



## 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

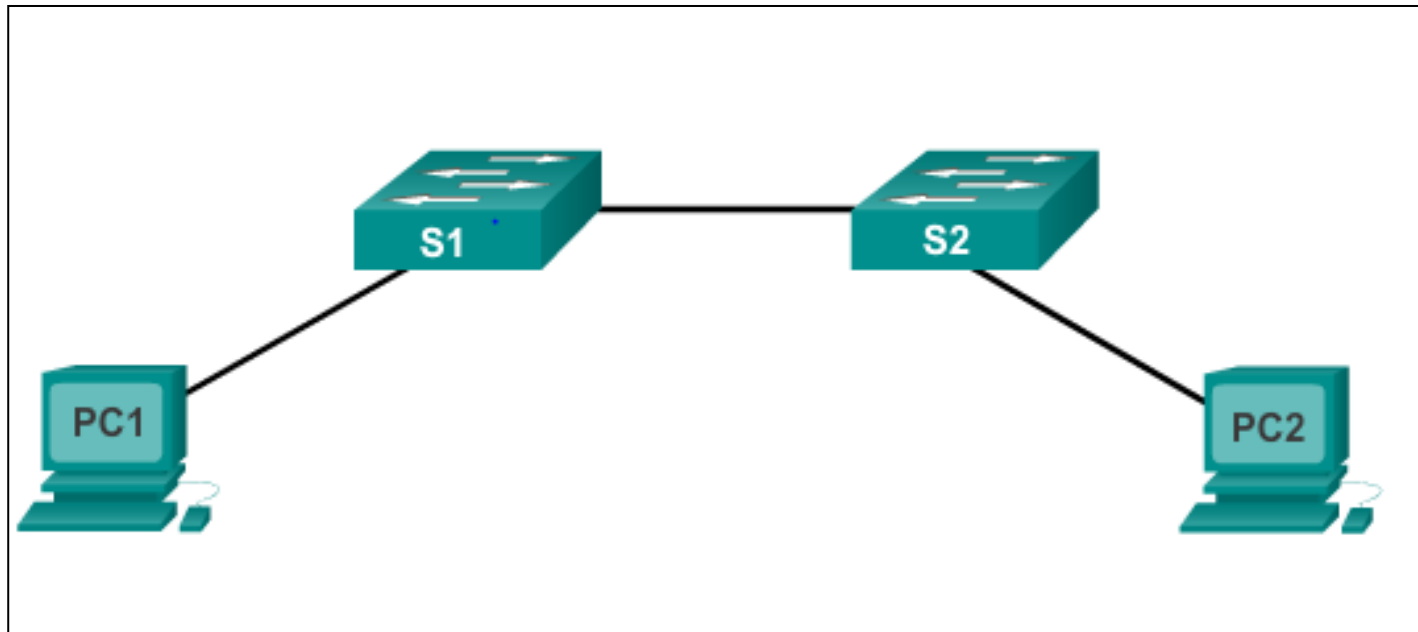


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# Cisco IOS Operating Systems

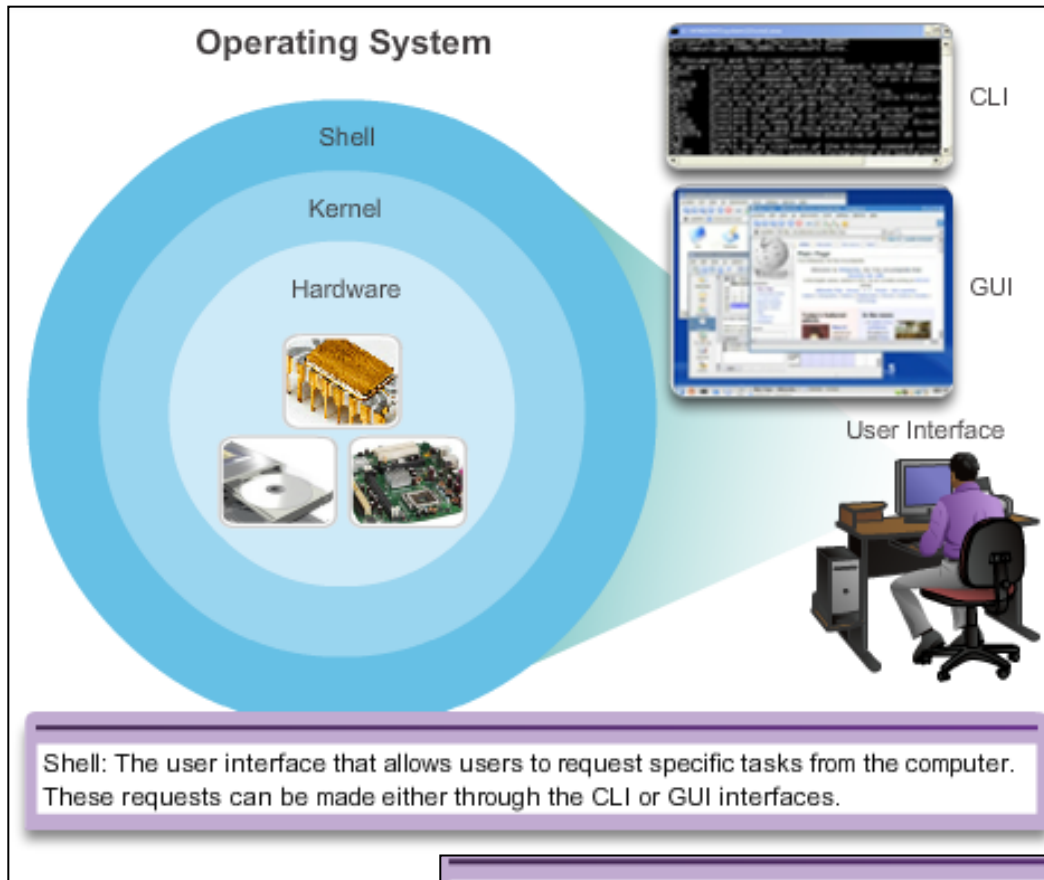
- All networking equipment dependent on operating systems
- The operating system on home routers is usually called firmware
- Cisco IOS – Collection of network operating systems used on Cisco devices





# Cisco IOS

## Operating Systems (cont.)



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.



