# Lecture 3 – Cisco Router Basics

## CPSC 456 Network Security Fundamentals

# Cisco Router Components Overview

| Component | Description |
|---|---|
| Bootstrap | Stored in the microcode of the ROM, the bootstrap is used to bring a router up during initialization. It will boot the router and then load the IOS. |
| POST (power-on self-test) | Stored in the microcode of the ROM, the POST is used to check the basic functionality of the router hardware and determines which interfaces are present. |
| ROM monitor | Stored in the microcode of the ROM, the ROM monitor is used for manufacturing, testing, and troubleshooting. |
| Mini-IOS | Called the RXBOOT or bootloader by Cisco, the mini-IOS is a small IOS in ROM that can be used to bring up an interface and load a Cisco IOS into flash memory. The mini-IOS can also perform a few other maintenance operations. |
| RAM (random access memory) | Used to hold packet buffers, ARP cache, routing tables, and also the software and data structures that allow the router to function. Running-config is stored in RAM, and most routers expand the IOS from flash into RAM upon boot. |
| ROM (read-only memory) | Used to start and maintain the router. Holds the POST and the bootstrap program as well as the mini-IOS. |
| Flash memory | Stores the Cisco IOS by default. Flash memory is not erased when the router is reloaded. It is EEPROM (electronically erasable programmable read-only memory) created by Intel. |
| NVRAM (nonvolatile RAM) | Used to hold the router and switch configuration. NVRAM is not erased when the router or switch is reloaded. Does not store an IOS. The configuration register is stored in NVRAM. |
| Configuration register | Used to control how the router boots up. This value can be found as the last line of the `show version` command output and by default is set to 0x2102, which tells the router to load the IOS from flash memory as well as to load the configuration from NVRAM. |

Image source: https://learning.oreilly.com/library/view/ccna-cisco-certified/9781118088050/c07-anchor-1.xhtml

# External Configuration Sources To Manage Routers

- Console
  - Direct PC serial access
- Auxiliary port
  - Modem access
- Virtual terminals
  - Telnet/SSH access
- TFTP Server
  - Copy configuration file into router RAM
- Network Management Software
  - e.g., Cisco Prime Infrastructure and Cisco Digital Network Architecture (DNA) Center

# Router Access Modes

- User EXEC mode – limited examination of router (router prompt ends with a greater than sign)
  - Router>
- Privileged EXEC mode – detailed examination of router, debugging, testing, file manipulation (router prompt changes to a hash symbol)
  - Router#

