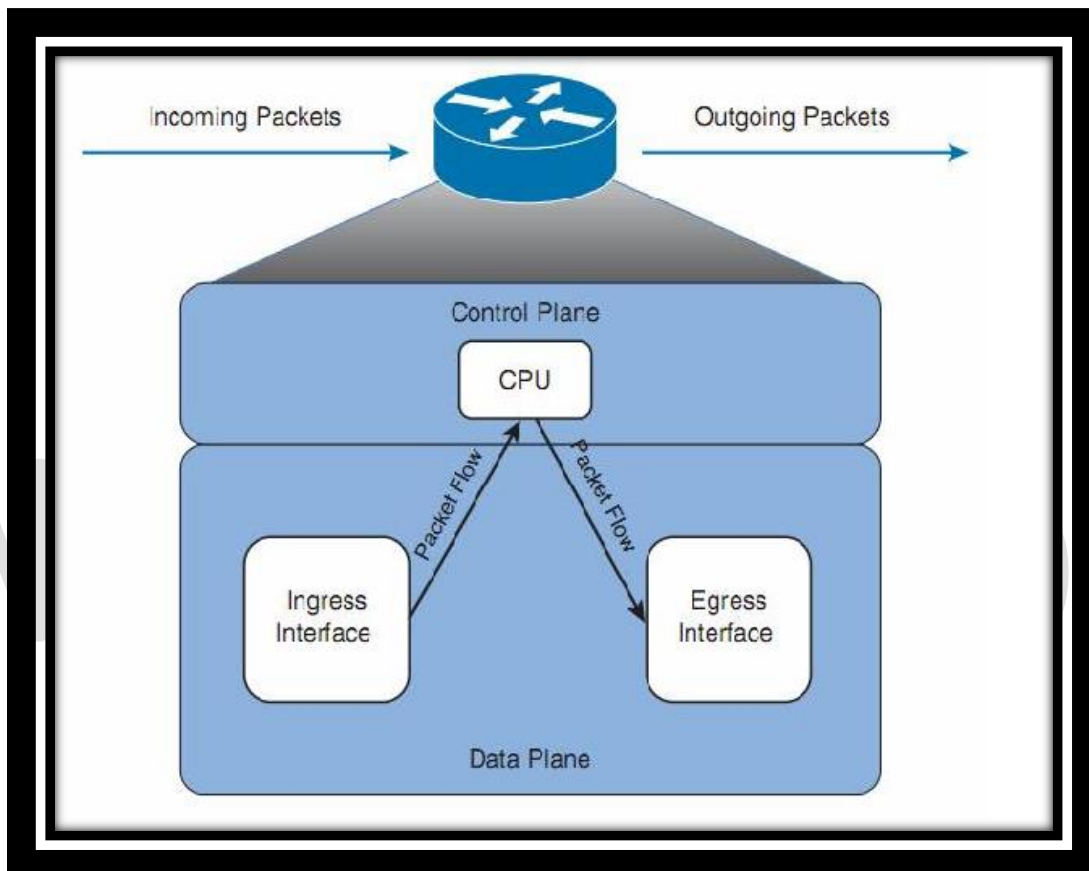
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- Like Router looks on destination IP address, compare it with routing table next hop address.



RIB (Routing Information Base):

