Network Device Management

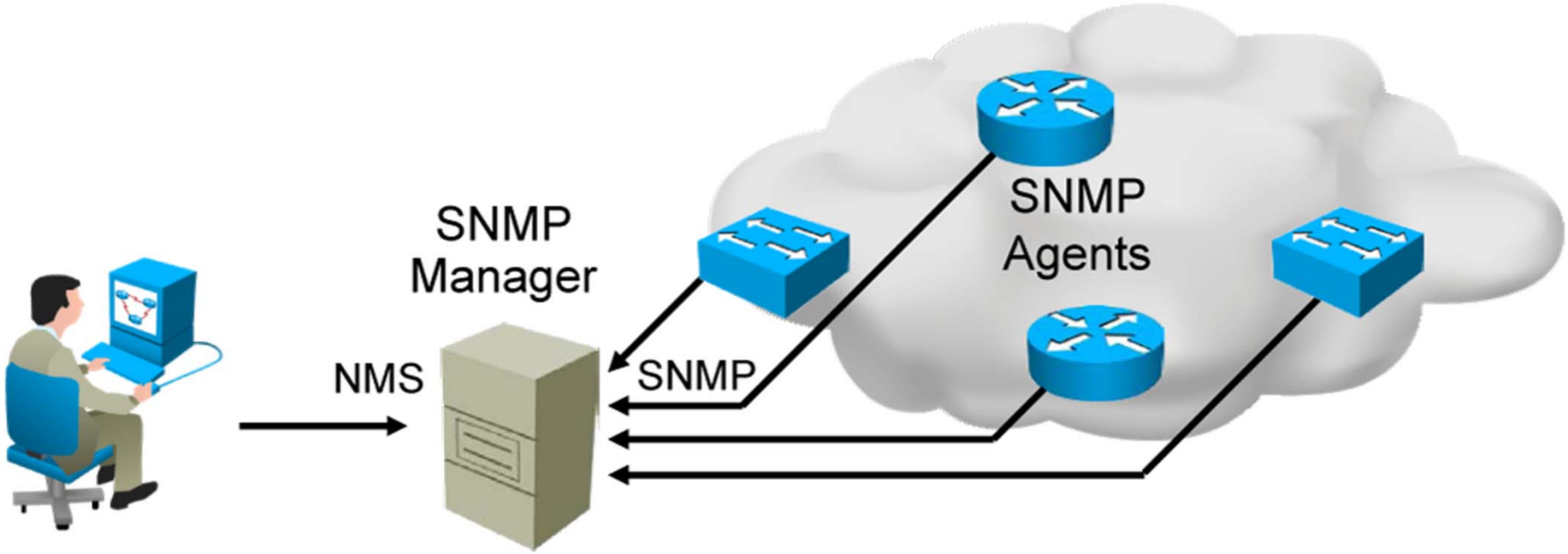
Interconnecting Cisco Networking Devices, Part 2 (ICND2) v2.0

Configuring Network Devices to Support Network Management Protocols

Network Device Management

SNMP Overview

- NMS polls the SNMP agent on the network device to obtain statistics.
- Analyzing and representing the results:
  - Graphing
  - Reporting
- Thresholds can be set to trigger a notification process when exceeded.

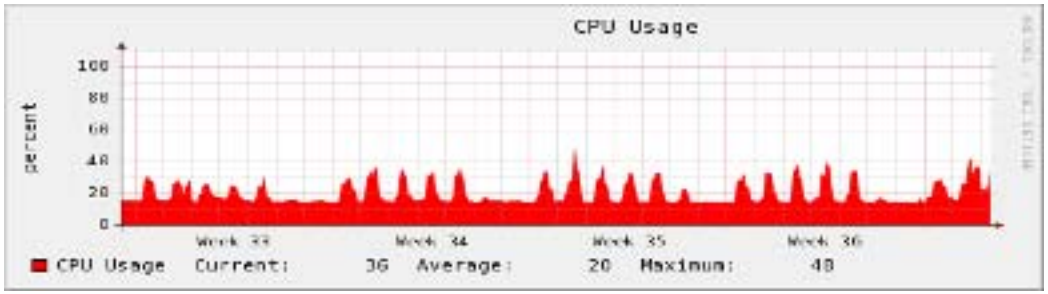


SNMP Versions

SNMP Version	Security	Bulk Retrieval Mechanism
SNMPv1	Plaintext authentication with community strings	No
SNMPv2c	Plaintext authentication with community strings	Yes
SNMPv3	Strong authentication, confidentiality, and integrity	Yes

