Chapter 2:
Configuring a Network Operating System

Introduction to Networks

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Chapter 2 - Objectives

Upon completion of this chapter you will be able to:

- Explain the purpose of the Cisco IOS.

- Explain how to access and navigate Cisco IOS to configure network devices.

- Describe the command structure of the Cisco IOS software.

- Configure hostnames on a Cisco IOS device using the CLI.

- Use Cisco IOS commands to limit access to device configurations.

- Use Cisco IOS commands to save the running configuration.

- Explain how devices communicate across network media.

- Configure a host device with an IP address.

- Verify connectivity between two end devices.

Chapter 2

2.0 Introduction

2.1 IOS Bootcamp

2.2 Getting Basic

2.3 Addressing Schemes
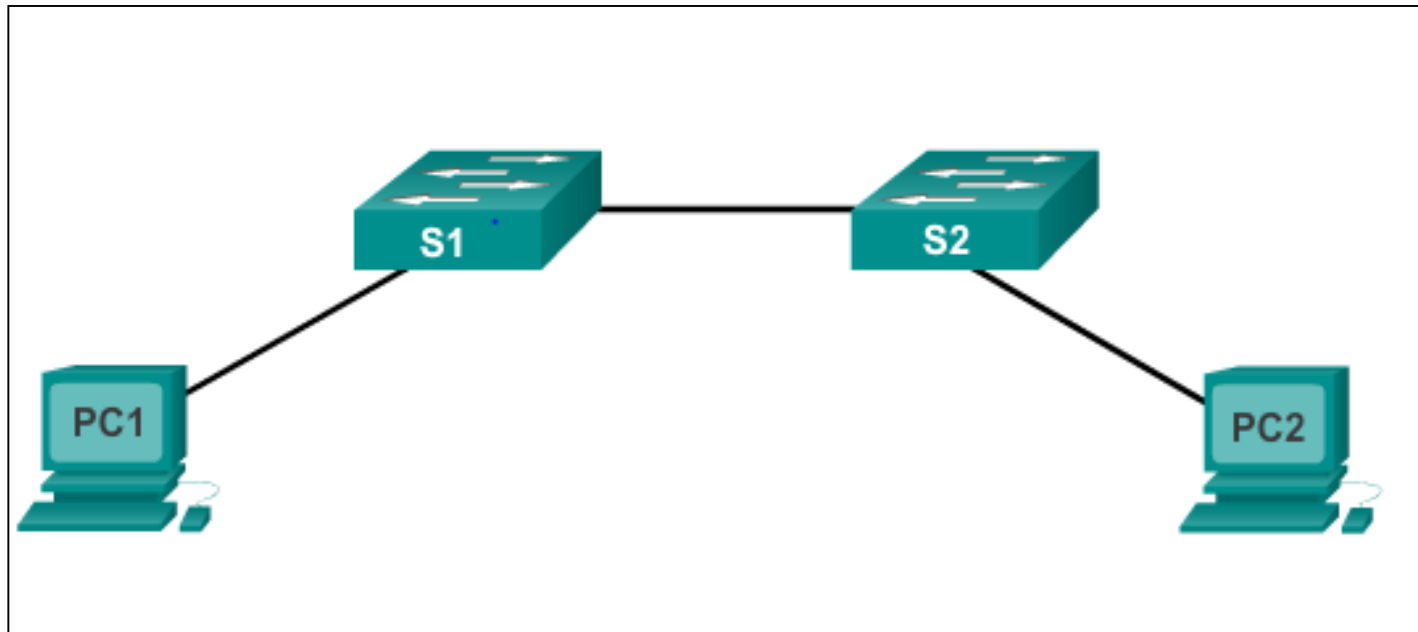
2.4 Summary

2.1 IOS Bootcamp
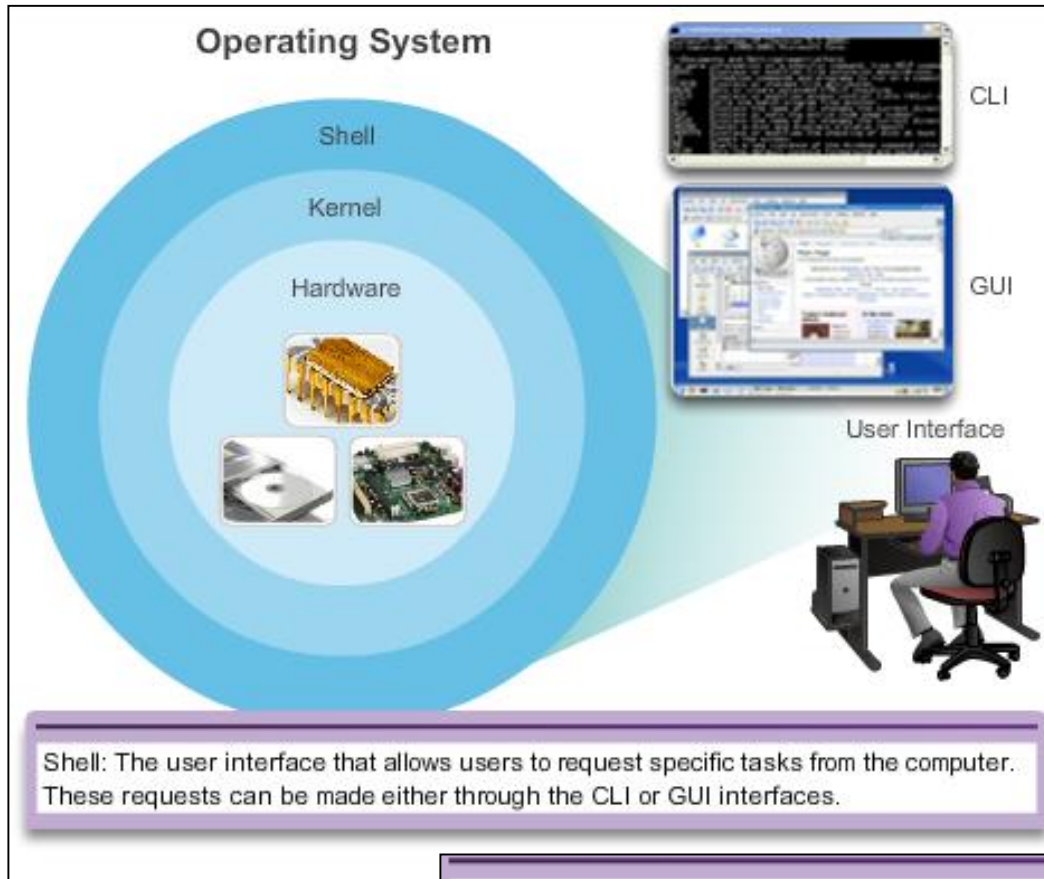
Cisco IOS
Operating Systems

- All networking equipment dependent on operating systems

- The operating system on home routers is usually called firmware

- Cisco IOS – Collection of network operating systems used on Cisco devices

Operating Systems (cont.)

Operating System

Shell

Kernel

Hardware

CLI

GUI

User Interface

Shell: The user interface that allows users to request specific tasks from the computer. These requests can be made either through the CLI or GUI interfaces.

Kernel: Communicates between the hardware and software of a computer and manages how hardware resources are used to meet software requirements.

Hardware: The physical part of a computer including underlying electronics.

