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**Lesson Seven**

**A. Routing Basics**

- *routing* is the act of moving information across an internetwork from a source to a destination

- in contrast with bridging, bridging occurs at Layer 2 of the OSI reference model, whereas routing occurs at Layer 3

- routing involves two basic activities:
  - determining optimal routing paths
  - transporting packets through an internetwork ("packet switching")

- routers maintain routing tables, which contain route information
  - destination/next hop associations
  - the desirability of a path
  - ***metrics*** to determine the optimal path to a destination
    - ✓ path length
    - ✓ reliability
    - ✓ delay
    - ✓ bandwidth
    - ✓ load
    - ✓ communication cost

- routers communicate with one another to maintain their routing tables
  - ***routing update message***
  - ***a link-state advertisement***

- packet-switching is relatively simple
  - the source host sends a packet addressed specifically to a router's physical (Media Access Control [MAC]-layer) address, with the network layer address of the destination host
  - the router determines that it either knows or does not know how to forward the packet to the next hop
  - if it does not know how to forward the packet, it drops the packet
  - if it knows how to forward the packet, it changes the destination physical address to that of the next hop and transmits the packet
  - as the packet moves through the internetwork, its physical address changes, but its protocol address remains constant

- ISO terminology
  - network devices without the capability to forward packets between subnetworks are called ***end systems*** *(ESs)*
  - network devices with these capabilities are called ***intermediate systems*** *(ISs)*
    - ISs that can communicate only within routing domains (under a common administrative authority) are called ***intradomain ISs***
      - routing domains are also called ***autonomous systems***
    - ISs that communicate both within and between routing domains are called ***interdomain ISs***

- routing algorithms often have one or more of the following design goals:
  - Optimality – best route selection
  - Simplicity and low overhead
  - Robustness and stability
  - Rapid convergence
  - Flexibility

- routing algorithms can be classified by type; key differentiators include these:
  - Static versus dynamic
  - Single-path versus multipath (load sharing)
  - Flat (peer) versus hierarchical (backbone)
  - Host-intelligent (source-routing) versus router-intelligent
  - Intradomain versus interdomain
  - Link-state ("shortest path first") versus distance vector (Bellman-Ford)

- *link-state algorithms* flood routing information to all nodes in the internetwork
  - each router builds a picture of the entire network in its routing tables
  - routers send only the portion of the routing table that describes the state of its own links
  - small updates are sent everywhere
  - fast convergence; thus less prone to routing loops
  - require more CPU power and memory
  - more expensive
  - more scalable

- *distance vector algorithms* send all or some portion of its routing table to its neighbors
  - larger updates are sent to neighboring routers
  - know only about their neighbors

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- routed protocols v. routing protocols
  - ***routed*** protocols are referred to as network protocols
    - occur at the upper five layers of the OSI reference model
    - **routed** protocols are routed over an internetwork
      - Internet Protocol (IP)
      - DECnet
      - AppleTalk
      - Novell NetWare
      - OSI
      - Banyan VINES
      - Xerox Network System (XNS)
  - ***routing*** protocols implement routing algorithms and build tables
      - Interior Gateway Routing Protocol (IGRP)
      - Enhanced Interior Gateway Routing Protocol (Enhanced IGRP)
      - Open Shortest Path First (OSPF)
      - Exterior Gateway Protocol (EGP)
      - Border Gateway Protocol (BGP)
      - Intermediate System-to-Intermediate System (IS-IS)
      - Routing Information Protocol (RIP)

- administrative distance
  - the first criterion that a router uses to determine which routing protocol to use if two protocols provide route information for the same destination
  - a measure of the trustworthiness
  - of the source of the routing information. Keep in mind that administrative distance has only local significance; it is not advertised in routing updates.
  - the smaller the administrative distance value, the more reliable the protocol

The table below lists the administrative distance default values of the protocols that Cisco supports.