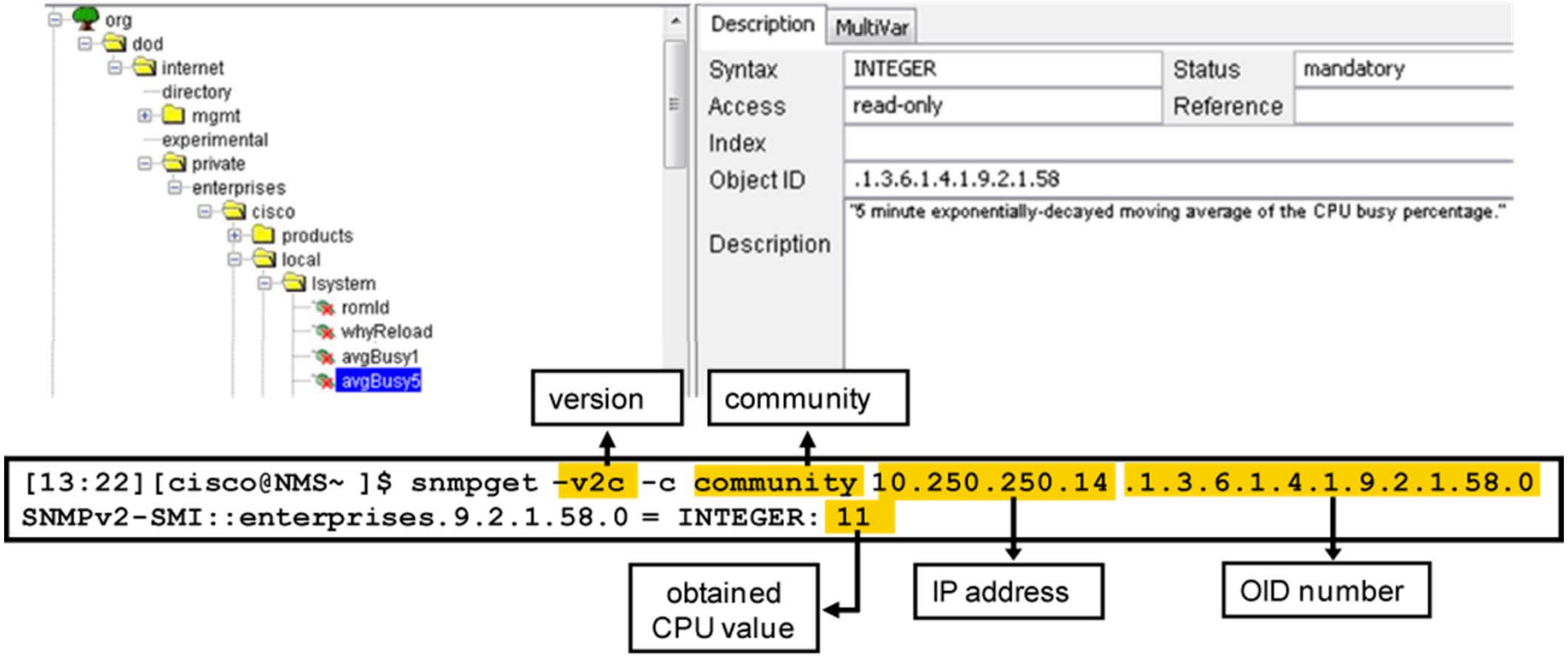
Obtaining Data from an SNMP Agent

An SNMP graphing tool periodically polls an SNMP agent (for example, a router) and graphs obtained values:



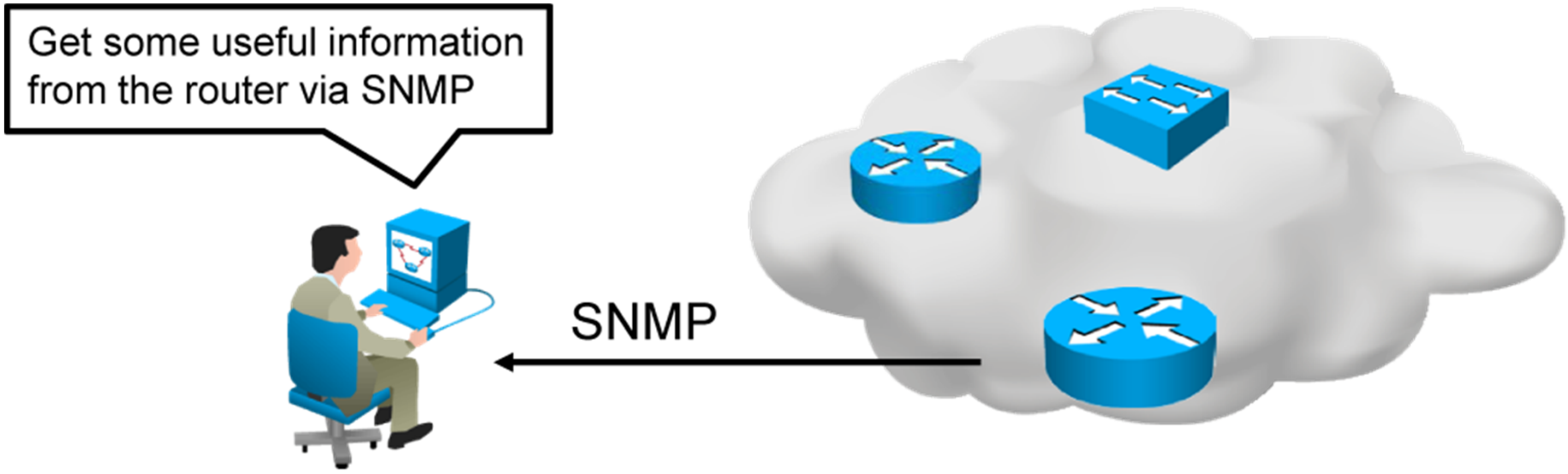
Obtaining Data from an SNMP Agent (Cont.)