Purpose of OS

- PC operating systems (Windows 8 and OS X) perform technical functions that enable:
    - Use of a mouse
    - View output
    - Enter text
- Switch or router IOS provides options to:
    - Configure interfaces
    - Enable routing and switching functions
- All networking devices come with a default IOS
- Possible to upgrade the IOS version or feature set
- In this course, primary focus is Cisco IOS Release 15.x

Location of the Cisco IOS

Cisco IOS stored in **Flash**

- Non-volatile storage, not lost when power is lost
- Can be changed or overwritten as needed
- Can be used to store multiple versions of IOS
- IOS copied from flash to volatile RAM
- Quantity of flash and RAM memory determines IOS that can be used

IOS Functions

These are the major functions performed or enabled by Cisco routers and switches.

Internetwork Operating System for Cisco networking devices

Console Access Method

Most common methods to access the CLI:

- Console
- Telnet or SSH
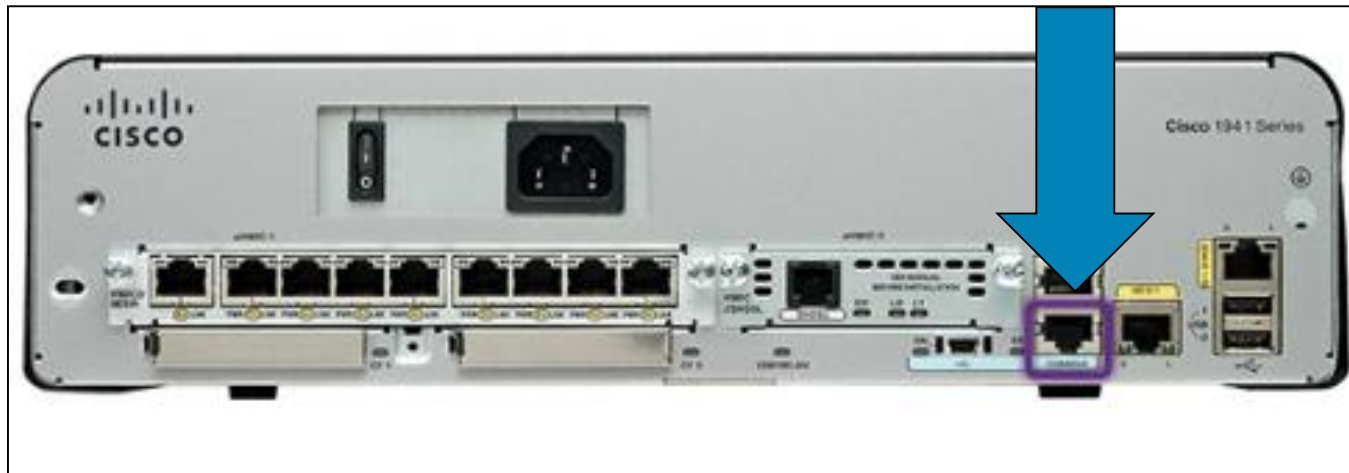- AUX port

Console Access Method

Console Port

- Device is accessible even if no networking services have been configured (out-of-band)

- Need a special console cable

- Allows configuration commands to be entered

- Should be configured with passwords to prevent unauthorized access

- Device should be located in a secure room so console port cannot be easily accessed

Telnet, SSH, and AUX Access Methods

Telnet

- Method for remotely accessing the CLI over a network

- Require active networking services and one active interface that is configured

Secure Shell (SSH)

- Remote login similar to Telnet, but utilizes more security

- Stronger password authentication

- Uses encryption when transporting data

Aux Port

- Out-of-band connection
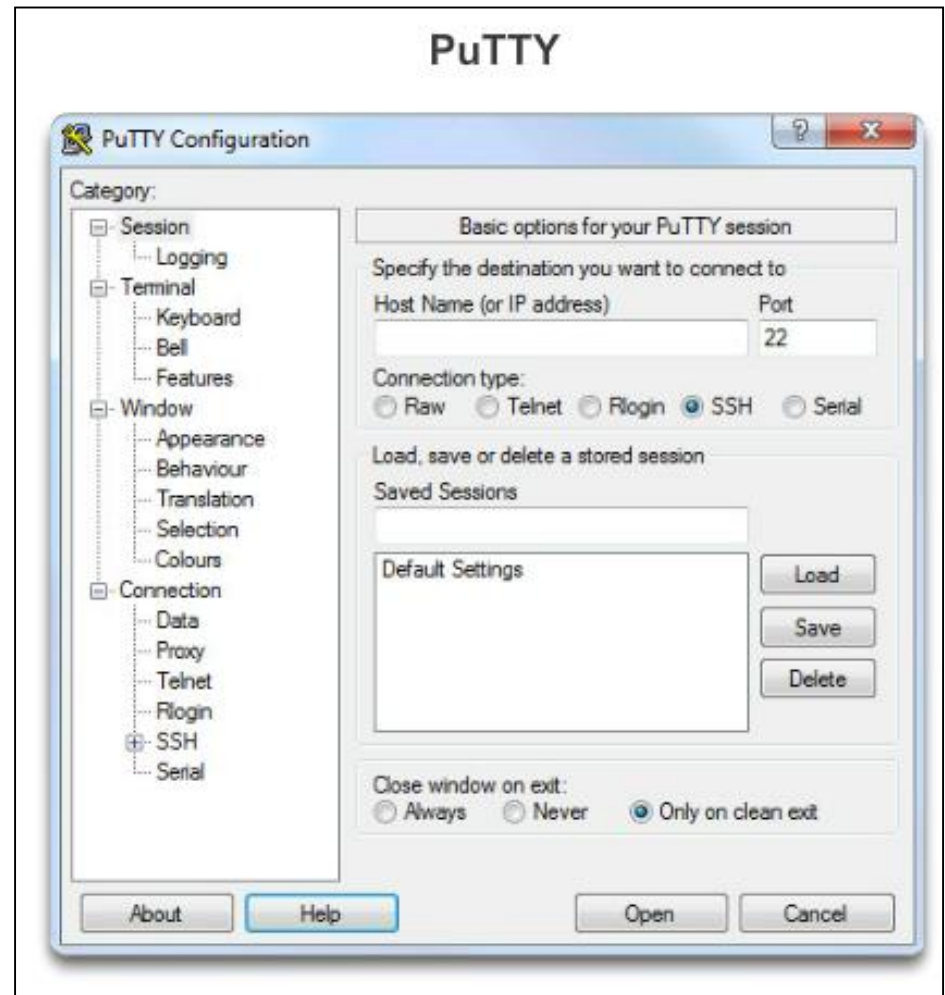
- Uses telephone line

- Can be used like console port

Terminal Emulation Programs

Software available for connecting to a networking device:

- PuTTY

- Tera Term

- SecureCRT
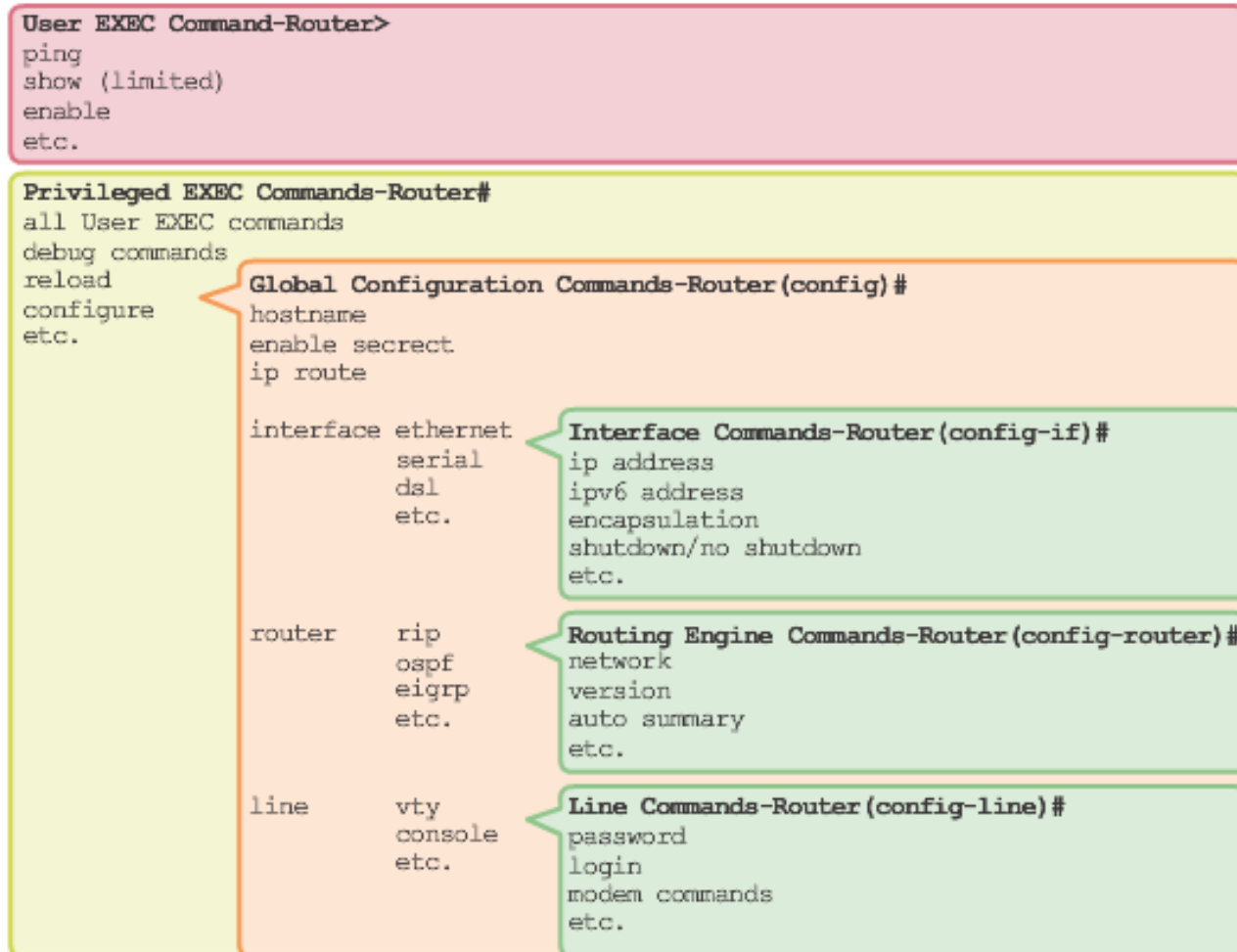
- HyperTerminal

- OS X Terminal

Cisco IOS Modes of Operation

IOS Mode Hierarchical Structure

User EXEC Command-Router>
ping
show (limited)
enable
etc.

Privileged EXEC Commands-Router#
all User EXEC commands
debug commands
reload
configure
etc.

Global Configuration Commands-Router(config)#
hostname
enable secrect
ip route

interface ethernet
         serial
         dsl
         etc.

Interface Commands-Router(config-if)#
ip address
ipv6 address
encapsulation
shutdown/no shutdown
etc.

router   rip
        ospf
        eigrp
        etc.

Routing Engine Commands-Router(config-router)#
network
version
auto summary
etc.

line   vty
       console
       etc.

Line Commands-Router(config-line)#
password
login
modem commands
etc.

Primary Modes

User EXEC Mode

Limited examination of router.
Remote access.

```
Switch>
Router>
```

The **User EXEC** mode allows only a limited number of basic monitoring commands and is often referred to as view-only mode.

Privileged EXEC Mode

Detailed examination of router. Debugging and testing. File manipulation. Remote access.

```
Switch#
Router#
```

The **Privileged EXEC** mode, by default, allows all monitoring commands, as well as execution of configuration and management commands.
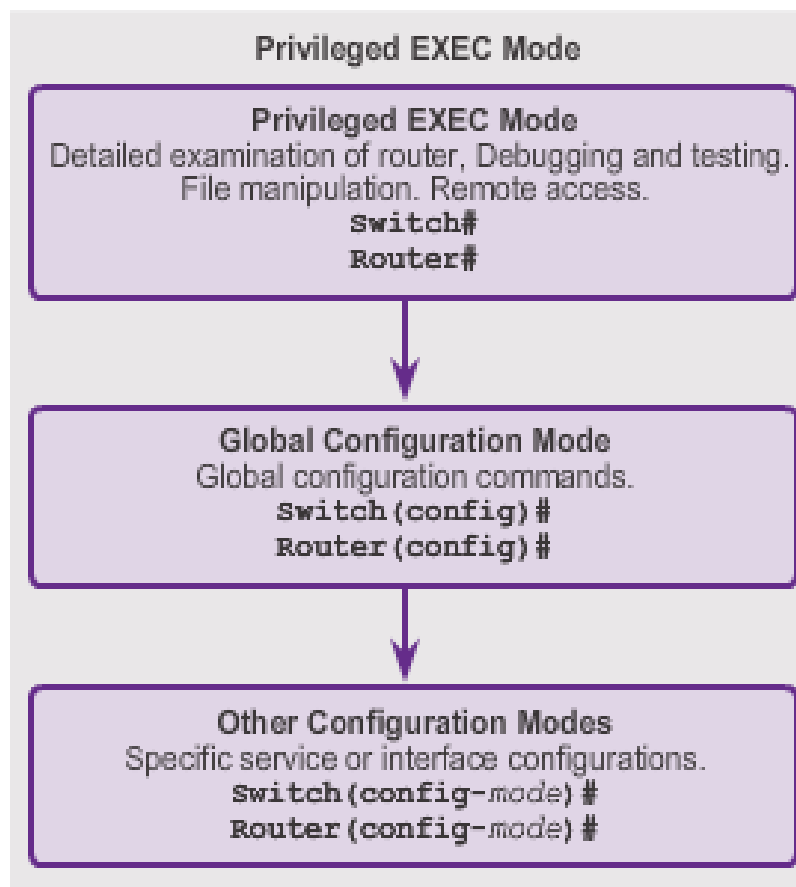
Global Configuration Mode and Submodes

Privileged EXEC Mode

Privileged EXEC Mode
Detailed examination of router, Debugging and testing.
File manipulation. Remote access.
```
Switch#
Router#
```

Global Configuration Mode
Global configuration commands.
```
Switch(config)#
Router(config)#
```

Other Configuration Modes
Specific service or interface configurations.
```
Switch(config-mode)#
Router(config-mode)#
```

IOS Prompt Structure

```
Router>ping 192.168.10.5

Router#show running-config

Router(config)#Interface FastEthernet 0/0

Router(config-if)#ip address 192.168.10.1 255.255.255.0
```

The prompt changes to denote the current CLI mode.

```
Switch>ping 192.168.10.9

Switch#show running-config

Switch(config)#Interface FastEthernet 0/1

Switch(config-if)#Description connection to WEST LAN4
```

Navigating Between IOS Modes

```
Router con0 is now available.

Press RETURN to get started.

User Access Verification
Password:
Router>                          User EXEC Mode Prompt
Router>enable
Password:
Router#                          Privileged EXEC Mode Prompt
Router#disable
Router>                          User EXEC Mode Prompt
Router>exit
```