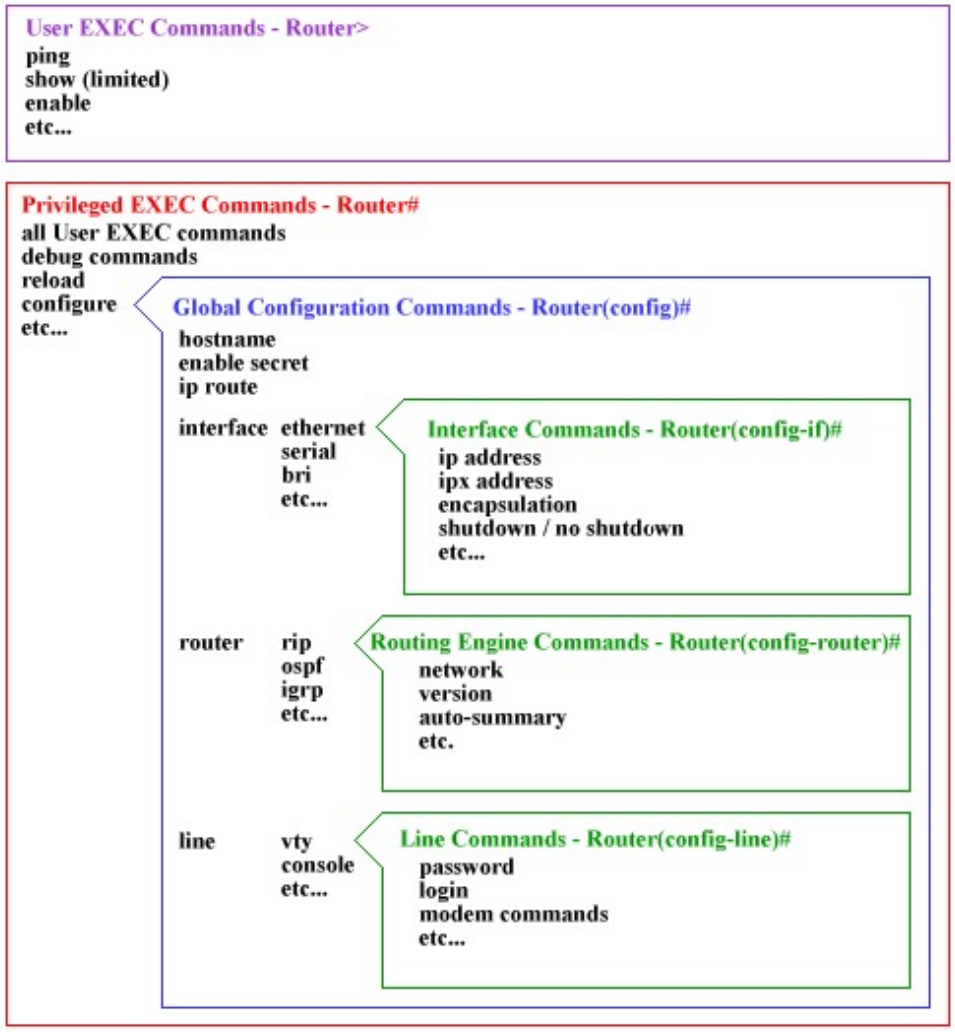



Image source: https://www.cisco.com/E-Learning/bulk/public/tac/cim/cib/using_cisco_ios_software/02_cisco_ios_hierarchy.htm

# Router Prompts – Where am I on the router?

| | |
|---|---|
| **Router>** | - User EXEC mode |
| **Router#** | - Privileged EXEC mode |
| **Router(config)#** | - Configuration mode (notice the # sign indicates this is accessible only at privileged EXEC mode) |
| **Router(config-if)#** | - Interface level within configuration mode |
| **Router(config-router)#** | - Routing engine level within configuration mode |
| **Router(config-line)#** | - Line level (vty, tty, async) within configuration mode |

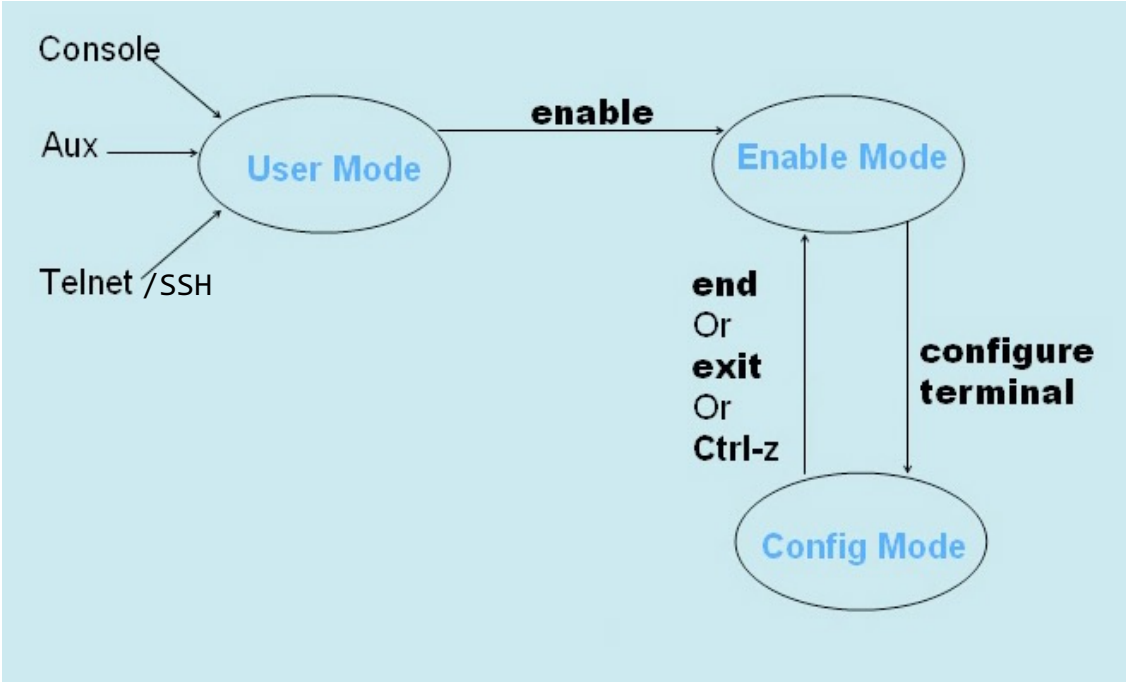
Image source: https://www.cisco.com/E-Learning/bulk/public/tac/cim/cib/using_cisco_ios_software/02_cisco_ios_hierarchy.htm