- MIB is a collection of information that is organized hierarchically.
- OIDs uniquely identify managed objects in an MIB.
  - A 5-minute, exponentially moving average of the CPU busy percentage: 1.3.6.1.4.1.9.2.1.58.0

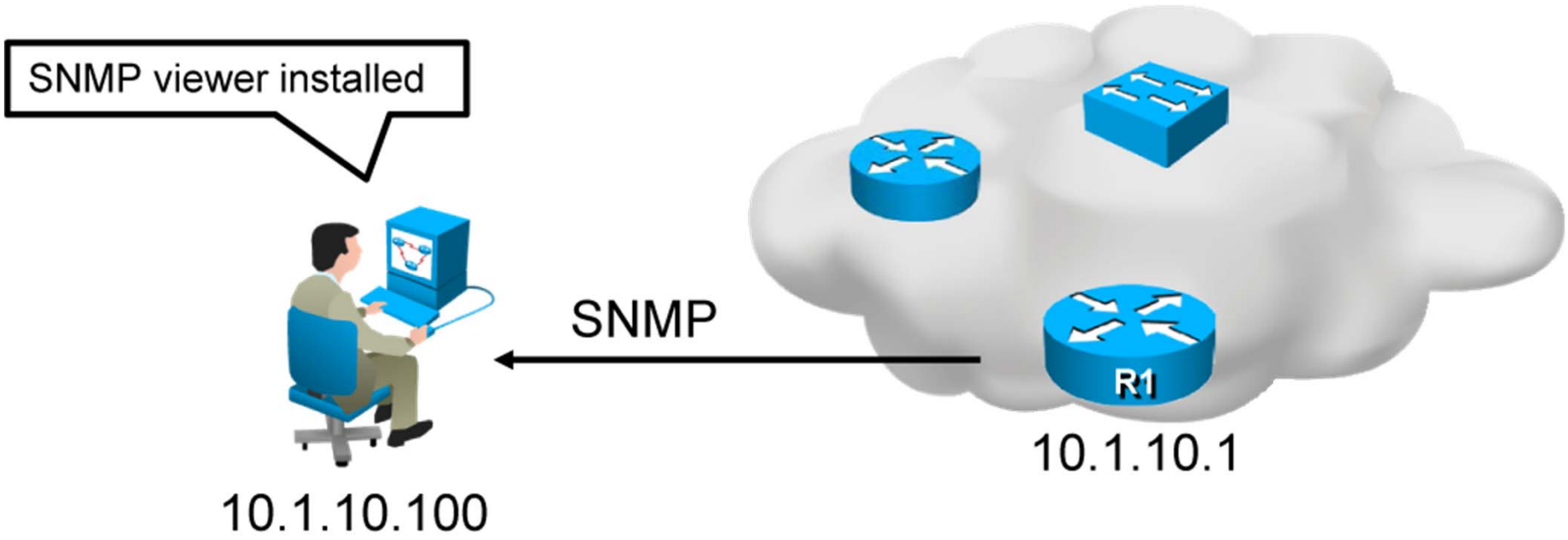


SNMP Configuration

- Enable SNMP read-write access to the router
- Configure SNMP contact
- Configure SNMP location



SNMP Configuration (Cont.)




```
R1(config)#snmp-server community Cisco RW
R1(config)#snmp-server location San Jose
R1(config)#snmp-server contact Joe Summer
```

- SNMP configuration on R1

Syslog Overview

- Syslog is a protocol that allows a network device to send event notification messages across IP networks to event message collectors.
- A device can be configured so that it generates a syslog message and forwards it to various destinations:
  - logging buffer
  - console line
  - terminal lines
  - syslog server

Syslog Message Format

```
seq no:timestamp: %facility-severity-MNEMONIC:description
```