Router

Navigating Between IOS Modes (cont.)

```
Switch> enable
Switch# configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
Switch(config)# interface vlan 1
Switch(config-if)# exit
Switch(config)# exit
Switch#
```

```
Switch# configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
Switch(config)# vlan 1
Switch(config-vlan)# end
Switch#
```

```
Switch# configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
Switch(config)# line vty 0 4
Switch(config-line)# interface fastethernet 0/1
Switch(config-if)# end
Switch#
```

IOS Command Structure

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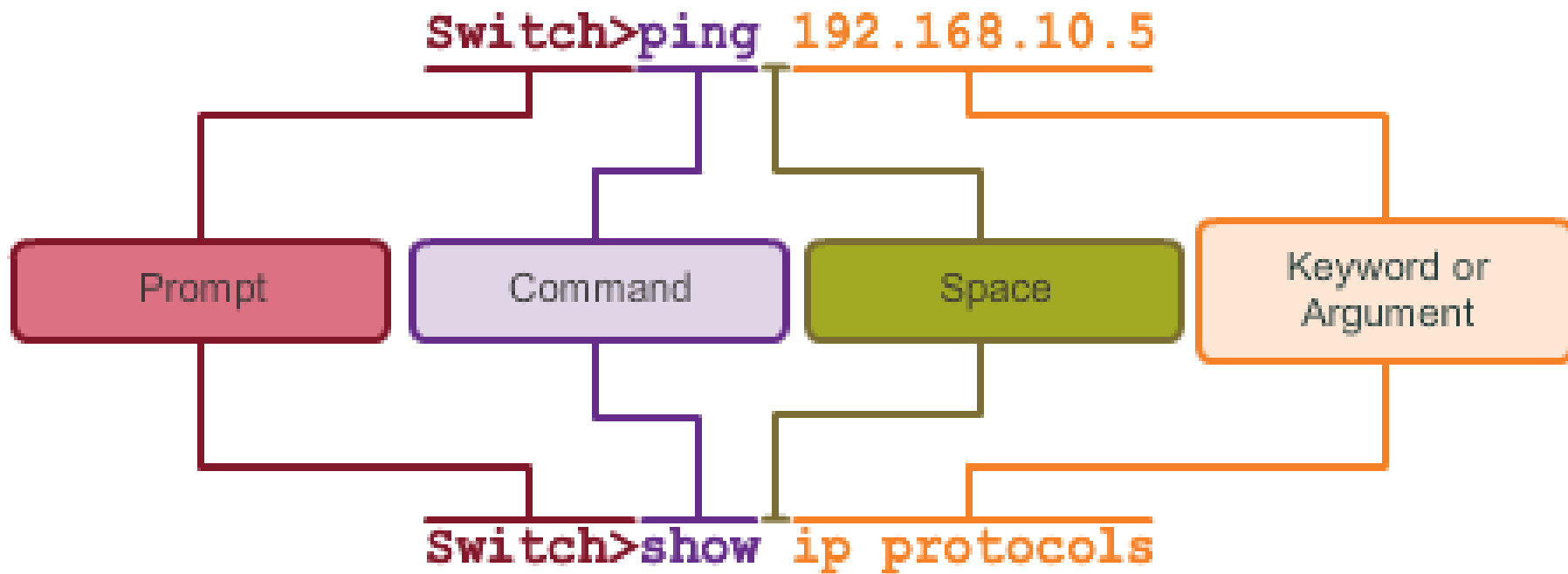
Cisco IOS Command Reference

To navigate to Cisco's *IOS Command Reference* to find a command:

1. Go to http://www.cisco.com.

2. Click **Support**.

3. Click **Networking Software (IOS & NX-OS)**.

4. Click **15.2M&T** (for example).

5. Click **Reference Guides**.

6. Click **Command References**.

7. Click the particular technology that encompasses the command you reference.

8. Click the link on the left that alphabetically matches the command you referencing.

9. Click the link for the command.

Context-Sensitive Help

Context Sensitive Help


```
Switch#cl?
clear   clock
```
Command options - display a list of commands or keywords that start with the characters **cl**

```
Switch#clock set ?
  hh:mm:ss   Current Time
```
Command explanation - the IOS displays what command arguments or variables can be next, and provides an explanation of each

```
Switch#clock set 19:50:00 ?
  <1-31>   Day of the month
  MONTH    Month of the year
```
Command explanation with more than one argument or variable option

```
Switch#clock set 19:50:00 25 June 2012
Switch#
```

Command Syntax Check

```
Switch#>clock set
% Incomplete command.
Switch#clock set 19:50:00
% Incomplete command.
```

The IOS returns a help message indicating that required keywords or arguments were left off the end of the command.

```
Switch#c
% Ambiguous command:'c'
```

The IOS returns a help message to indicate that there were not enough characters entered for the command interpreter to recognize the command.

```
Switch#clock set 19:50:00 25 6
                                ^
% Invalid input detected at '^'
marker.
```

The IOS returns a "^" to indicate where the command interpreter can not decipher the command.
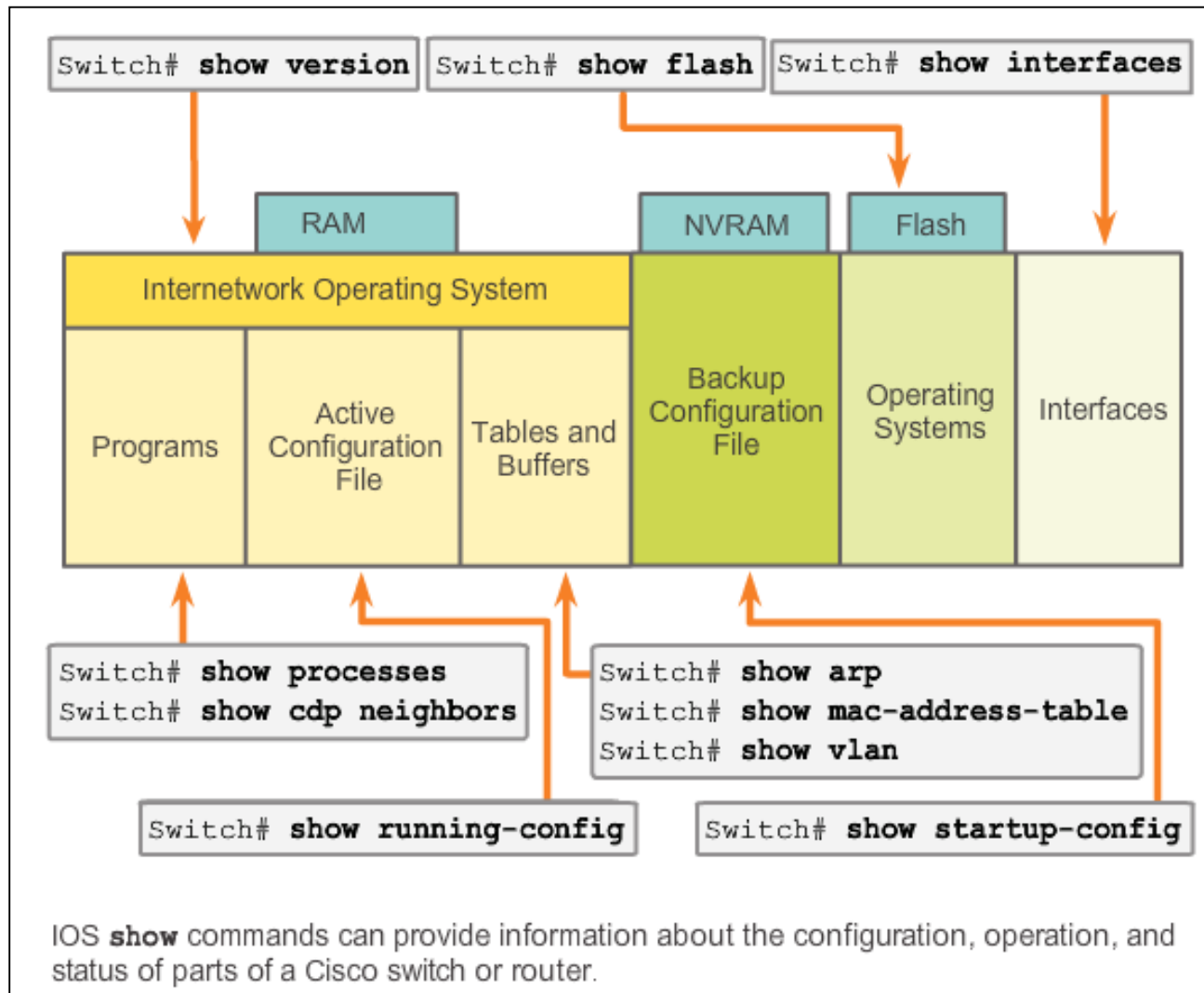
Hot Keys and Shortcuts