Cisco IOS

# 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







# Cisco IOS

## IOS Functions

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





## Accessing a Cisco IOS Device

# Console Access Method

Most common methods to access the CLI:

- Console
- Telnet or SSH
- AUX port



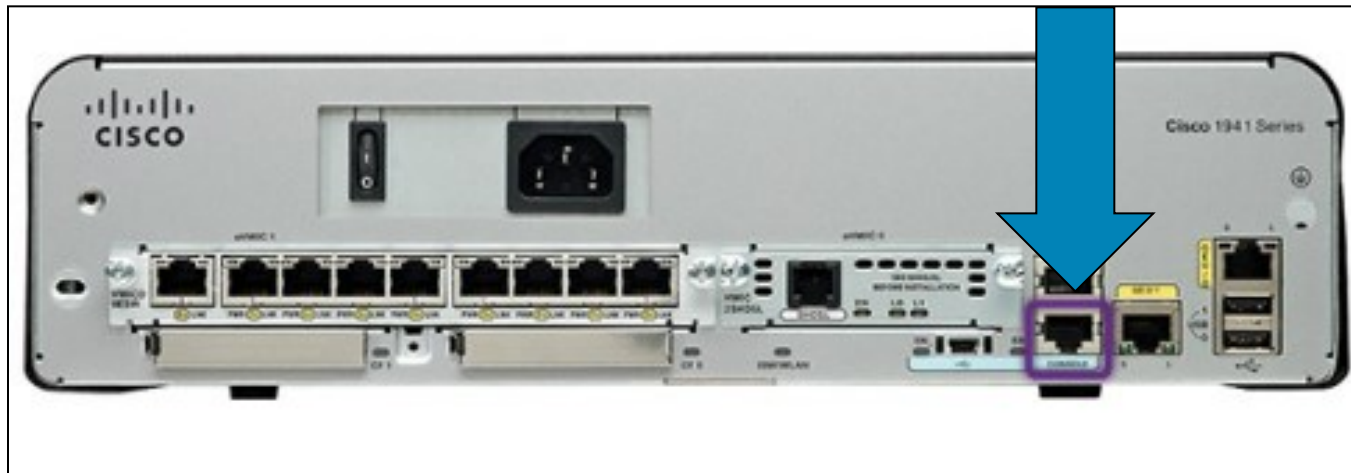


## Accessing a Cisco IOS Device

# 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



## Accessing a Cisco IOS Device

# 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



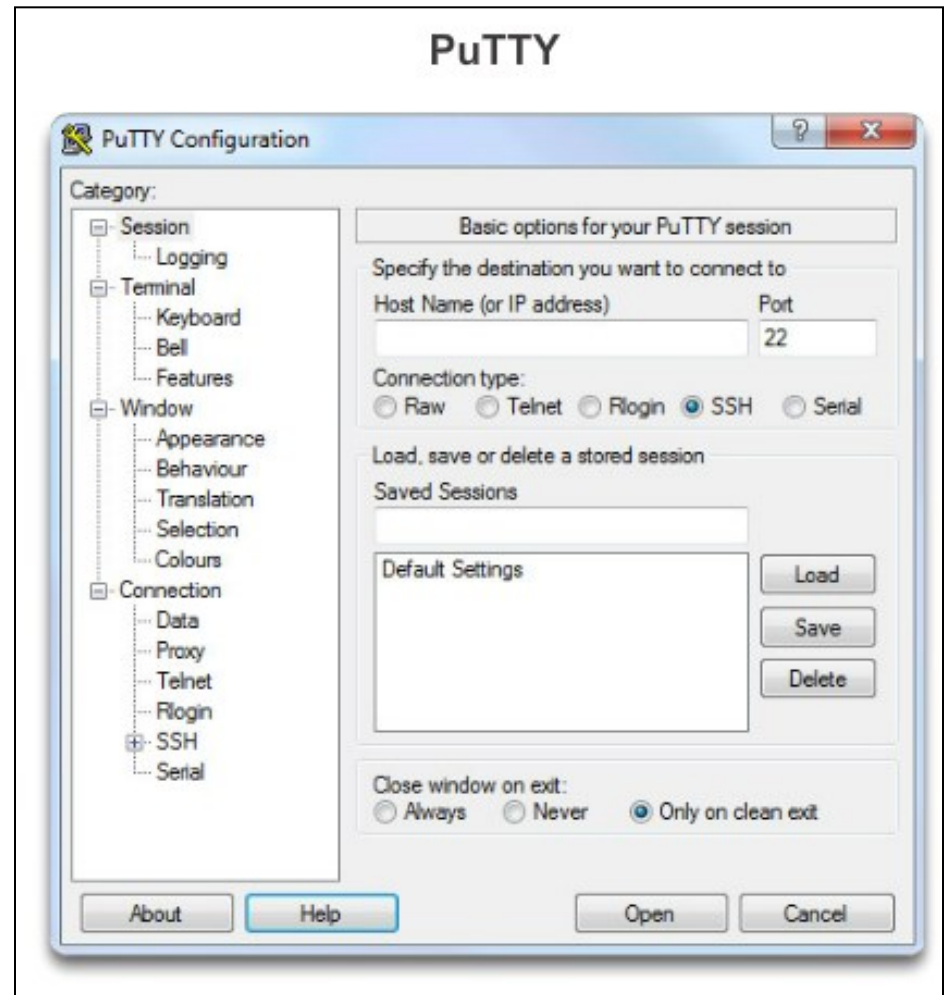


## Accessing a Cisco IOS Device

# Terminal Emulation Programs

Software available for connecting to a networking device:

- PuTTY
- Tera Term
- SecureCRT
- HyperTerminal
- OS X Terminal

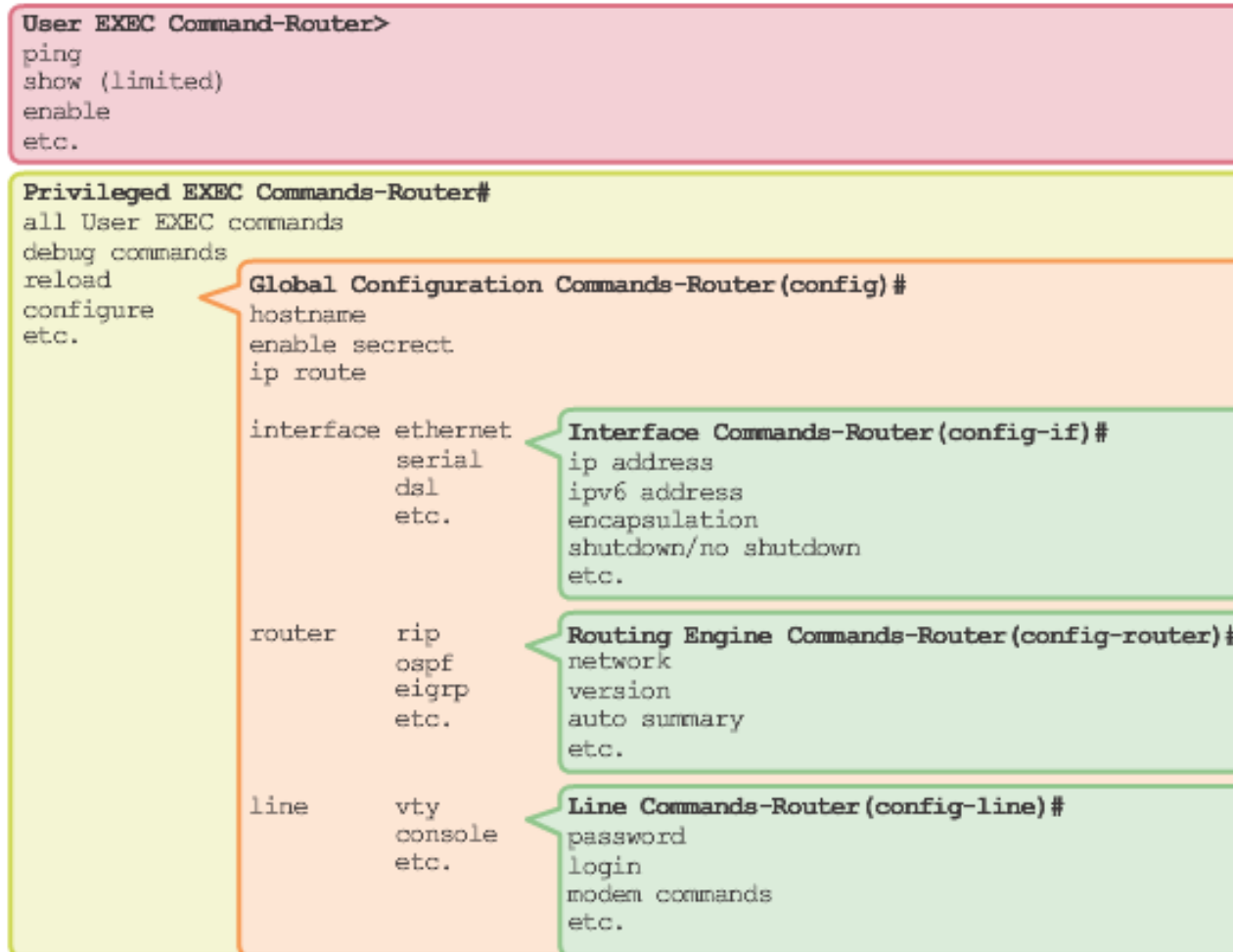




# Navigating the IOS

## Cisco IOS Modes of Operation

### IOS Mode Hierarchical Structure





# Navigating the IOS

## 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

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

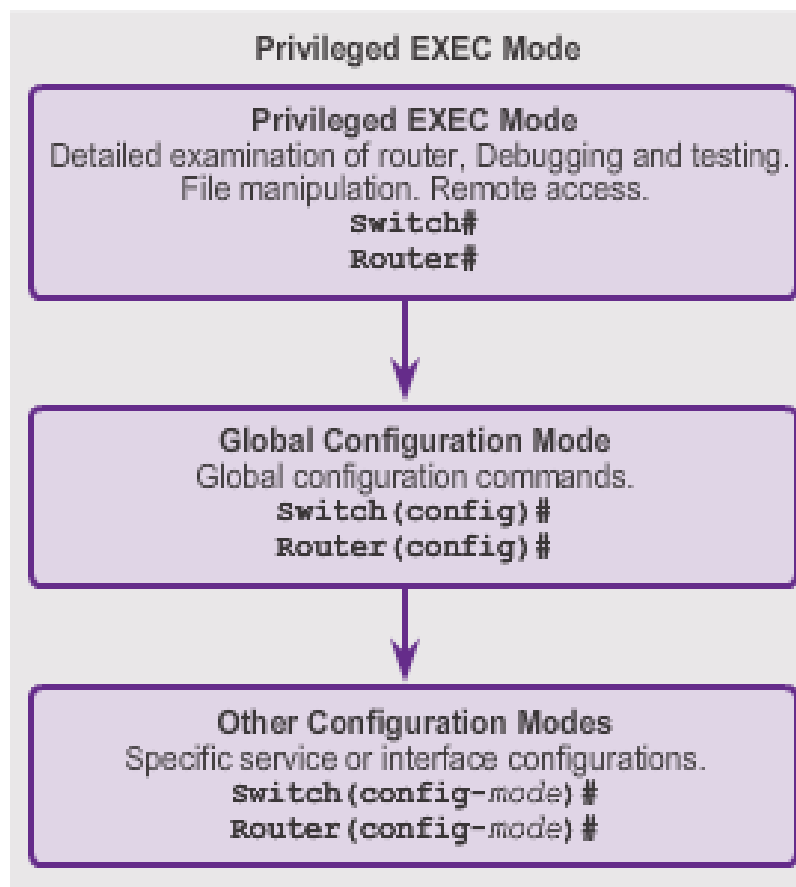
Detailed examination of router. Debugging and testing. File manipulation. Remote access.

```
switch#
Router#
```



## Navigating the IOS

# Global Configuration Mode and Submodes



### 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 the IOS

# 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 the IOS

## 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#
```

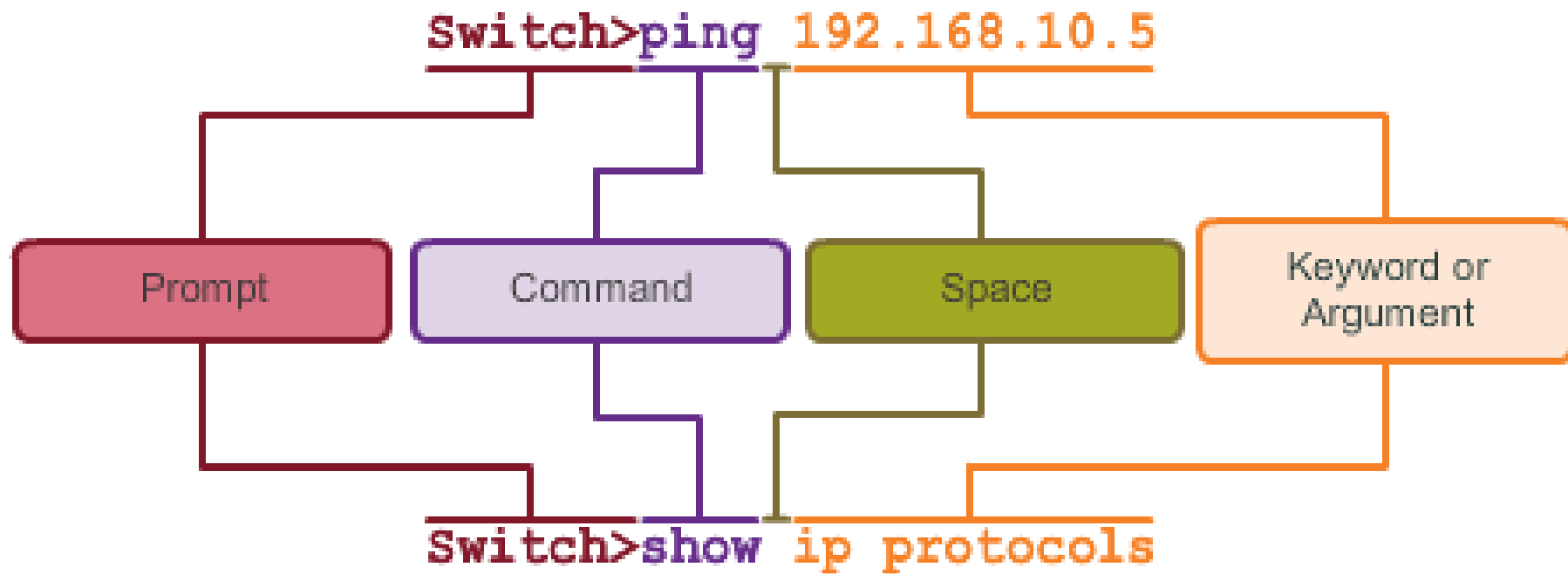
```
Switch# configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
Switch(config)# vlan 1
Switch(config-vlan)# end
Switch#
```

