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ROUTING: PACKET-FORWARD MECHANISMS

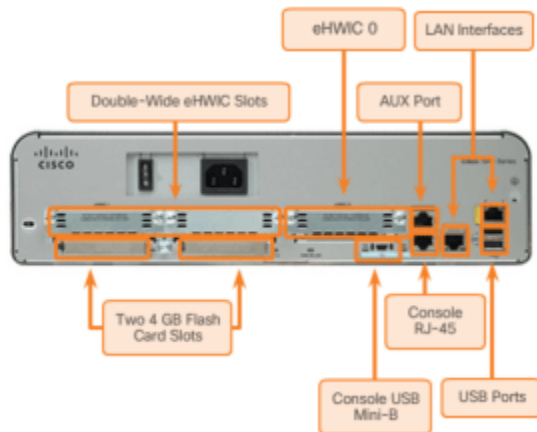
Switches: Fwd frames w/in same network: **Routers:** Interconnect separate networks

- Packet delivery: Uses routing table to determine best path
- Packet to diff network > Fwds to default gateway > Gateway routes traffic: Local-out

Basic network structure

1. Topology: Physical (HW/devices): Logical: Data transfer paths
2. Speed: Data rate in b/s of given link: # of bits transmission: NOT how fast they travel over medium
3. Cost
4. Security
5. Availability
6. Scalability
7. Reliability

Routers are computers



CPU	
OS	Cisco IOS
RAM	<ul style="list-style-type: none">◦ Temp storage (apps/procs)◦ Config-files◦ Tables (Routing table, Eth0 ARP table): Buffers for packet processing◦ Volatile (loses contents on reboot)
ROM	<ul style="list-style-type: none">◦ Bootup instruction◦ Diagnostic SW◦ Limited IOS if can't load full-feature (troubleshooting)◦ Non-volatile (info not lost on reboot)
NVRAM	<ul style="list-style-type: none">◦ Perm storage for startup-config◦ Non-volatile
Flash	<ul style="list-style-type: none">◦ Perm storage for IOS/sys-related files◦ Copied from flash to RAM during boot◦ Non-volatile
HDD	

No/ vid/sound cards: Specialized ports/net int cards

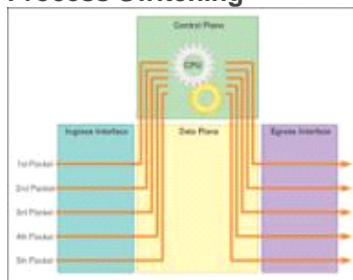
Primary functions:

Determine best path	<ul style="list-style-type: none"> ▪ Routing table determines best path ▪ Packet received: Examines destination address ▪ Static routes/dynamic routing protocols: Teach remote networks/build tables ▪ Table includes int used to fwd packets for each known network <p>When match found:</p> <ul style="list-style-type: none"> ○ Router encapsulates packet into data link frame of outgoing int ○ Packet fwded
Forwards packets	<ul style="list-style-type: none"> ▪ Can receive packet encapsulated in 1 type: Fwd out of int that uses different type <p>Example:</p> <ul style="list-style-type: none"> ▪ Packet received as eth0 int: Fwds packet out of int config'd w/PPP ▪ Data link encapsulation depends on type of int on router ▪ AND type of medium it connects to ▪ Ethernet/PPP/frame relay/DSL/cable/wireless/Bluetooth <p>PPP: Point-to-point Protocol</p>