- **Tab –** Completes the remainder of a partially typed command or keyword.

- **Ctrl-R –** Redisplays a line.

- **Ctrl-A –** Moves to the beginning of the line.

- **Ctrl-Z –** Exits the configuration mode and returns to user EXEC.

- **Down Arrow –** Allows the user to scroll forward through former commands.

- **Up Arrow –** Allows the user to scroll backward through former commands.

- **Ctrl-shift-6 –** Allows the user to interrupt an IOS process such as **ping** or **traceroute**.

- **Ctrl-C –** Exits the current configuration or aborts the current command.

IOS Examination Commands

IOS **show** commands can provide information about the configuration, operation, and status of parts of a Cisco switch or router.

The show version Command

```
Router# show version
Cisco IOS Software, C1900 Software (C1900-UNIVERSALK9-M), Version
15.2(4)M1, RELEASE SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2012 by Cisco Systems, Inc.
Compiled Thu 26-Jul-12 19:34 by prod_rel_team

ROM: System Bootstrap, Version 15.0(1r)M15, RELEASE SOFTWARE (fc1)

cisco1941 uptime is 41 minutes
System returned to ROM by power-on
System image file is ""flash0:c1900-universalk9-mz.SPA.152-
4.M1.bin""
Last reload type: Normal Reload
Last reload reason: power-on




This product contains cryptographic features and is subject to
United
States and local country laws governing import, export, transfer
and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use
encryption.
```
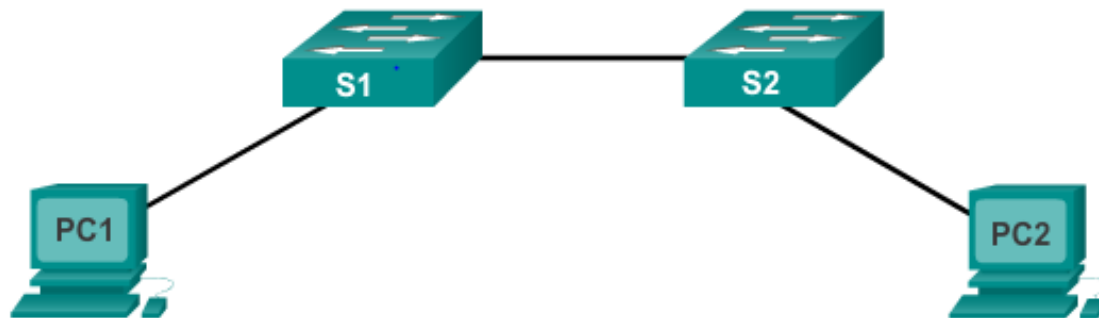
```
Router# show version
```

2.2 Getting Basic

Why the Switch

Let's focus on:

- Creating a two PC network connected via a switch
- Setting a name for the switch
- Limiting access to the device configuration
- Configuring banner messages
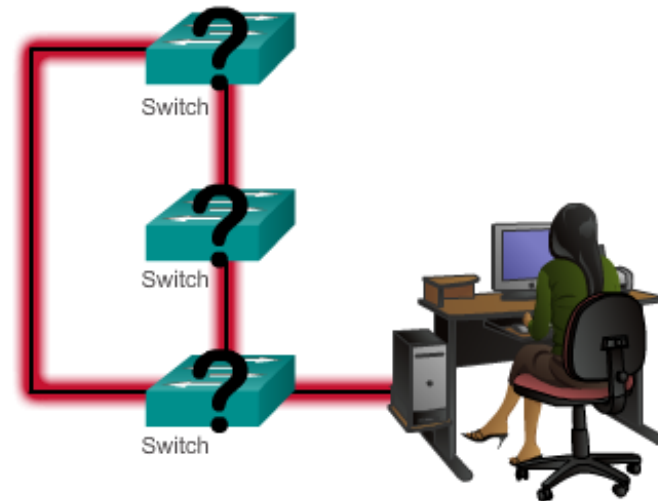- Saving the configuration

Device Names

Some guidelines for naming conventions:

- Start with a letter

- Contains no spaces

- Ends with a letter or digit

- Uses only letters, digits, and dashes
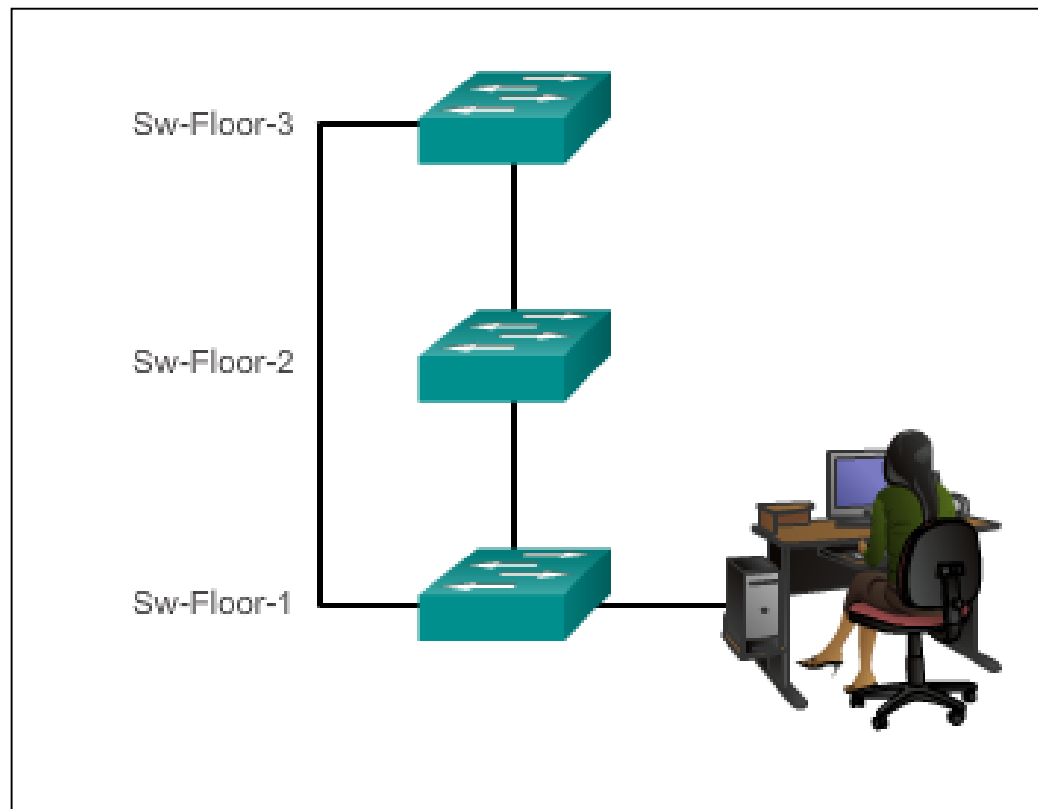
- Be less than 64 characters in length

Without names, network devices are difficult to identify for configuration purposes.