- The Routing Information Base RIB is where all IP routing information is stored.
- The routing table also known as the RIB (Routing Information Base) table.
- RIB built from dynamic or static routing protocol or with directly connected.
- RIB is the repository where all the routing protocols place all of their routes.
- Routing Information Base (RIB) is routing table which is built in Control plane.



```
R1#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route
Gateway of last resort is 192.168.12.2 to network 0.0.0.0

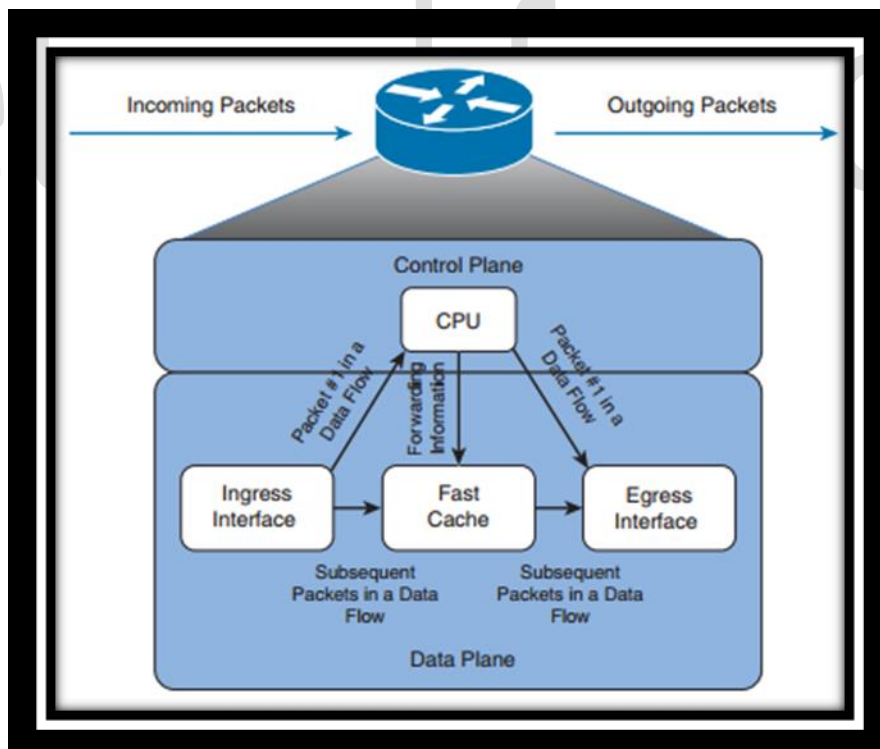
C    192.168.12.0/24 is directly connected, FastEthernet0/0
C    1.0.0.0/24 is subnetted, 1 subnets
C      1.1.1.0 is directly connected, Loopback1
C    11.0.0.0/24 is subnetted, 1 subnets
C      11.11.11.0 is directly connected, Loopback0
S*   0.0.0.0/0 [1/0] via 192.168.12.2
R1#
```

```
R1#show ip cef
Prefix          Next Hop          Interface
0.0.0.0/0       192.168.12.2     FastEthernet0/0
0.0.0.0/32      receive
1.1.1.0/24      attached         Loopback1
1.1.1.0/32      receive
1.1.1.1/32      receive
1.1.1.255/32    receive
11.11.11.0/24   attached         Loopback0
11.11.11.0/32   receive
11.11.11.11/32  receive
11.11.11.255/32 receive
192.168.12.0/24 attached         FastEthernet0/0
192.168.12.0/32 receive
192.168.12.1/32 receive
192.168.12.2/32 192.168.12.2     FastEthernet0/0
192.168.12.255/32 receive
224.0.0.0/4     drop
224.0.0.0/24    receive
255.255.255.255/32 receive
R1#
```



Fast Switching (Route Caching):

- Fast Switching improves on process switching by making use of cache concept.
- In Fast Switching the first packet to a destination is process switched method
- And subsequent packets are forwarded using the information stored in fast cache.
- In other word we can say fist packet is examined by CPU and store decision in cached in hardware.
- When another packet going to same destination, next hop info can be used from cache as it is present already as before that packet send and store in cache.
- So, the processor does not have to look up and assemble all the information again.
- And if any other packet for other destination came then it will process by CPU and send information to Cache so next time for destination info can use directly without involving CPU etc.





CISCO Express Forwarding (CEF):

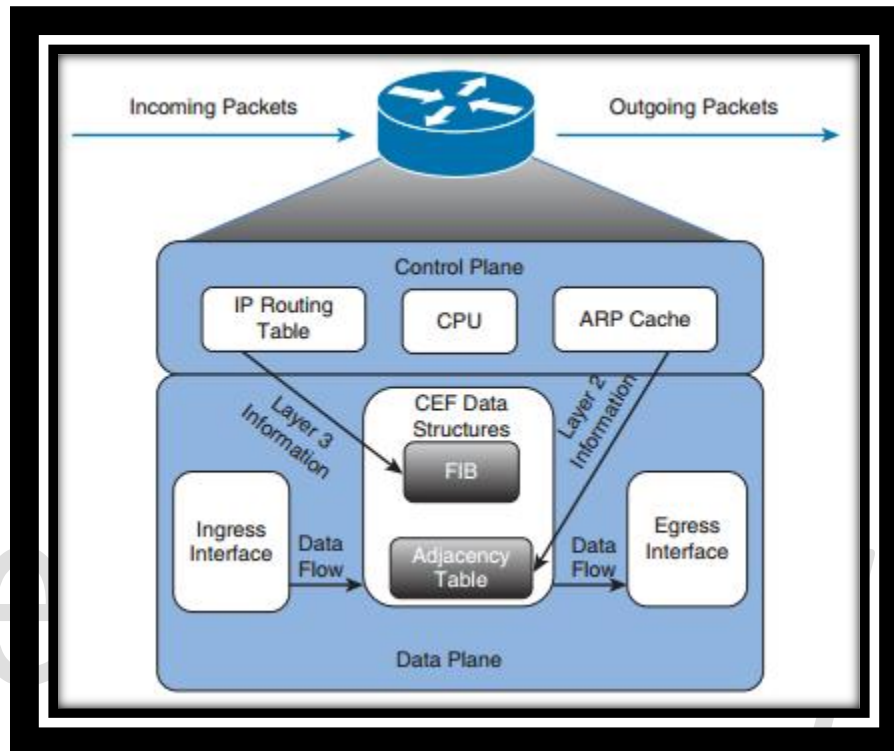
- CEF Stand for CISCO Express forwarding.
- CEF is built around two main components **Forwarding Information Base** and **Adjacency Table**.
- CEF put all this information into single Hardware table which allows very fast packet forwarding.
- CEF is a feature that allows a router to very quickly and efficiently make a router lookup.
- CEF is enabled by default in Cisco Multilayer switch and Routers.
- **CEF also called Topology based switching**
- **CEF have two table FIB (Forwarding Information Base) and Adjacency Table.**