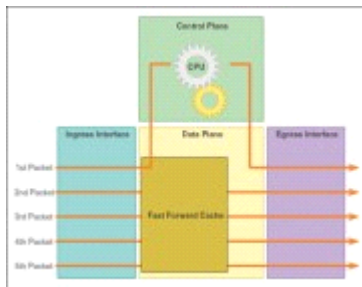
3 Packet-Forwarding Mechanisms

Process switching	<ul style="list-style-type: none"> ▪ Older: Still available for Cisco routers ▪ Packet arrives on int ▪ Forwarded to control plane: CPU matches destination address w/entry in table ▪ Determines exit int: Fwds packet ▪ Done for EVERY PACKET received: Slower <p>Example: Redoing calc for same math problem: Even after an answer</p>
Fast Switching	<ul style="list-style-type: none"> ▪ Uses fast-switching cache to store next-hop info ▪ Packet arrives on int ▪ Fwded to control plane: CPU searches for match in fast-switching cache <ul style="list-style-type: none"> □ If not there: Process switched/fwded to exit int ▪ Path info for packet stored in cache <ul style="list-style-type: none"> □ If another packet goes to same destination: Next-hop in cache is re-used w/out CPU <p>Example: Problem is done: Same answer used for identical problems</p>
CEF	<ul style="list-style-type: none"> ▪ Cisco Express Forwarding: Most recent ▪ CEF builds FIB (Forwarding Information Base) and adjacency table ▪ Table entries: Not packet-triggers like fast switching ▪ Table entries: Change-triggered (e.g. changes in topology) ▪ When network converges: FIB/adjacency tables contain all info for fwding ▪ FIB contains pre-computed reverse lookups ▪ FIB contains next hop info for routes/L2 info ▪ Fastest mechanism <p>Example: Every possible problem pre-calculated ahead of time via spreadsheet</p>

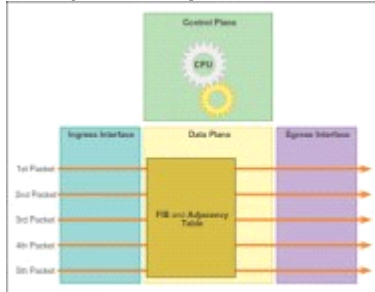
Process Switching



Fast-Switching



CEF (Cisco Express Forwarding)



Default Gateway: Devices config'd w/IP/Mask/Gateway

IP	Unique host on local network
Subnet mask	Which network subnets host can communicate w/
Default Gateway	ID's router to send packet to: When destination isn't on same subnet

Host sends packet to device on same IP: Packet is fwded out host int to destination

Host sends packet to device on diff network: Packet fwded to gateway

- Host device can't communicate w/devices outside of local network

Default gateway: Destination that routes traffic from local to devices on remote network

Example: Local network -> Internet

- Usually address of int on router connected to local
- Router maintains table of connected/remote networks: Determines best path

Gateway of Last Resort: Router usually config'd w/own gateway

Documenting: When designing/mapping network: Have docs

Docs should ID	Device names	Ints used in design	IP/Subnet/Gateway
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Topology diagram: Visual ref showing physical connectivity/logical L3 addressing (SW like MS Visio)

Addressing table: Table captures names/ints/IPv4/masks/gateway addresses

Enabling IP on Host: Can be assigned

Statically	<ul style="list-style-type: none"> ○ Manual assignment IP/Mask/Gateway ○ DNS IP can also be config'd
Dynamically	<ul style="list-style-type: none"> ○ Info provided by server using DHCP ○ DHCP services can be available on Cisco Catalyst switch/Cisco ISR

Device LEDs

S	Speed	L	Link	1 Blink/Pause	10/100/1000Mb/s
Green	Good	Blinking Green	Activity	Amber	Uh oh
No Light	Possible uh oh				

Console Access

- Infrastructure devices commonly accessed remotely via SSH or HTTPS
- Console is only required w/initial config or access fails

Requirements

- RJ45 to DB9 console cable
- Tera Term/PuTTY/HyperTerminal
- Cable connected bet serial of host/console of device
- No serial? USB-to-RS232 serial adapter required when using USB
- ISR G2: Supports USB serial console connection
- USB Type-A to USB Type B (mini-B USB) required; as well as, OS device driver
- Device driver available on cisco.com
- Only 1 console port can be active

- Cable plugged into USB console: RJ45 becomes inactive: Cable USB removed: RJ45 active

Switch doesn't have dedicated int to assign IP: IP info config'd on virtual int (SVI: Switch virtual int)

Config switch int

```
switch(config)# int vlan 1
switch(config-if)# ip address 192.168.10.2 255.255.255.0
switch(config-if)# no shutdown
switch(config-if)# exit
switch(config)# ip default-gateway 182.168.10.2
```

Config Basic Router Settings

- Cisco routers/switches similarities: OS, cmd structure, cmds, initial config

When config Cisco switch/router

- Name
- Secure mgmt. access: Secure priv EXEC/usr EXEC/Telnet access/encrypt passwords
- MOTD for legal purposes
- Save changes/verify basic config