Configuring Device Names

Hostnames allow devices to be identified by network administrators over a network or the Internet.

Hostnames
Configuring Hostnames

Configure a Hostname

Configure the switch hostname to be 'Sw-Floor-1'.

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#hostname Sw-Floor-1
Sw-Floor-1(config)#
```

You successfully configured the switch hostname.

Securing Device Access

These are device access passwords:

- **enable password** – Limits access to the privileged EXEC mode
- **enable secret** – Encrypted, limits access to the privileged EXEC mode
- **console password** – Limits device access using the console connection
- **VTY password** – Limits device access over Telnet

Note: In most of the labs in this course, we will be using simple passwords such as **cisco** or **class**.

Securing Privileged EXEC Access Mode

- Use the **enable secret** command, not the older **enable password** command.

- The **enable secret** command provides greater security because the password is encrypted.

```
Sw-Floor-1>enable
Sw-Floor-1#
Sw-Floor-1#conf terminal
Sw-Floor-1(config)#enable secret class
Sw-Floor-1(config)#exit
Sw-Floor-1#
Sw-Floor-1#disable
Sw-Floor-1>enable
Password:
Sw-Floor-1#
```

Securing User EXEC Access

```
Sw-Floor-1(config)#line console 0
Sw-Floor-1(config-line)#password cisco
Sw-Floor-1(config-line)#login
Sw-Floor-1(config-line)#exit
Sw-Floor-1(config)#
Sw-Floor-1(config)#line vty 0 15
Sw-Floor-1(config-line)#password cisco
Sw-Floor-1(config-line)#login
Sw-Floor-1(config-line)#
```

- Console port must be secured; it reduces the chance of unauthorized personnel physically plugging a cable into the device and gaining device access.

- VTY lines allow access to a Cisco device via Telnet. The number of VTY lines supported varies with the type of device and the IOS version.

Encrypting Password Display

Configuring Password Encryption

```
Enter the command to encrypt the plain text passwords.

Switch(config)# service password-encryption

Exit global configuration mode and view the running configuration.

Switch(config)# exit

Switch# show running-config

!

<output omitted>

!

line con 0
 password 7 094F471A1A0A
 login

!

line vty 0 4
 password 7 03095A0F034F38435B49150A1819
 login

!

!

end
```

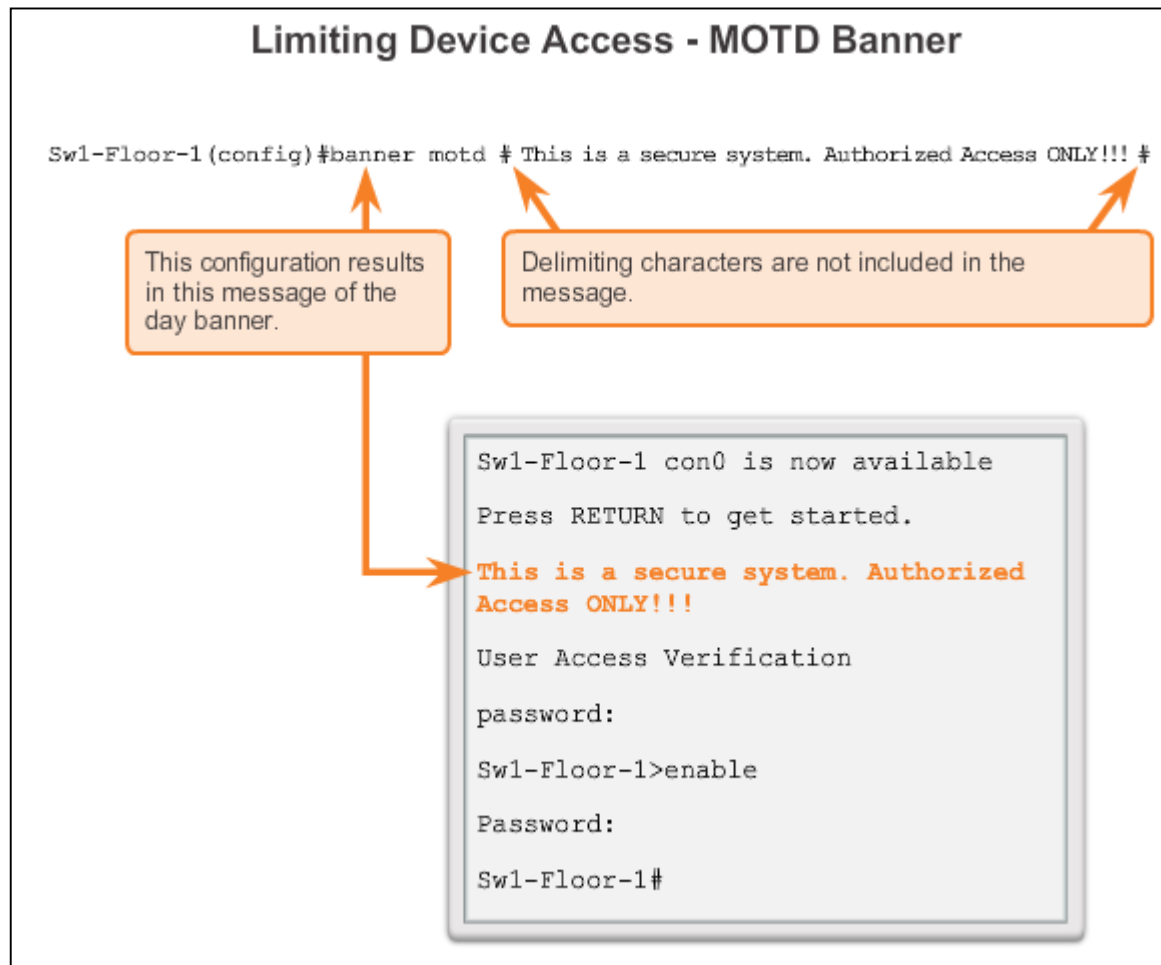### service password-encryption

- Prevents passwords from showing up as plain text when viewing the configuration

- Keeps unauthorized individuals from viewing passwords in the configuration file

- Once applied, removing the encryption service does not reverse the encryption

Banner Messages

- Important part of the legal process in the event that someone is prosecuted for breaking into a device

- Wording that implies that a login is "welcome" or "invited" is not appropriate

- Often used for legal notification because it is displayed to all connected terminals

Limiting Device Access - MOTD Banner

Sw1-Floor-1(config)#banner motd # This is a secure system. Authorized Access ONLY!!! #

This configuration results in this message of the day banner.

Delimiting characters are not included in the message.

```
Sw1-Floor-1 con0 is now available

Press RETURN to get started.