FIB:

- FIB stand for Forwarding Information Base.
- FIB maintains layer 3 forwarding information.
- FIB maintains mirror image of forwarding information contained in the IP routing table.
- FIB maintains next-hop address information based on information in the IP routing table.
- FIB table contains destination reachability information as well as the next hop information.
- FIB contains interface identifier and next hops info for each reachable destination network.
- FIB contains necessary information from the routing table.

Adjacency Table:

- **The Adjacency table, also known as the Adjacency Information Base (AIB) table**
- The Adjacency table maintains **layer 2 information** for next hops listed in the FIB table.
- To avoid need for an Address Resolution Protocol request for each table lookup.
- The Adjacency table is tasked with maintaining the layer 2 next-hop information for the FIB.
- The Adjacency table maintains switching information linked to a particular FIB entry.



Commands to use Process switching, fast switching and CEF:

Command	Description
Ip cef	Globally enable CEF
Int f0/0	Enter Interface mode
Ip route-cache cef	Enables CEF on an interface
Int f0/0	Enter Interface mode
Ip route-cache	Enable Fast switching on an interface
Int f0/0	Enter interface mode
No ip route-cache	Enable Process Switching on an interface
Sh ip int interface-id	Interface info include packet switching mode
Sh ip cef	Displays the contents of routers FIB
Sh adjacency	Display information contained in the adjacency table

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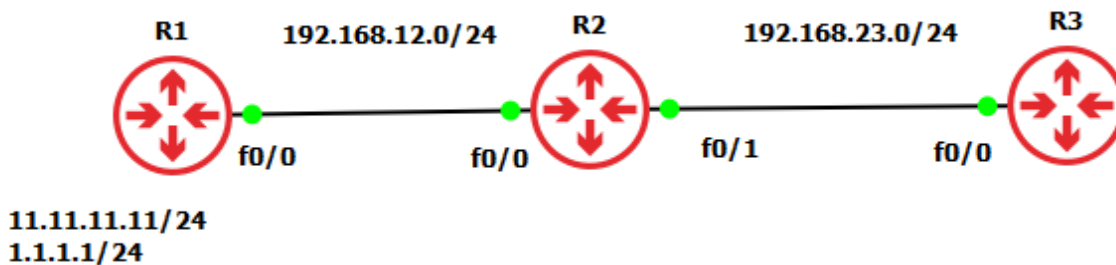
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Sh adjacency summary	Display how many adjacencies we have
Debug ip packet	To check real time IP packets details
Sh proc cpu inc ip input	Verify CPU load for IP input Fast Switching
Sh ip cache	Display fast switching table
Sh ip int f0/0	Display fastethernet 0/0 details
Debug ip cef receive	Enable debugging for CEF receive packets
Ip multicast-routing	Enable Multicasting on Router
Interface f0/0	Enter Interface mode
No ip route-cache	Disable fast switching also CEF on given interface

Lab:



R1 Configuration	R2 Configuration	R3 Configuration
En Config t Int f0/0 Ip add 192.168.12.1 255.255.255.0 No sh Int loop 0 Ip add 11.11.11.11 255.255.255.0 No sh Int loop 1	En Config t Int f0/0 Ip add 192.168.12.2 255.255.255.0 No sh Int f0/1 Ip add 192.168.23.1 255.255.255.0 No sh Ip route 1.1.1.0 255.255.255.0	En Config t Int f0/0 Ip add 192.168.23.2 255.255.255.0 No sh Ip route 0.0.0.0 0.0.0.0 192.168.23.1