```
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#
```



## The Command Structure

# IOS Command Structure





## The Command Structure

# 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.



# The Command Structure

## 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#
```



## The Command Structure

# 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.



## The Command Structure

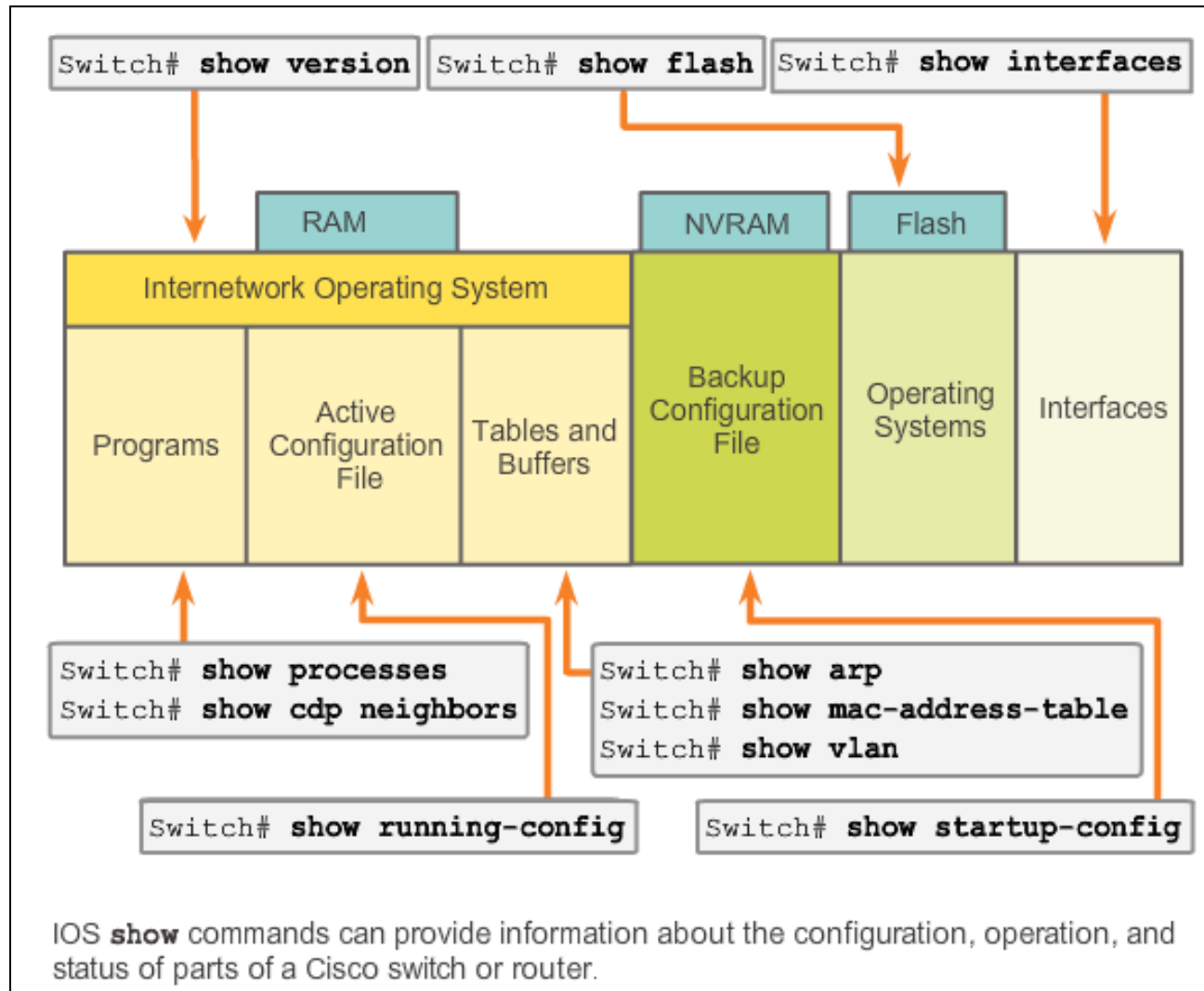
# Hot Keys and Shortcuts

- **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.



## The Command Structure

# IOS Examination Commands







## The Command Structure

# 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



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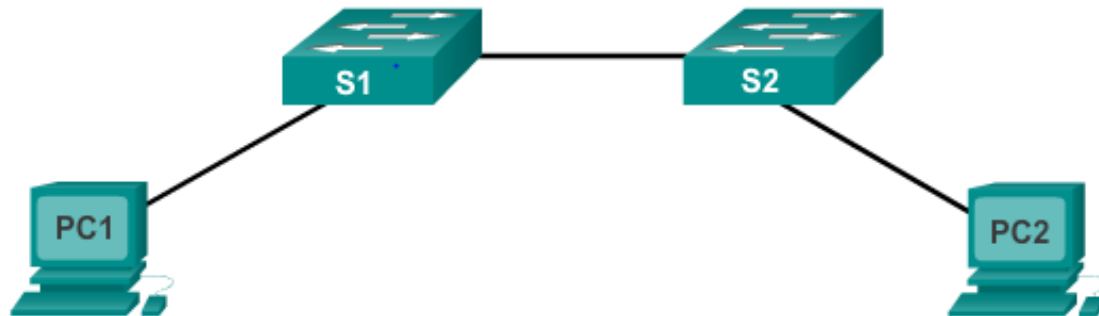