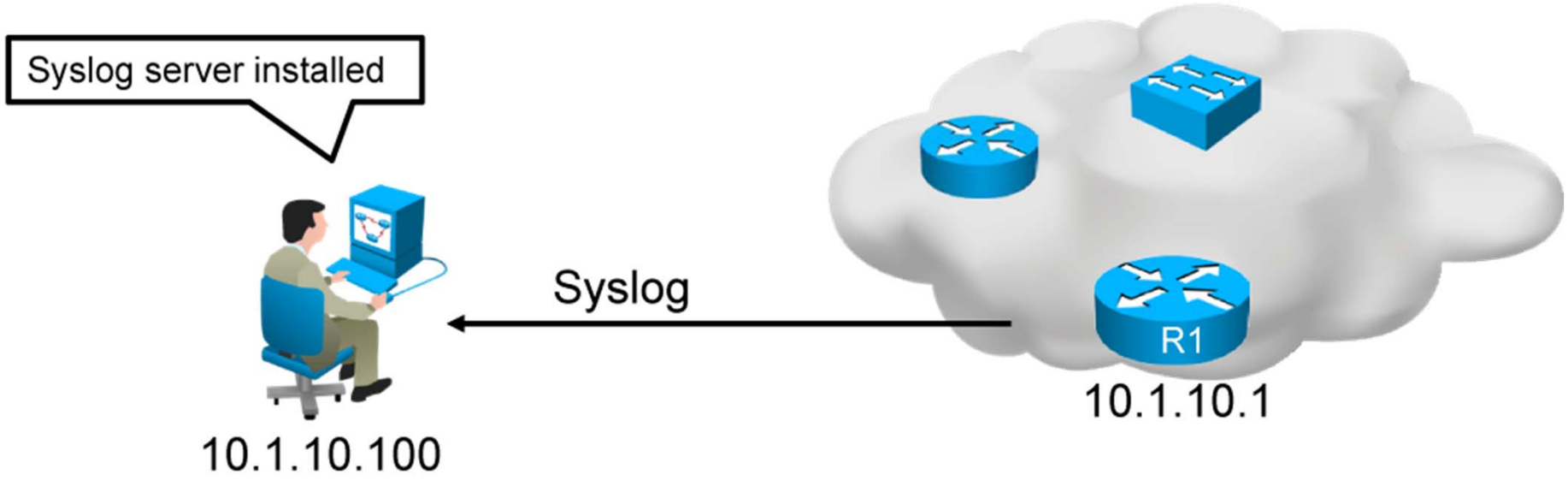
- The general format of syslog messages is generated by the syslog process on Cisco IOS Software.

```
*Apr 22 11:05:55.423: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/22, changed state to up
```

- An example of a syslog message is informing the administrator that FastEthernet 0/22 came up.

Syslog Configuration

- Specify the syslog server host as a destination for syslog messages.
- Limit the syslog messages that are sent to the syslog server, based on severity.




```
R1(config)#logging 10.1.10.100
R1(config)#logging trap informational
```