This is a secure system. Authorized
Access ONLY!!!

User Access Verification

password:

Sw1-Floor-1>enable

Password:

Sw1-Floor-1#
```

Configuration Files

Saving and Erasing the Configuration

Switch#**show running-config**

Switch#show running-config
Building configuration...
Current configuration : 2904 bytes
!
! Last configuration change at 00:02:32
UTC Mon Mar 1 1993
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
!

Lists the complete configuration currently active in RAM.

The active configuration can be copied to NVRAM.

Switch#**copy running-config startup-config**

- Switch# **reload**

  System configuration has been modified. Save? [yes/no]: **n**

  Proceed with reload? [confirm]

- Startup configuration is removed by using the **erase startup-config**

  Switch# **erase startup-config**

- On a switch, you must also issue the **delete vlan.dat**

  Switch# **delete vlan.dat**

  Delete filename [vlan.dat]?

  Delete flash:vlan.dat? [confirm]
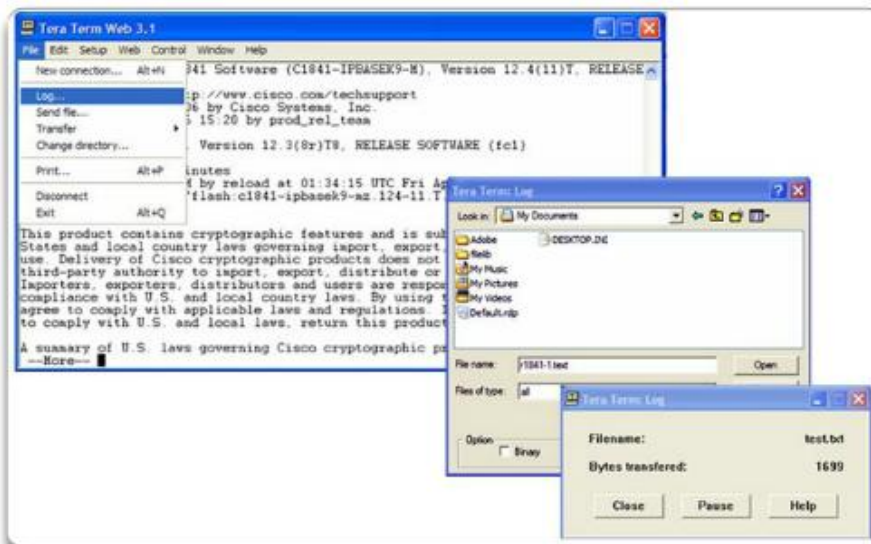
Capturing Text

Saving to a Text File in HyperTerminal
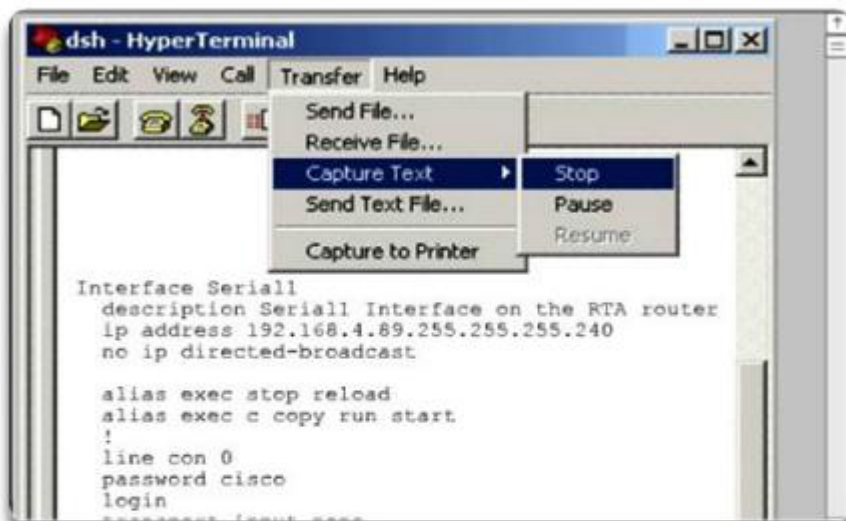
In the terminal session:
1. Start the text capture process
2. Issue a **show running-config** command
3. Stop the capture process
4. Save the text file

Saving to a Text File in Tera Term

In the terminal session:
1. Start the log process
2. Issue a **show running-config** command
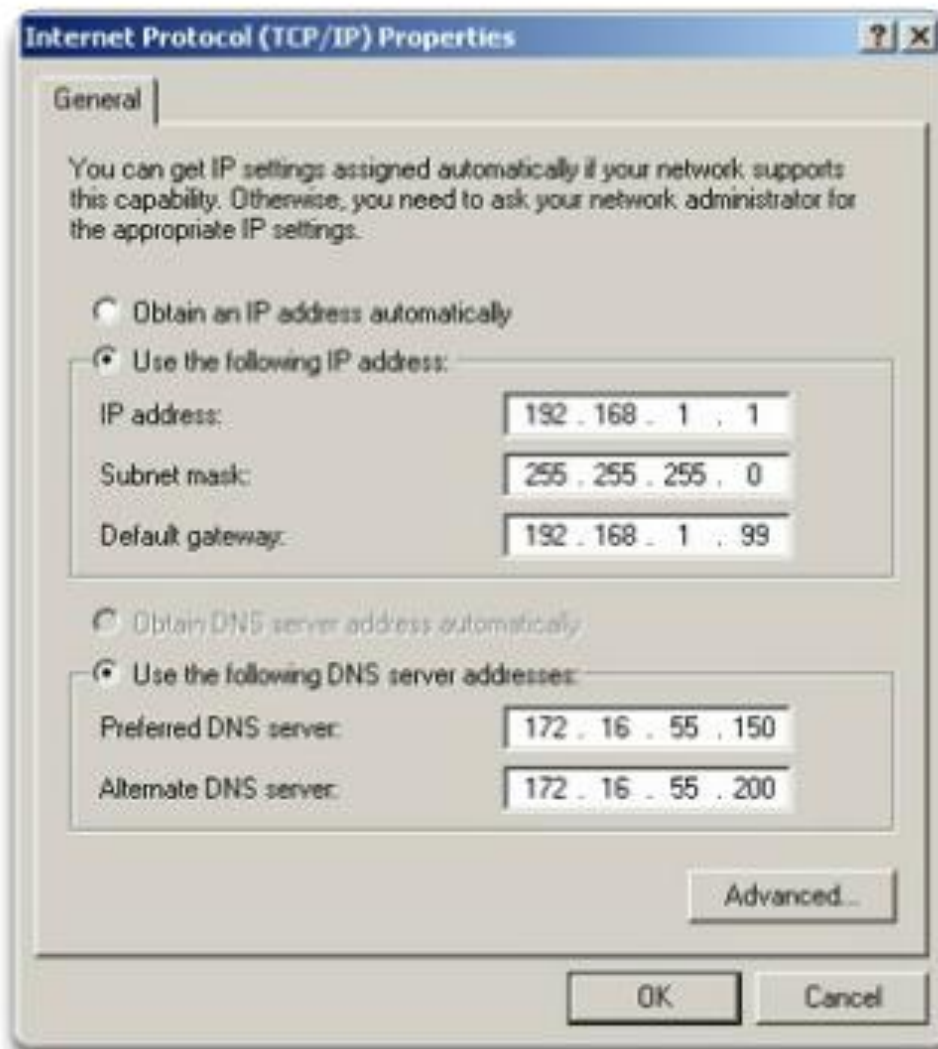3. Close the log

2.3 Addressing Schemes

IP Addressing of Devices

- Each end device on a network must be configured with an IP address.

- Structure of an IPv4 address is called *dotted decimal*.

- IP address displayed in decimal notation, with four decimal numbers between 0 and 255.

- With the IP address, a subnet mask is also necessary.

- IP addresses can be assigned to both physical ports and virtual interfaces.

Interfaces and Ports

- Network communications depend on end user device interfaces, networking device interfaces, and the cables that connect them.

- Types of network media include twisted-pair copper cables, fiber-optic cables, coaxial cables, or wireless.

- Different types of network media have different features and benefits.

- Ethernet is the most common local area network (LAN) technology.

- Ethernet ports are found on end user devices, switch devices, and other networking devices.

- Cisco IOS switches have physical ports for devices to connect to, but also have one or more switch virtual interfaces (SVIs; no physical hardware on the device associated with it; created in software).

- SVI provides a means to remotely manage a switch over a network.

Configuring a Switch Virtual Interface

- **IP address** – Together with subnet mask, uniquely identifies end device on internetwork.

- **Subnet mask** – Determines which part of a larger network is used by an IP address.

- `interface VLAN 1` – Available in interface configuration mode,

- `ip address 192.168.10.2 255.255.255.0` – Configures the IP address and subnet mask for the switch.

- **no shutdown** – Administratively enables the interface.

- Switch still needs to have physical ports configured and VTY lines to enable remote management.

Configuring a Switch Virtual Interface

Enter interface configuration mode for VLAN **1**.