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```
Ip add 1.1.1.1 255.255.255.0
Ip route 0.0.0.0 0.0.0.0
192.168.12.2
```

192.168.12.1

```
Ip route 11.11.11.0
255.255.255.0 192.168.12.1
```

CEF Verification

Commands	Description
R2#debug ip packet	Enable packet debug on Router 2
R1#ping 192.168.23.2	Ping from R1 to R3 interface

Let Check there is no Debug output every packet is going through FIB table Hardware.

```
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
```

Fast Switching Verification

Commands	Description
R2(config)#no ip cef	Disable CEF on Router 2
R3#ping 1.1.1.1	Ping from R3 to R1 interface

Only First packet hit RIB (Routing Information Base) CPU, Rest of all packet cache

```
R2(config)#
R2(config)#
R2(config)#
*Mar 1 00:24:55.491: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:24:55.495: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
R2(config)#
```



Let's Verify Fast Switching Cache Table.

```
R2#sh ip cache
IP routing cache 1 entry, 180 bytes
  2 adds, 1 invalidates, 0 refcounts
Minimum invalidation interval 2 seconds, maximum interval 5 seconds,
  quiet interval 3 seconds, threshold 0 requests
Invalidation rate 0 in last second, 0 in last 3 seconds
Last full cache invalidation occurred 00:01:51 ago

Prefix/Length      Age      Interface      Next Hop
1.1.1.0/24         00:01:27 FastEthernet0/0 192.168.12.1

R2#
```

Fast Processing Verification	
Commands	Description
R2(config)#interface f0/0	Enter interface mode
R2(config-if)#no ip route-cache	Disable Fast Switching on Interface.
R2(config-if)#exit	Exit from interface mode.
R2(config)#interface f0/1	Enter interface mode
R2(config-if)#no ip route-cache	Disable Fast Switching on Interface
R3#ping 1.1.1.1	Ping from R3 to R1 interface



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Let's verify, every single packet is hitting RIB (Routing information Base) means Control plan.

```
*Mar 1 00:15:40.131: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:40.131: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:40.143: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:40.143: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:40.167: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:41.087: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:41.087: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:41.107: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:41.111: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:41.131: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:41.135: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:42.083: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:42.087: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:42.099: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:42.099: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:42.127: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:42.127: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:42.147: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:42.147: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:42.159: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:42.159: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:42.171: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:42.171: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.23.2, len 100, forward
*Mar 1 00:15:43.091: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:43.091: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:43.111: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:43.111: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:43.135: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:43.135: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:44.123: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:44.123: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:44.143: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:44.143: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:44.163: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB, g=192.168.12.1, len 100, forward
*Mar 1 00:15:45.107: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:45.107: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:45.131: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:45.135: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:45.153: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB, g=192.168.12.1, len 100, forward
*Mar 1 00:15:46.139: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:46.139: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:46.143: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:46.147: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:46.155: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:46.243: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
*Mar 1 00:15:46.255: IP: tableid=0, s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), routed via RIB
*Mar 1 00:15:46.255: IP: s=192.168.23.2 (FastEthernet0/1), d=1.1.1.1 (FastEthernet0/0), g=192.168.12.1, len 100, forward
*Mar 1 00:15:46.263: IP: tableid=0, s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), routed via RIB
*Mar 1 00:15:46.267: IP: s=1.1.1.1 (FastEthernet0/0), d=192.168.23.2 (FastEthernet0/1), g=192.168.23.2, len 100, forward
R2#
```

Fast Switching is disable there is no entry in table.

```
R2#sh ip cache
IP routing cache 0 entries, 0 bytes
  2 adds, 2 invalidates, 0 refcounts
Minimum invalidation interval 2 seconds, maximum interval 5 seconds,
quiet interval 3 seconds, threshold 0 requests
Invalidation rate 0 in last second, 0 in last 3 seconds
Last full cache invalidation occurred 00:20:55 ago
```

Prefix/Length	Age	Interface	Next Hop
---------------	-----	-----------	----------

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```
R2#sh ip int f0/0 | section swit
R2#sh ip int f0/0 | section switching
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP CEF switching is disabled
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
R2#
```

```
R2#sh ip int f0/1 | section switching
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP CEF switching is disabled
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
R2#
```

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