Config basic router settings (in order of above)

```
router# config t
router(config)# hostname r1
```

```
r1(config)# enable secret class
r1(config)# line con 0
r1(config-line)# password [passwd]
r1(config-line)# login
r1(config-line)# exit
```

```
r1(config)# line vty 0 4
r1(config-line)# password [passwd]
r1(config-line)# login
r1(config-line)# exit
```

```
r1(config)# service password-encryption
r1(config)# banner motd #blah blah blah#
r1# copy running-config startup-config
```

Config IPv4 router int

Differences between switches/routers: Types of ints supported by each

Example:

- L2 switches support LANs/have multiple FastEth0/Gigabit Eth0 ports
- Routers support LANs/WANs/connect diff network types: Support many ints
- G2 ISR: 1-2 integrated Gigabit Eth0 ints/High-Speed WAN int card (HWIC) slots
- G2 ISR: Accommodates other types of network ints (serial/DSL/cable)

To be available: Int must be:

- Config'd with address/mask: ip-address subnet-mask cmd
- **Activated:** Default: LAN/WAN ints aren't active (shutdown): Use no shutdown
- Int must be connected to another device for physical layer to be active
- Config description (txt limit 240 chars)
- More params may be needed: Like clock rate

Config (G0/0) Int

```
r1(config)# interface gigabitethernet 0/0
r1(config-if)# description Link to LAN 1
r1(config-if)# ip address 192.168.10.1 255.255.255.0
r1(config-if)# no shutdown
r1(config-if)# exit
```

Config Serial 0/0/0 Int

```
r1(config)# int serial 0/0/0
r1(config-if)# description Link to R2
r1(config-if)# ip address 209.162.200.225 255.255.255.252
r1(config-if)# clock rate 128000
r1(config-if)# no shutdown
```

r1(config-if)# exit

Config IPv6 Router Int

- Similar to IPv4: Very similar in Cisco IOS: add ipv6 in place of ip in the cmds

IPv6 int must be:

- Config'd w/IPv6 address/mask
- `ipv6 address ipv6-address/prefix-length [link-local | eui-64] int cmd`
- Active: int must be activated w/no shutdown
- Int can generate IPv6 link-local address w/out global unicast address
- `ipv6 enable int config` does this
- Typically more than 1 IPv6 address
- Must have link-local address: Will most likely also have IPv6 global unicast
- Supports int to have multiple IPv6 global unicasts from same subnet

Statically create global unicast/link-local IPv6 address

`ipv6 address ipv6-address /prefix-length` Creates global unicast IPv6 as specified

Config global unicast IPv6 address w/int ID (identifier) in low-order 64 bits of IPv6 address using EUI-64 process (EUI: Extended Unique Identifier:) Eliminates manual config/DHCP

`ipv6 address ipv6-address /prefix-length eui-64`

Config static link-local address on int that is used instead of link-local auto config'd when global unicast IPv6 is assigned to int or enabled using `ipv6 enable int cmd`.

`ipv6 address ipv6-address /prefix-length link-local`

So

2001:0DB8:ACAD:0001::/64

`ipv6 unicast-routing global config cmd`

- Router begins sending ICMPv6 advertisement msgs to int
- Enables a PC connected to int to auto config IPv6 address/set gateway
- Without services of DHCPv6 server
- PC connected to IPv6 network can get address statically assigned

Config R1 G0/0 Int

r1(config)# `int gigabitethernet 0/0`

r1(config-if)# `description Link to LAN 1`

r1(config-if)# `ipv6 address 2001:0DB8:ACAD:0001::/64`

r1(config-if)# `no shutdown`

r1(config)# `exit`

Config R1 Serial 0/0/0 Int

r1(config)# `int serial 0/0/0`

r1(config-if)# `description Link to R2`

r1(config-if)# `ipv6 address`

r1(config-if)# `clock rate 128000`

r1(config-if)# `no shutdown`

Config IPv6 Loopback Int

- Logical int internal to router: Not assigned physical port
- Can't be connected to other device/SW int/auto **UP** state
- Test/Managing devices: 1 int will be available
- Impt to processes on router that use IPv4 for ID: OSPF (Open Shortest Path First)

Config Loopback0 Int

r1(config)# `interface loopback 0`

r1(config-if)# `ip address 10.0.0.1 255.255.255.0`

r1(config-if)# `exit`