## Hostnames

# 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





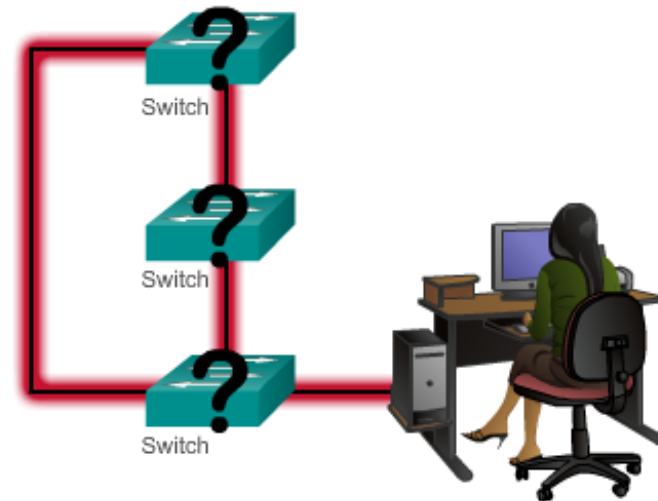
## Hostnames

# 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

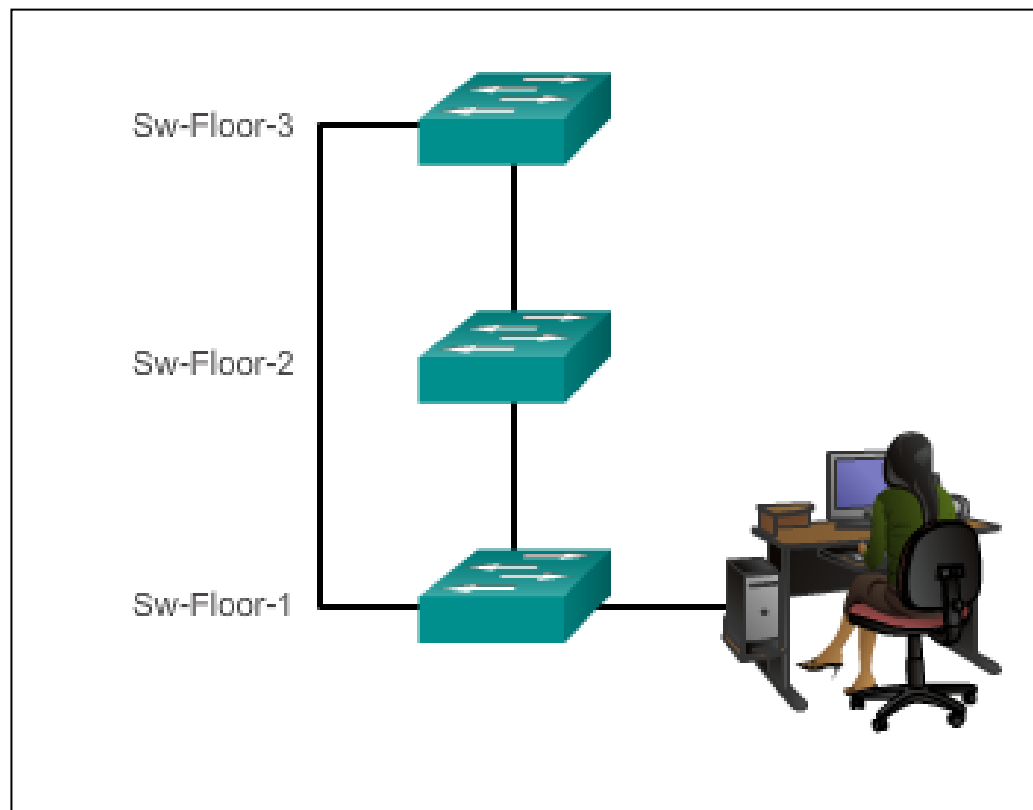
Without names, network devices are difficult to identify for configuration purposes.



## Hostnames

# 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.**



## Limiting Access to Device Configurations

# 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**.



## Limiting Access to Device Configurations

# 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#
```





## Limiting Access to Device Configurations

# 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.



# Limiting Access to Device Configurations

## 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
  