- Configuration of syslog on R1

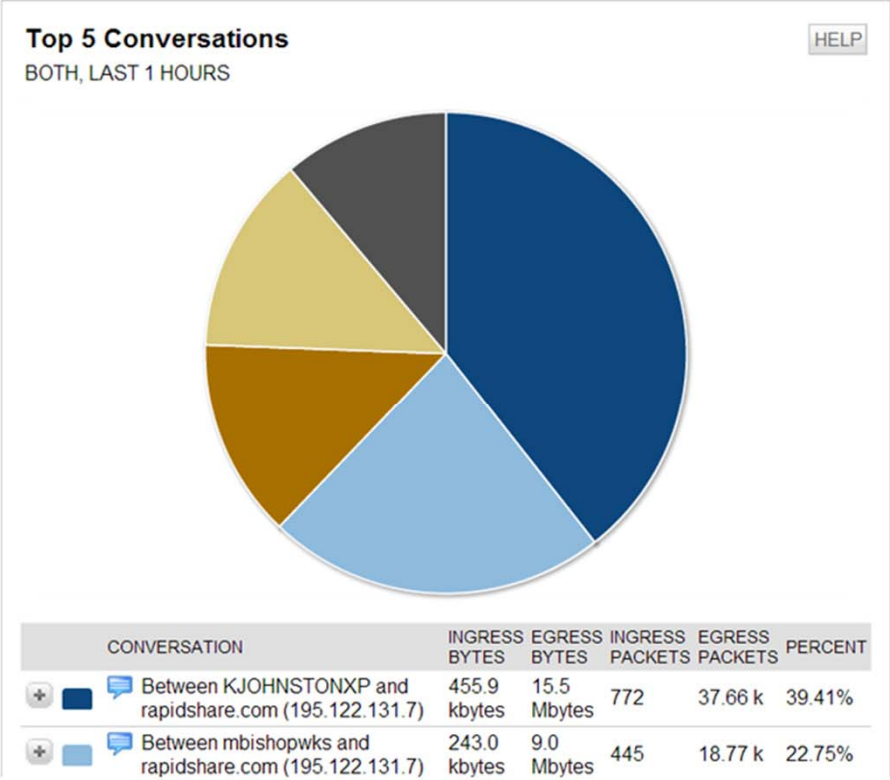
NetFlow Overview

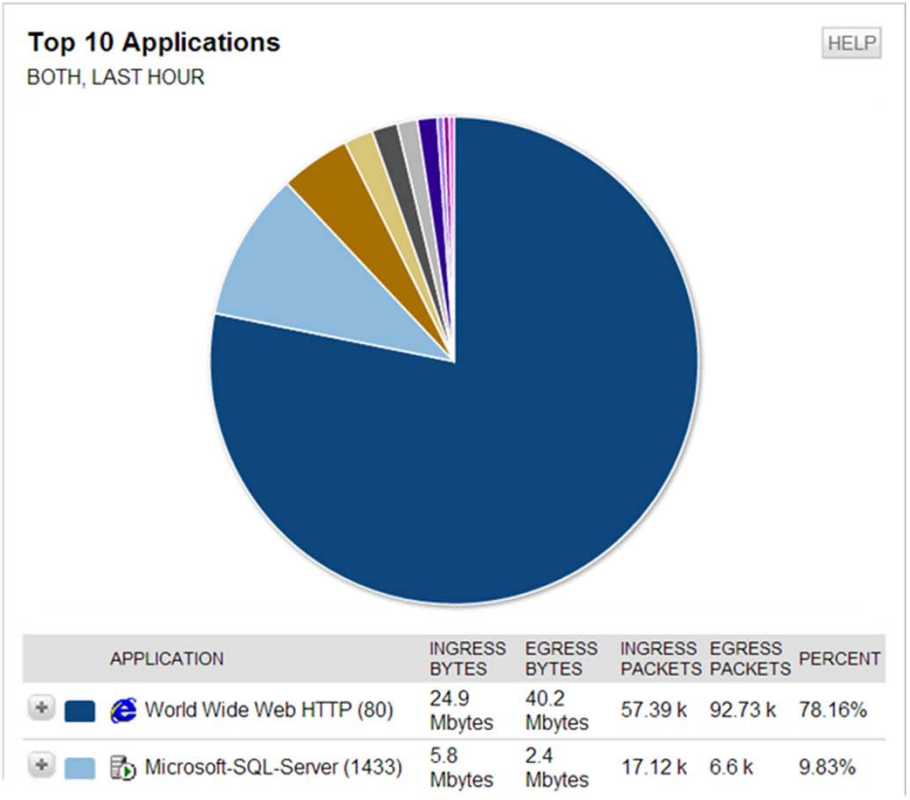
- NetFlow is an application for collecting IP traffic information.
- Reports from NetFlow are like a phone bill.
- NetFlow enables the following:
  - Measuring who uses network resources
  - Accounting and charging for resource utilization
  - Using the measured information to do effective network planning
  - Using the measured information to customize applications and services

NetFlow Overview (Cont.)

Example of analysis on a NetFlow collector:

- Shows the top talkers, top listeners, top protocols, and more.





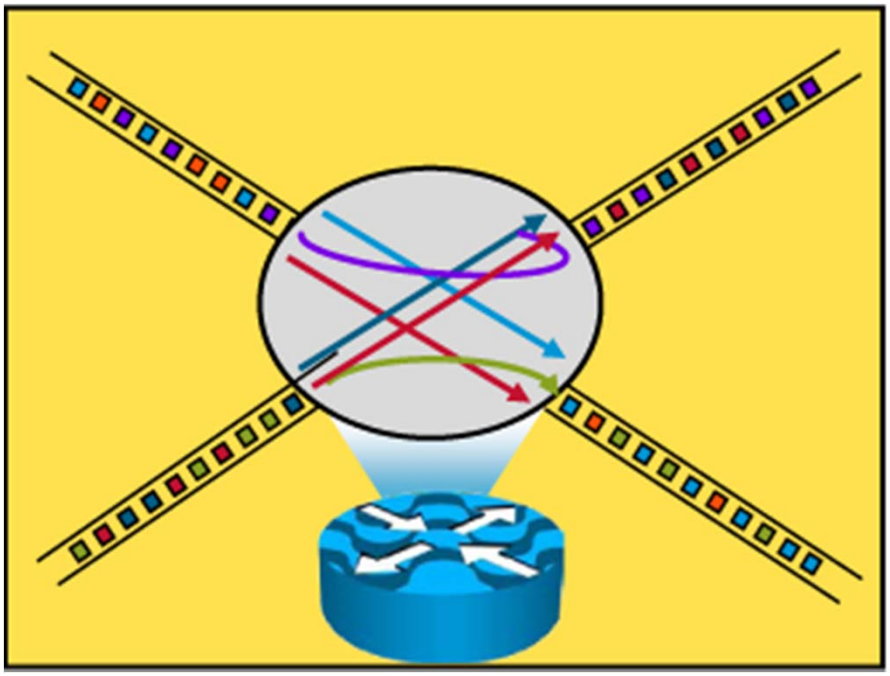
NetFlow Overview (Cont.)

- NetFlow components:
  - NetFlow-enabled network devices
  - NetFlow collector
- NetFlow devices generate NetFlow records that are exported and then collected by a NetFlow collector. Cisco Network Analysis Module is an example of a NetFlow collector. It also processes NetFlow data and provides the results through its GUI.

NetFlow Overview (Cont.)