# Router Prompts - Configuration Mode Command Prompt Reference

| Name of Sub-mode | Purpose | Command Prompt |
|---|---|---|
| Interface | Configure details about a specific router interface, such as the IP address | Router(config-if)# |
| Line | Configure details about lines (console, vty, and aux) | Router(config-line)# |
| Router | Configure details about a particular routing protocol | Router(config-router)# |

# How to Get to The Global Configuration Mode

*Note: The GNS3 Dynamips routers maybe booted in Enable Mode by default.*




**Console|Aux|Telnet/SSH** - External configuration sources
`enable` : Switch from User mode to enter the Enable mode
`exit` : Exit from the config mode
`end` : Return to privileged EXEC mode
`Ctrl-z` : Apply the command line and return to privileged EXEC mode

# Router Management

- Access router terminal from an external source

```
router>                 % user exec mode prompt
router>enable           % switch to Enable mode

router#                 % privilege exec mode;
Dynamips IOS may default in this mode

router#?                % display help command
```

- Enter the router's global configuration mode

```
router#configure terminal
router(config)#
```

# Router Configurations

A router has two configurations:

- Running configuration
  - The current router configuration operating in RAM
  - Can be modified using the `configure` command
  - Changes take effect (almost) immediately
  - **`router#`** `show running-config`

- Startup confguration
  - The current router configuration stored in NVRAM that will be loaded after next reboot
  - Can be modified using the `copy` or `write` command
  - **`router#`** `show startup-config`

# Getting Help

- IOS has a built-in help facility

  - Use the ? to get a list of all possible commands

    ```
    router#?
    ```

  - Use the "<partial keyword>?" or "<partial commands> ?" lists all possible command or subcommand corresponding to the already entered characters

    ```
    % show possible commands that starts with con
    router#con?
    % display all commands after the keyword show
    router#show ?
    % display all commands after the keywords show ip
    router#show ip ?
    ```

  - Has built-in auto completion feature of partial words using the tab key

# Getting Help

- Question mark also works in configuration mode

```
router(config)#ip a?
 access-list          Named access-list
 accounting-list      Select hosts for which IP accounting information is
                      kept
 accounting-threshold    Sets the maximum number
...

router(config)#int fa0/0
router(config-if)#ip a?
 access-group  accounting      address    admission
 auth-proxy    authentication
```

# Getting Help

- Can "explore" a command to figure out the syntax

  ***n.n.n.n*** : denotes dotted decimal IPv4 address

  ***m.m.m.m*** : denotes dotted decimal IPv4 subnet mask

```
router(config-if)#ip addr ?
  A.B.C.D  IP address

router(config-if)#ip addr n.n.n.n ?
  A.B.C.D  IP subnet mask

router(config-if)#ip addr n.n.n.n m.m.m.m ?
  secondary  Make this IP address a secondary address
  <cr>

router(config-if)#ip addr n.n.n.n m.m.m.m
```

# Getting Help

- TAB character will complete a partial word

```
router(config)#int[TAB]
router(config)#interface fa[TAB]
router(config)#interface fastEthernet
router(config)#interface fastEthernet 0/0
router(config-if)#ip add[TAB]
router(config-if)#ip address n.n.n.n m.m.m.m
```

- Unique partial commands can be used

```
router#conf t
router(config)#int fa0/0   % or 'int f0/0'
router(config-if)#ip addr n.n.n.n
```

# Getting Help

- Access command history
  - IOS maintains a short list of previously typed commands
    - up-arrow or ctrl-p (`^p`) recalls previous command
    - down-arrow or ctrl-n (`^n`) recalls next command
- Navigating line editing
    - left-arrow, right-arrow moves cursor inside command
    - ctrl-d (`^d`) or backspace will delete character in front of cursor
    - ctrl-a (`^a`) takes you to start of line
    - ctrl-e (`^e`) takes you to end of line