- static routing is always 1 and takes precedence over all other protocols
- 255 means the router does not believe the source of that route and does not install the route in its routing table

| Route Source | Default Distance Values |
|---|---|
| Connected interface | 0 |
| Static route | 1 |
| Enhanced Interior Gateway Routing Protocol (EIGRP) summary route | 5 |
| External Border Gateway Protocol (BGP) | 20 |
| Internal EIGRP | 90 |
| IGRP | 100 |
| OSPF | 110 |
| Intermediate System-to-Intermediate System (IS-IS) | 115 |
| Routing Information Protocol (RIP) | 120 |
| Exterior Gateway Protocol (EGP) | 140 |
| On Demand Routing (ODR) | 160 |
| External EIGRP | 170 |
| Internal BGP | 200 |
| Unknown | 255 |

- modify the administrative distance of a protocol using the **distance** command

```
R1(config)# router rip
R1(config-router)# distance 90
R1# show ip route

Gateway of last resort is not set

172.16.0.0/24 is subnetted, 1 subnets
C 172.16.1.0 is directly connected, Ethernet0
I 10.0.0.0/8 [100/1600] via 172.16.1.200, 00:00:01, Ethernet0
C 192.168.1.0/24 is directly connected, Loopback0
```

R2# **show ip route**

```
Gateway of last resort is not set

172.16.0.0/24 is subnetted, 1 subnets
C 172.16.1.0 is directly connected, Ethernet0
C 10.0.0.0/8 is directly connected, Loopback0
I 192.168.1.0/24 [100/1600] via 172.16.1.100, 00:00:33,
```

- Passive-interfaces

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To prevent routing updates through a specified interface, perform the following task in router configuration mode:

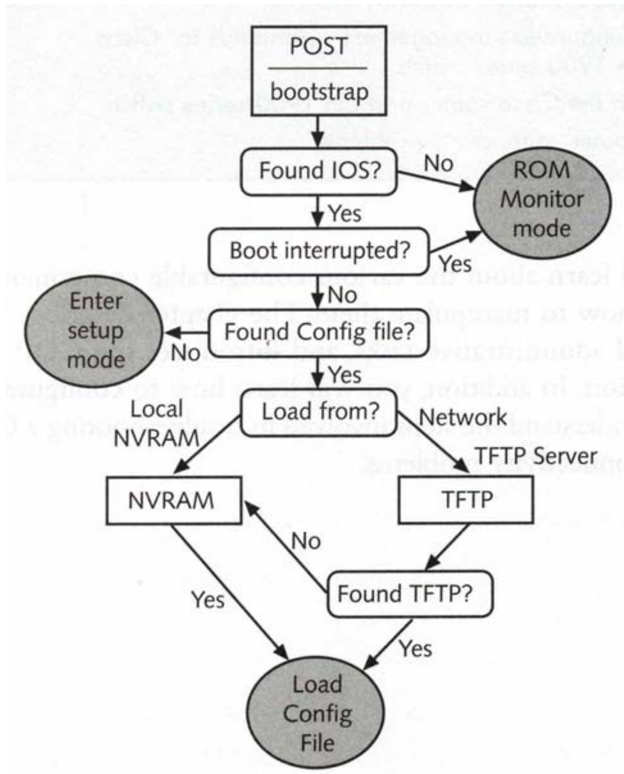
| **Task** | **Command** |
|---|---|
| Suppress the sending of routing updates through a router interface. | **passive-interface** *type number* |

The following example sends IGRP updates to all interfaces on network 131.108.0.0 except interface Ethernet 1.

```
router igrp 109
network 131.108.0.0
passive-interface ethernet 1
```

**B. Router Components and Booting the Router for the First Time**

- ROM – bootstrap	rommon>
- Flash	eraseable, programmable, read-only memory (EPROM)
- NVRAM
- RAM/DRAM
- Interfaces




Each time you power on the router, it goes through the following boot sequence:

1. POST: power-on self-test

2. system bootstrap software (ROM Monitor) executes and searches for a valid Cisco ***IOS image***

   a. flash memory
   b. Trivial File Transfer Protocol [TFTP] server
      - determined by the configuration register setting
      - factory-default is 0x2102, flash memory

3. if after five attempts no image is found, then boot ROM mode = `rommon>`
   a. used to install or upgrade a Cisco IOS image

4. if a valid Cisco IOS image is found, then the router searches for a valid ***configuration file***

5. if a valid configuration file is not found in NVRAM, the router runs the System Configuration Dialog

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6. normal router operation requires a valid Cisco IOS image in Flash memory and a configuration file in NVRAM

7. the first time you boot your router, you will need to configure the router interfaces and then save the configuration to a file in NVRAM