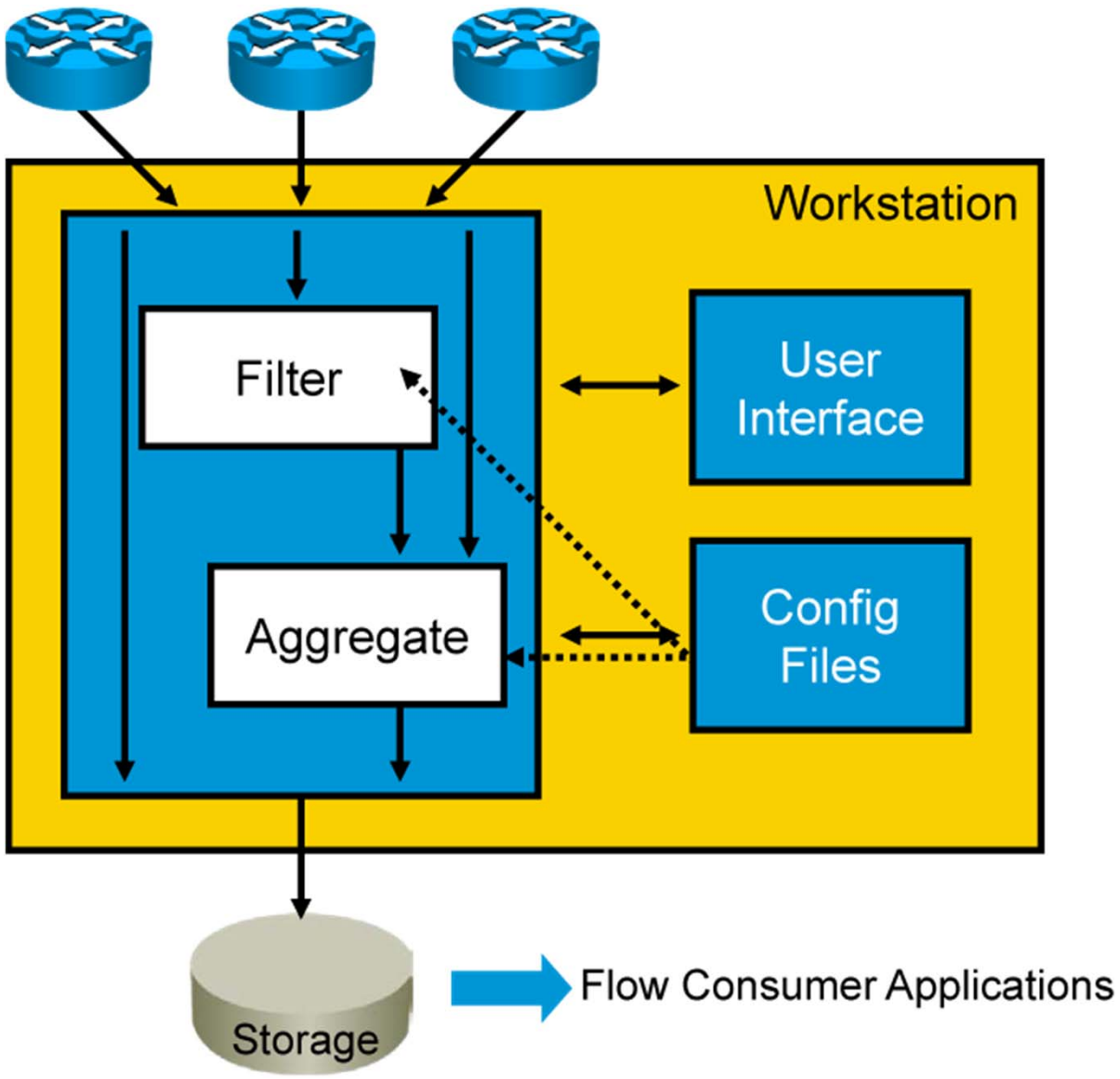
Cisco defines a flow as a unidirectional sequence of packets with seven common values:

- Source IP address
- Destination IP address
- Source port number
- Destination port number
- Layer 3 protocol type
- ToS
- Input logical interface