# New Router Configuration Process

- Load configuration parameters into RAM
  - `Router#configure terminal`
- Personalize router identification
  - `Router(config)#hostname R1`
    `Router(config)#exit`
- Set clock
  - `R1# clock set 9:00:00 Feb 26 2021`
- Display IOS version, hardware, etc.
  - `R1# show version`

# Configuring your Router

- Set the enable (secret) password:
  - `R1(config)# enable secret` <chosen_password>
    - This MD5 encrypts the password
    - This old method uses clear text. ABSOLUTELY NOT RECOMMENDED TO USE IN PRODUCTION!

- Ensure that all passwords stored on router are encrypted rather than clear text:
  - `R1(config)# service password-encryption`

# Configuring Your Router

- Configure an interface by going to the interface configuration prompt

```
% Specify which interface to configure
R1(config)#interface fastethernet 0/0
% Assign a static IP for interface fa0/0 (n & m
% are decimal values of IPv4 and Subnet mask
R1(config-if)#ip address n.n.n.n m.m.m.m
% Assign a static IP for interface fa0/0
R1(config-if)#no shutdown
```

- Save your configuration

```
R1#copy running-config startup-config
% or
R1#write memory
```

# Global Configuration

- IP specific global configuration statements:

```
% create DHCP address pool and enters pool
  configuration mode
R1(config)#ip dhcp pool <pool_name>
% assign a DNS server of 10.0.0.4 to the DHCP
  address pool
R1(config-dhcp)#ip name-server n.n.n.n
```

- Static Route Creation

```
ip route n.n.n.n m.m.m.m g.g.g.g
```

*n.n.n.n* : denotes the destination network address

*m.m.m.m* : denotes the destination subnet mask

*g.g.g.g* : denotes the next hop or destination gateway address packets are sent

# The NO Command

- Set and unset (no command) configurations

e.g.:

```
ip address 10.0.0.1 255.255.255.0      % set ip
   address for a specified interface
no ip address                          % unset ip
   address config for a specified interface

router ospf 1                  % set ospf routing
   process-id(1) and enters router config mode
no router ospf 1               % unset ospf routing
   process-id 1

no logging console             % suppress all console
   logs from displaying
```

# Interface Configuration

- Interfaces are named by slot/type; *e.g.*:
  - ethernet0/0
  - fastethernet0/0
  - Serial0/0, serial1 ... Serial3

- And can be abbreviated:
  - eth0 or e0
  - fa0/0 or f0/0
  - Serial0/0 or ser0/0 or s0/0

# Interface Configuration

- Access interface configuration mode

```
R1(config)#int f0/0
R1(config-if)#
```

- Administratively enable/disable the interface

```
R1(config-if)#no shutdown
R1(config-if)#shutdown
```

- Add description to an interface

```
R1(config-if)#description uplink to SW1
```

- Display current summary of interface configuration

```
R1#show ip interface brief
```

# Interactive Configuration

- Show brief information of all the network interfaces
  e.g.:
  ```
  router#sh ip int br
  ```

- The **prompt** gives a hint about where you are
  e.g.:
  ```
  router#conf t
  router(config)#int f0/1
  router(config-if)#ip addr 10.0.0.1 255.0.0.0
  router(config-if)#no shut
  router(config-if)#end      % or ctrl+z
  router#wr      % save running-config to startup-
     config
  ```

# Using the DO Command

- Execute user mode commands *without* leaving the global configuration mode

e.g.:

```
% Show running-configuration
router(config)#do sh run
% Show IP interface brief
router(config-if)#do sh ip int br
% Show IP route
router(config-if)#do sh ip route
% save running-config to startup-config
router(config-if)#do wr
```

*Note*: Using the `do` command removes the availability of the tab completion feature.

# Hardening Cisco IOS Devices

- Best practices include:
  - Use SSH terminal instead of telnet
  - Use hashed secret password rather than plain text
  - Send logs to a central location (e.g., external syslog server)
  - Disable ICMP redirects (no ip redirects)
  - Disable or limit IP directed broadcasts
  - More can be found at: https://www.cisco.com/c/en/us/support/docs/ip/access-lists/13608-21.html

# Practical Exercise

https://docs.gns3.com/docs/getting-started/your-first-cisco-topology