**C. More Commands**

- `RouterA(config)#` **boot system tftp igs0j0l.111.5**
- `RouterA#` **copy running-config startup-config**
- `RouterA#` **erase flash**
- `RouterA#` **copy ?**

| | |
|---|---|
| flash: | Copy from flash: file system [Flash is the IOS] |
| flh: | Copy from flh: file system [Flash load helper] |
| ftp: | Copy from ftp: file system |
| null: | Copy from null: file system |
| nvram: | Copy from nvram: file system |
| rcp: | Copy from rcp: file system [Remote copy protocol] |
| running-config | Copy from current system configuration |
| startup-config | Copy from startup configuration |
| system: | Copy from system: file system |
| tftp: | Copy from tftp: file system |

**D. Cisco 2500 Password Recovery Procedures**

1. attach a terminal or PC to the console port of the router

2. turn the router off and then turn it back on

3. put the router into ROMMON mode by sending a “break sequence” to the router

    - On a Cisco 2500 press: `Ctrl Break`

4. type **?** to see the available options

    - Note that option "**o**" is "show configuration register option settings"
    - Note that option "**i**" is "initialize"

5. enter: **o**

6. record the current value of the configuration register (usually 0x2102, or 0x102):

    - the screen reads something like "Configuration register = 0x2102 at last boot"

7. enter: **o/r 0x2142**

    - to boot from Flash without loading the configuration

8. enter: **i**

9. press Ctrl−C to skip the initial setup procedure

10. enter: **enable**

11. enter: **copy startup•config running•config**

12. enter: **configure terminal**

13. enter: **enable secret <password>**

14. on every interface that is being used, enter: **no shutdown**

15. enter: **config•register 0x2102** (or the value you recorded in step 6)

16. Press Ctrl−Z to leave the configuration mode

17. enter: **write memory**

18. enter: **reload**

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E. **CDP (Cisco Discovery Protocol)**

RouterCHI# **sh cdp neighbors**

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
S - Switch, H - Host, I - IGMP, r - Repeater

| Device ID | Local Intrfce | Holdtme | Capability | Platform | Port ID |
|---|---|---|---|---|---|
| RouterNY | Ser 0 | 127 | R | 2500 | Ser 0 |
| RouterSF | Ser 1 | 157 | R | 2520 | Ser 0 |

F. **Telnet**

G. **Ping and Trace**

RouterCHI# **ping 192.168.40.2**

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/31/36 ms
RouterCHI# **trace 192.168.40.2**

Type escape sequence to abort.
Tracing the route to 192.168.40.2

1 172.20.10.2 16 msec 16 msec 16 msec
2 192.168.40.2 16 msec 16 msec 16 msec

H. **Checking an Interface**

RouterCHI# **sh int s0**

**Serial0 is up, line protocol is up**
Hardware is HD64570
**Internet address is 172.20.10.1/24**
**MTU 1500 bytes**, BW 1544 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation **HDLC**, loopback not set
Keepalive set (10 sec)
Last input 00:00:02, output 00:00:04, output hang never
Last clearing of "show interface" counters 1d18h
Queueing strategy: fifo
Output queue 0/40, 96 drops; input queue 0/75, 0 drops
5 minute input rate 0 bits/sec, 0 packets/sec

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5 minute output rate 0 bits/sec, 0 packets/sec
**50280 packets input**, 3138709 bytes, 0 no buffer
Received 17890 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
**50293 packets output**, 3136057 bytes, 0 underruns
0 output errors, 0 collisions, 7 interface resets
0 output buffer failures, 0 output buffers swapped out
40 carrier transitions
DCD=up  DSR=up  DTR=up  RTS=up  CTS=up

I. **Debug**

RouterCHI# **debug all**
**This may severely impact network performance. Continue? [confirm]**

**All possible debugging has been turned on**
RouterCHI#
1d18h: IP: s=172.20.10.1 (local), d=224.0.0.10 (Serial0), len 60, sending broad/multicast
1d18h: IP: s=172.31.20.2 (local), d=224.0.0.10 (Serial1), len 60, sending broad/multicast
1d18h: IP: s=172.31.20.1 (Serial1), d=224.0.0.10, len 60, rcvd 2
1d18h: IP: s=172.20.10.2 (Serial0), d=224.0.0.10, len 60, rcvd 2
1d18h: IP: s=172.31.20.2 (local), d=224.0.0.10 (Serial1), len 60, sending broad/multicast
1d18h: IP: s=172.20.10.1 (local), d=224.0.0.10 (Serial0), len 60, sending broad/multicast
1d18h: IP: s=172.31.20.1 (Serial1), d=224.0.0.10, len 60, rcvd 2

RouterCHI# **no debug all**