```

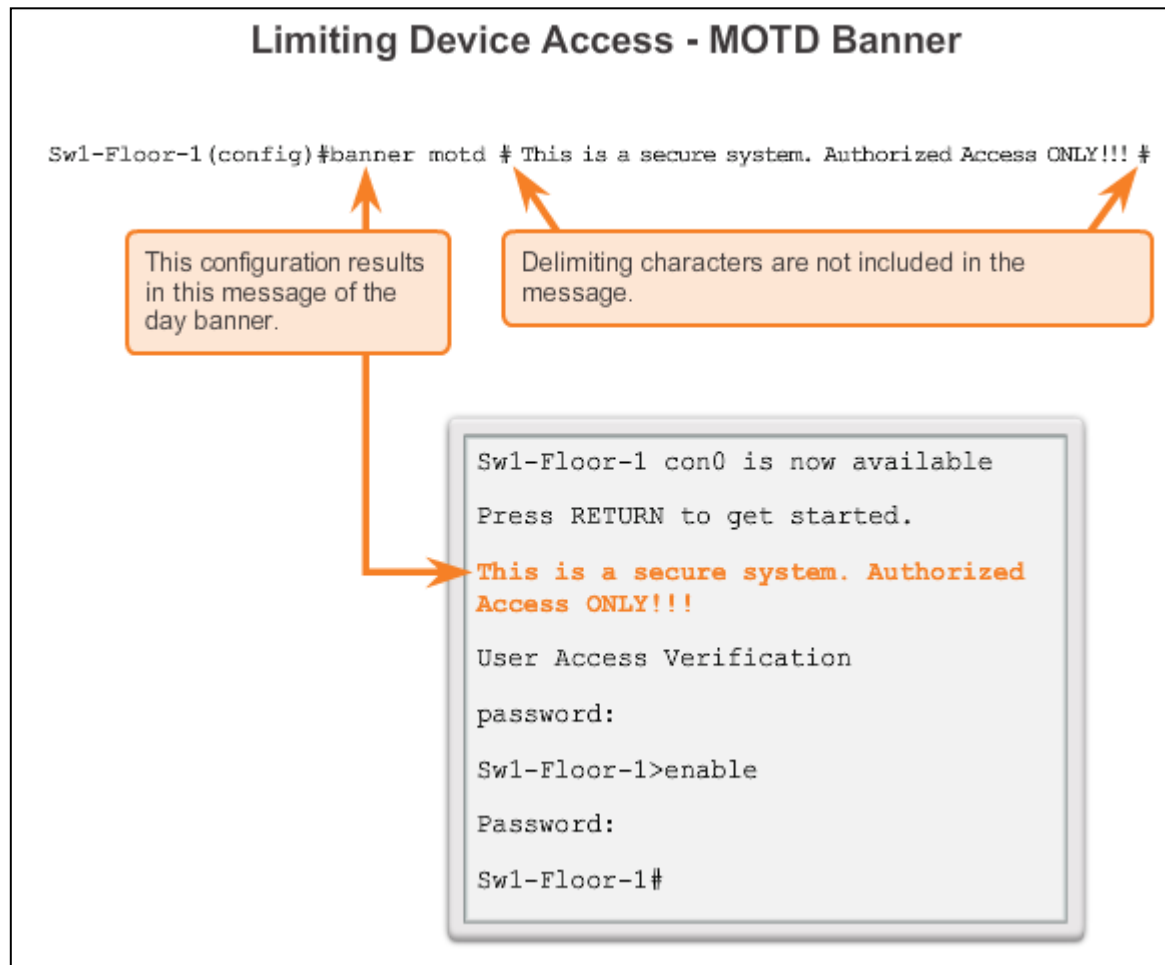
### service password-encryption

- 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

# Limiting Access to Device Configurations

## 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

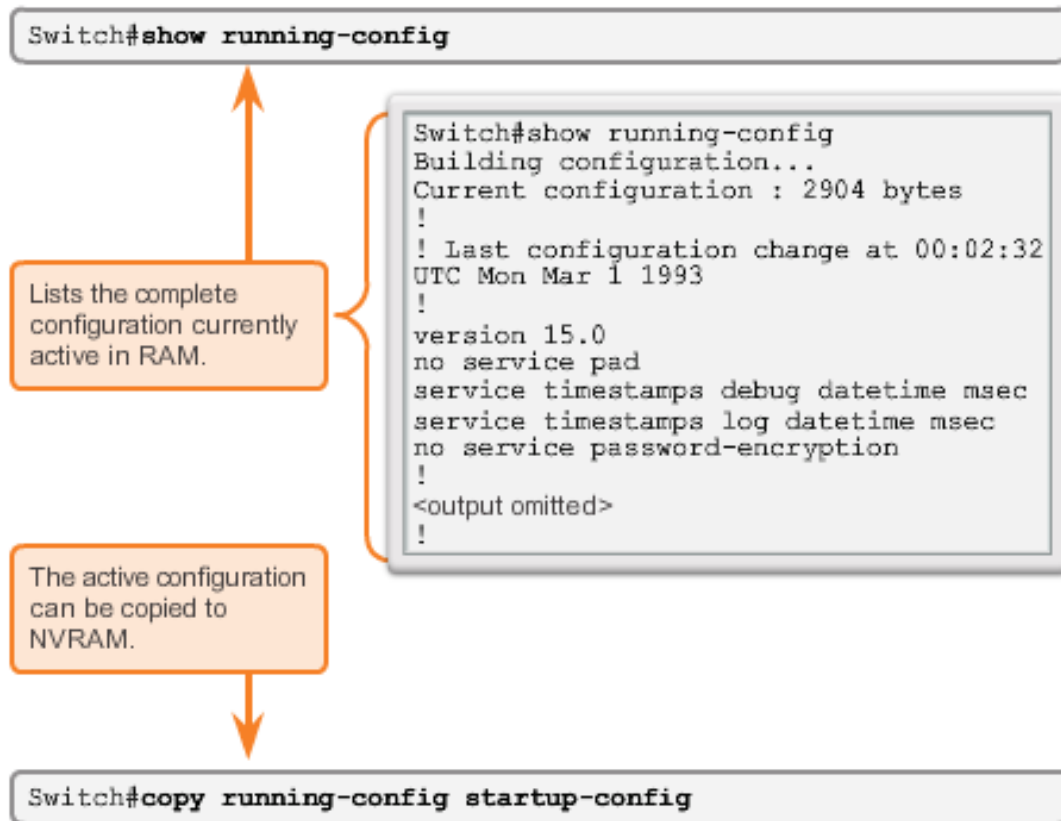




# Saving Configurations

## Configuration Files

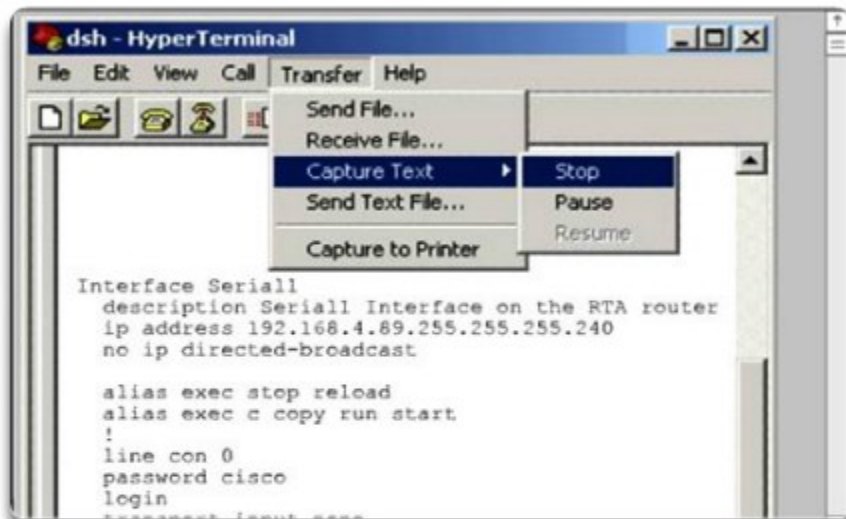
### Saving and Erasing the Configuration



- 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]

# Saving Configurations Capturing Text

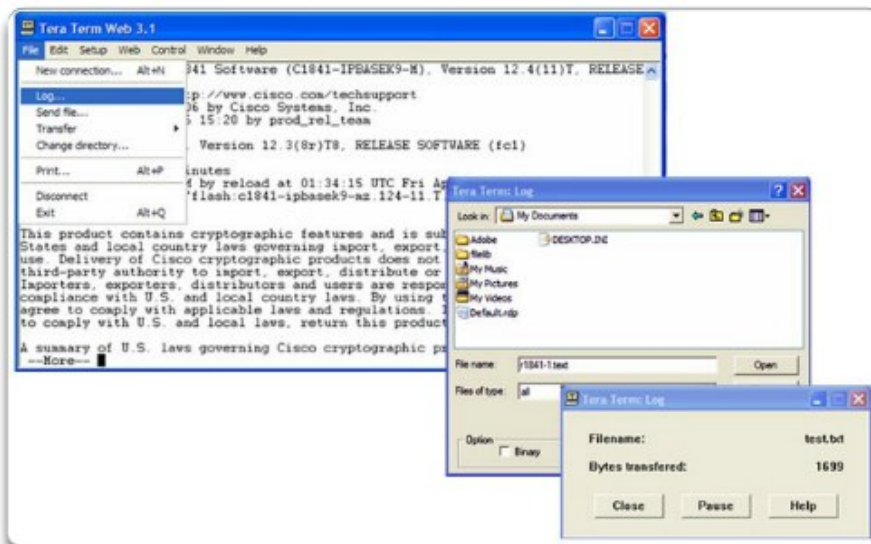
## Saving to a Text File in HyperTerminal