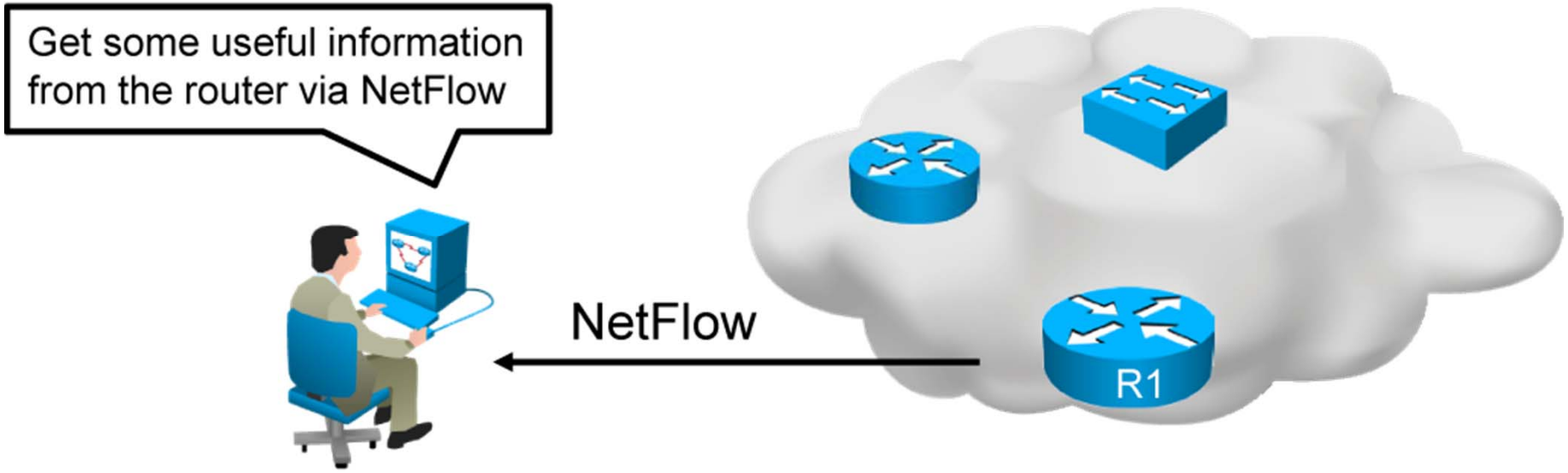
NetFlow Architecture

- Routers collecting data
- FlowCollector software:
  - Flow record reception (UDP)
  - Reduction and filtering of data volume
- Network FlowAnalyzer software for graphical display of data

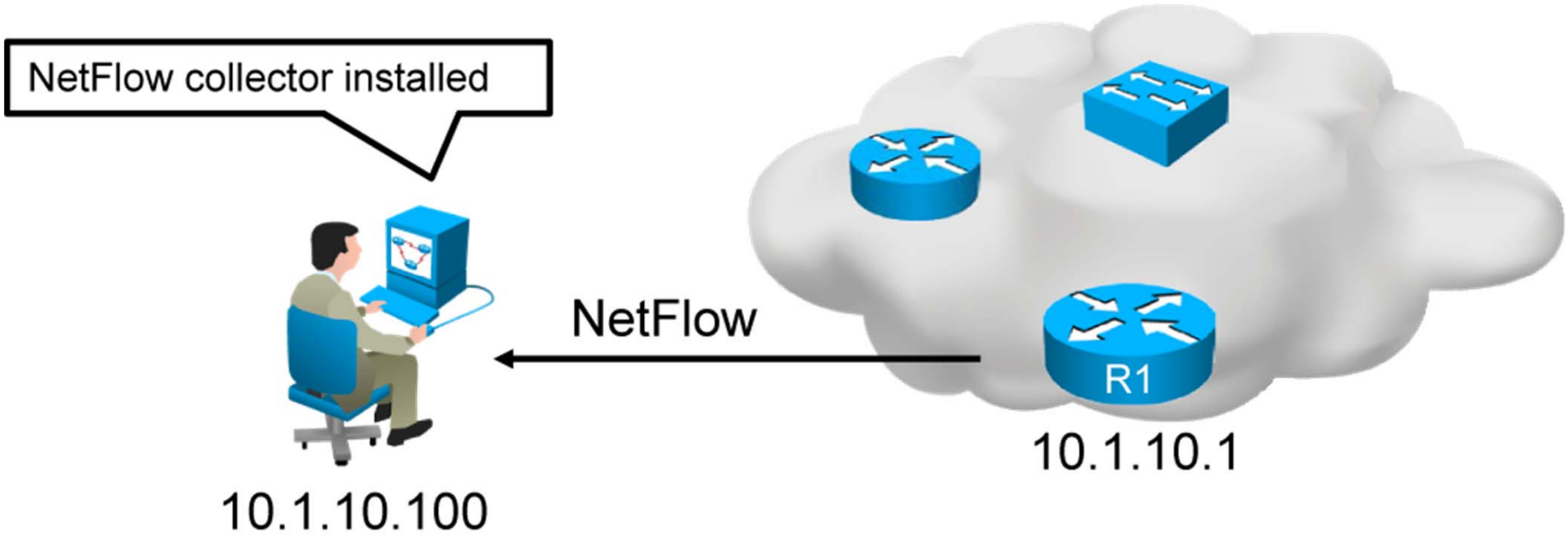


NetFlow Configuration

- Configure NetFlow data capture
- Configure NetFlow data export
- Configure NetFlow data export version
- Verify NetFlow, its operation, and statistics



NetFlow Configuration (Cont.)




```
R1(config)#interface GigabitEthernet0/1
R1(config-if)#ip flow ingress
R1(config-if)#ip flow egress
R1(config-if)#exit
R1(config)#ip flow-export destination 10.1.10.100 9996
R1(config)#ip flow-export version 9
```

- Configuration of NetFlow on router R1

NetFlow Configuration (Cont.)

```
R1#show ip interface GigabitEthernet0/1
<output omitted>
  Input features: Ingress-NetFlow, MCI Check
  Output features: Access List, Post-Ingress-NetFlow, Egress-NetFlow
```

- Displays whether NetFlow is enabled on an interface

```
R1#show ip flow export
Flow export v9 is enabled for main cache
  Export source and destination details :
  VRF ID : Default
    Destination(1)  10.1.10.100 (9996)
  Version 9 flow records
  43 flows exported in 15 udp datagrams
```