```
Switch(config)# interface vlan 1
```

Configure the IP address as **'192.168.10.2'** and the subnet mask as **'255.255.255.0'**.

```
Switch(config-if)# ip address 192.168.10.2 255.255.255.0
```

Activate the interface.

```
Switch(config-if)# no shutdown
%LINK-5-CHANGED: Interface Vlan1, changed state to up
```

Manual IP Address Configuration for End Devices

Automatic IP Address Configuration for End Devices

IP Address Conflicts

Network Error

Windows has detected an IP address conflict

Another computer on this network has the same IP address as this computer. Contact your network administrator for help resolving this issue. More details are available in the Windows System event log.

Close
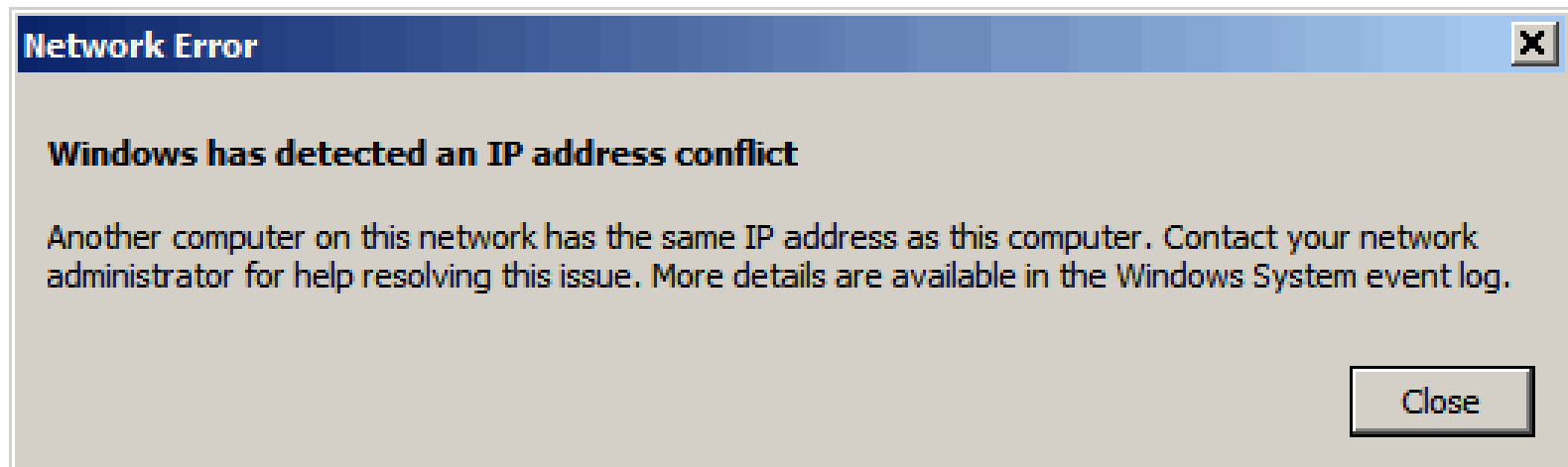
Test the Loopback Address on an End Device

Testing the Interface Assignment

Verifying the VLAN Interface Assignment

Enter the command to verify the interface configuration on S1.

```
S1# show ip interface brief
Interface          IP-Address      OK?  Method  Status      Protocol
FastEthernet0/1    unassigned      YES  manual  up          up
FastEthernet0/2    unassigned      YES  manual  up          up
<output omitted>
Vlan1              192.168.10.2    YES  manual  up          up
```

You are now on S2. Enter the command to verify the interface configuration on S2.

```
S2# show ip interface brief
Interface          IP-Address      OK?  Method  Status      Protocol
FastEthernet0/1    unassigned      YES  manual  up          up
FastEthernet0/2    unassigned      YES  manual  up          up
<output omitted>
Vlan1              192.168.10.3    YES  manual  up          up
```

You successfully verified the interface assignment on S1 and S2.

Testing End-to-End Connectivity

Enter the command to verify connectivity to PC2 at '192.168.10.11'.

```
C:\> ping 192.168.10.11

Pinging 192.168.10.11 with 32 bytes of data:
Reply from 192.168.10.11: bytes=32 time=838ms TTL=35
Reply from 192.168.10.11: bytes=32 time=820ms TTL=35
Reply from 192.168.10.11: bytes=32 time=883ms TTL=36
Reply from 192.168.10.11: bytes=32 time=828ms TTL=36

Ping statistics for 192.168.10.11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 820ms, Maximum = 883ms, Average = 842ms

C:\>
```
You successfully verified connectivity to S1 and PC2.

Chapter 2 Summary

Cisco IOS:

- The technician can enter commands to configure, or program, the device to perform various networking functions.

- Services are generally accessed using a command-line interface (CLI), which is accessed by either the console port, the AUX port, or through telnet or SSH.

- Once connected to the CLI, network technicians can make configuration changes to Cisco IOS devices.

- Cisco IOS is designed as a modal operating system, which means a network technician must navigate through various hierarchical modes of the IOS.

- Cisco IOS routers and switches support a similar modal operating system, support similar command structures, and support many of the same commands. In addition, both devices have identical initial configuration steps when implementing them in a network.

Chapter 2 Summary (cont.)

```
User EXEC Command-Router>
ping
show (limited)
enable
etc.
```

Chapter 2 Summary (cont.)

```
Privileged EXEC Commands-Router#
all User EXEC commands
debug commands
reload         Global Configuration Commands-Router(config)#
configure      hostname
etc.           enable secrect
               ip route

               interface ethernet     Interface Commands-Router(config-if)#
                       serial          ip address
                       dsl             ipv6 address
                       etc.            encapsulation
                                       shutdown/ no shutdown
                                       etc.

               router   rip            Routing Engine Commands-Router(config-router)#
                        ospf           network
                        eigrp          version
                        etc.           auto summary
                                       etc.

               line     vty            Line Commands-Router(config-line)#
                        console        password
                        etc.           login
                                       modem commands
                                       etc.
```

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