### 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



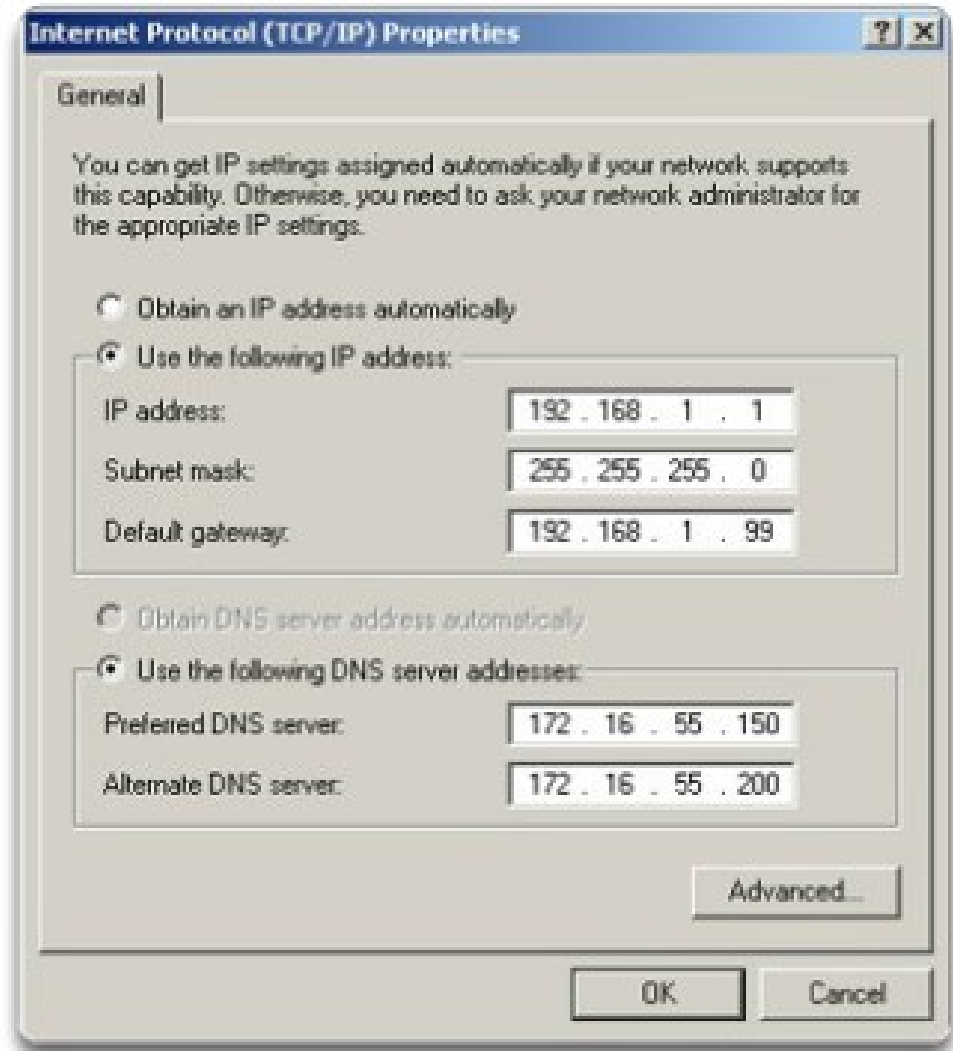
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## Ports and Addresses

# 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.







## Ports and Addresses

# 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.







## Addressing Devices

# 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.



## Addressing Devices

# 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
```



# Addressing Devices

## Manual IP Address Configuration for End Devices

**Addressing End Devices**

For manual static assignments, enter addresses:

IP address

Subnet mask

Default gateway

**Local Area Connection Properties**

Connect using:

Intel(R) PRO/100 VE Network Connection

Configure

Components checked are used by this connection:

- ☒ Client for Microsoft Networks
- ☒ File and Printer Sharing for Microsoft Networks
- ☒ Internet Protocol (TCP/IP)

**Internet Protocol (TCP/IP) Properties**

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

☐ Obtain an IP address automatically

☒ Use the following IP address:

IP address: 192.168.1.1

Subnet mask: 255.255.255.0

Default gateway: 192.168.1.99

☐ Obtain DNS server address automatically

☒ Use the following DNS server addresses:

Preferred DNS server: 172.16.55.150

Alternate DNS server: 172.16.55.200

Advanced...

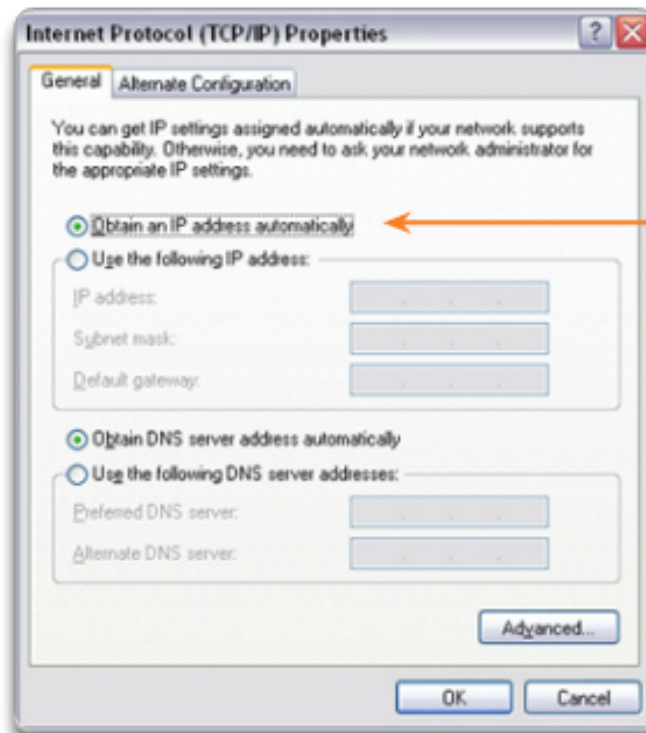
OK Cancel



# Addressing Devices

## Automatic IP Address Configuration for End Devices

### Assigning Dynamic Addresses

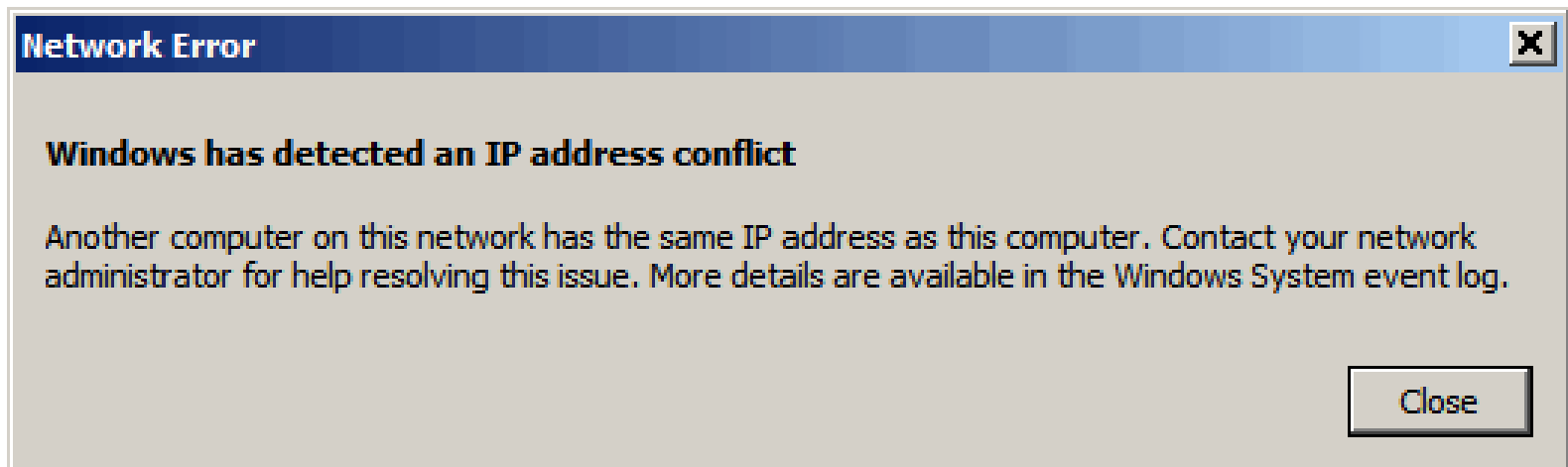


This property will set the device to obtain an IP address automatically.



## Addressing Devices

# IP Address Conflicts



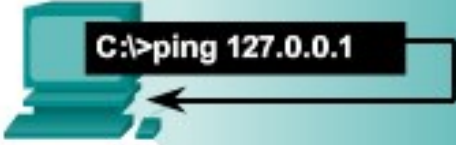


## Verifying Connectivity


# Test the Loopback Address on an End Device

**Testing Local TCP/IP Stack**

Pinging the local host confirms that TCP/IP is installed and working on the local network adapter.



Pinging **127.0.0.1** causes a device to ping itself.





## Verifying Connectivity

# 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.



# Verifying Connectivity

## 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.**





# Configuring a Network Operating System

## 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.



# Configuring a Network Operating System

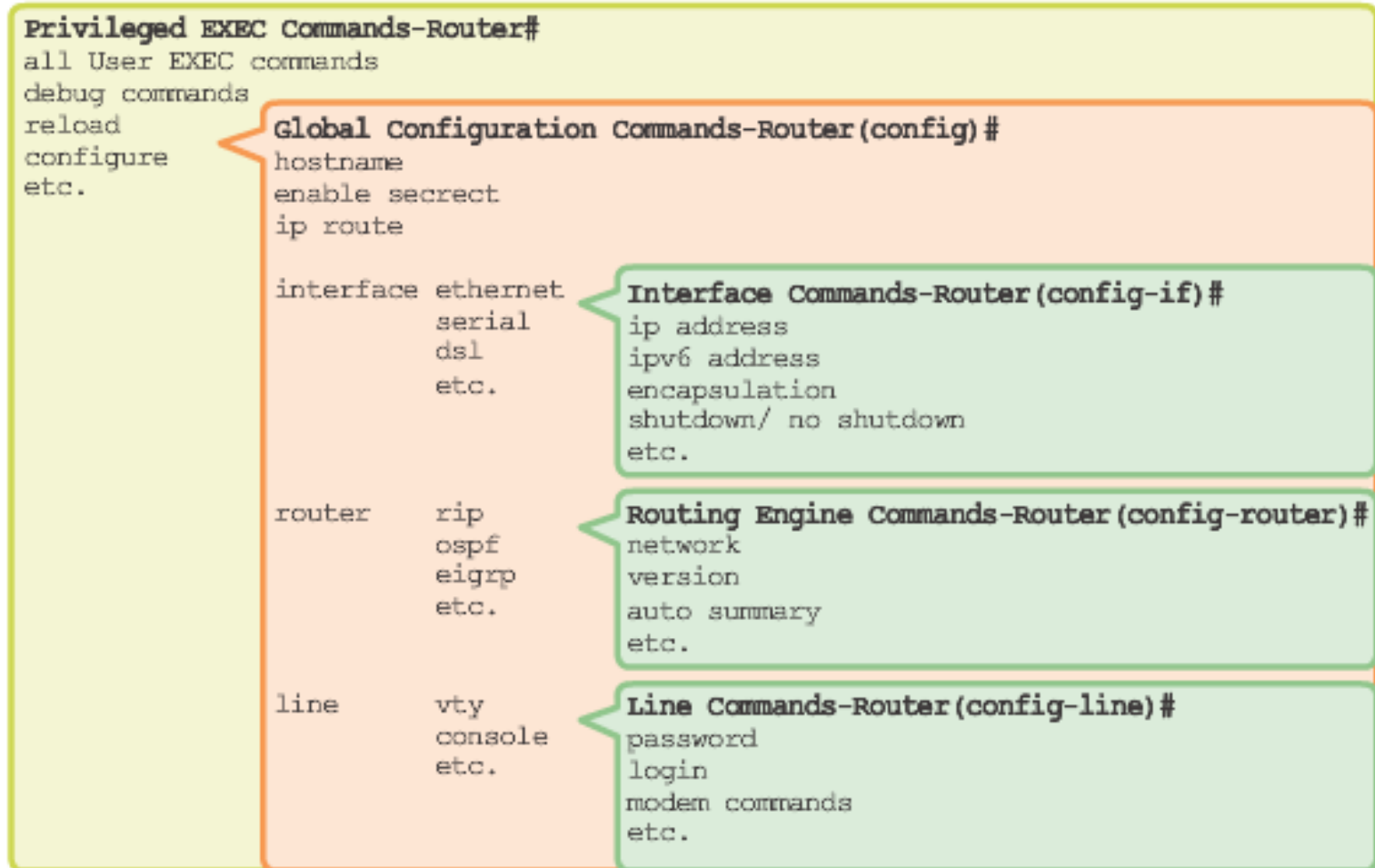
## Chapter 2 Summary (cont.)

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



# Configuring a Network Operating System

## Chapter 2 Summary (cont.)



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