- Displays the status and the statistics for NetFlow data export

NetFlow Configuration (Cont.)

```
Branch#show ip cache flow
<output omitted>
IP Flow Switching Cache, 278544 bytes
  2 active, 4094 inactive, 31 added
  6374 ager polls, 0 flow alloc failures
  Active flows timeout in 30 minutes
  Inactive flows timeout in 15 seconds
IP Sub Flow Cache, 34056 bytes
  2 active, 1022 inactive, 31 added, 31 added to flow
  0 alloc failures, 0 force free
  1 chunk, 0 chunks added
  last clearing of statistics 00:49:48
Protocol      Total   Flows  Packets   Bytes  Packets Active(Sec) Idle(Sec)
--------      Flows   /Sec    /Flow    /Pkt   /Sec     /Flow      /Flow
TCP-Telnet    19     0.0       19      58      0.1      6.5        11.7
TCP-WWW       14     0.0        8     202      0.0      0.0         1.5
TCP-other      2     0.0       19      98      0.0      2.2         8.9
<output omitted>

SrcIf      SrcIPaddress    DstIf         DstIPaddress    Pr SrcP DstP  Pkts
Gi0/1      172.16.1.100    Gi0/0.10      10.1.10.100     01 0000 0000  1341
```

- Displays a summary of the NetFlow accounting statistics

Summary

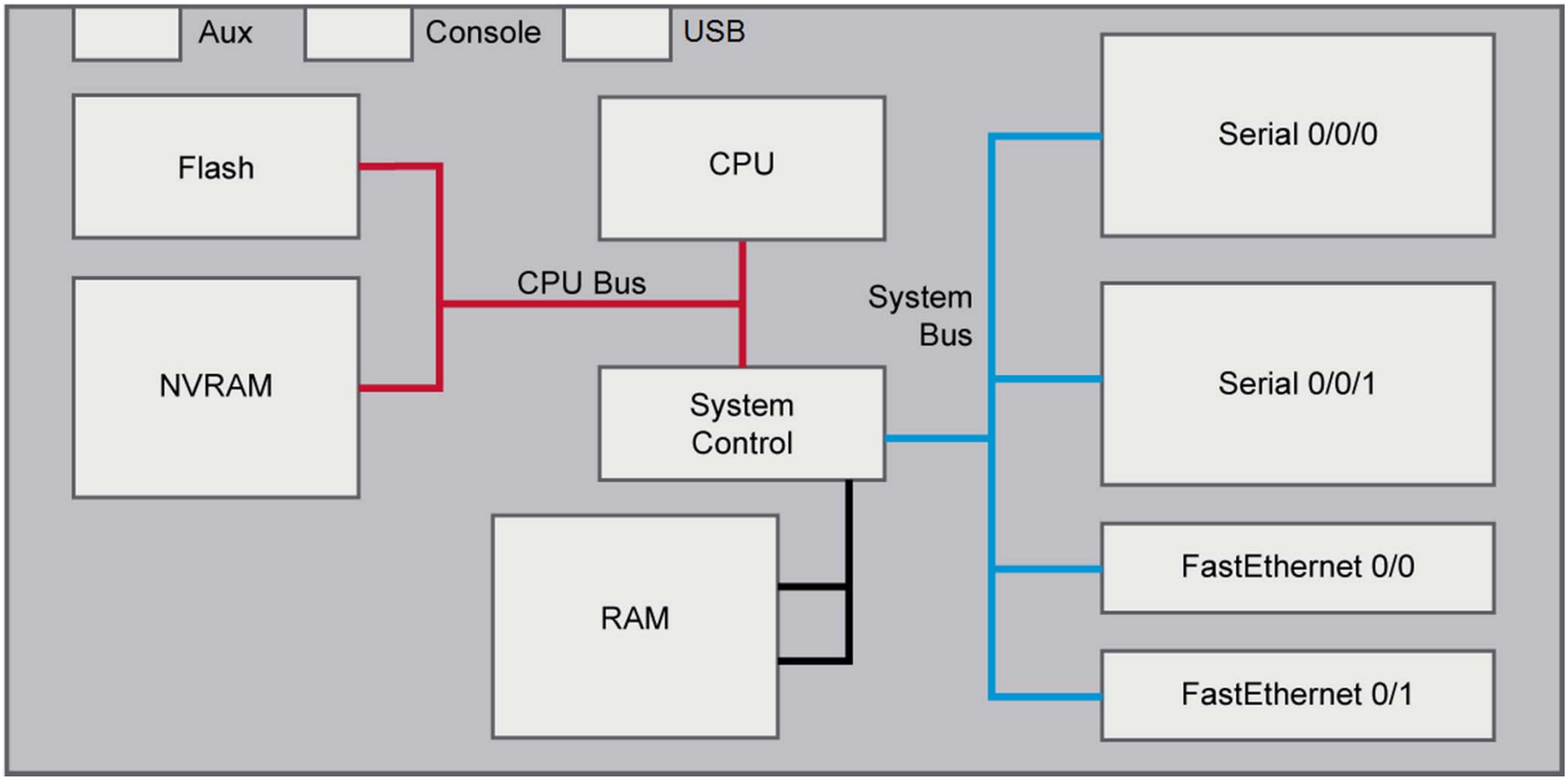
- NMS polls the SNMP agent on a network device to obtain statistics.
- Use the **snmp-server community** command to configure SNMP access to the router.
- Syslog is a protocol that allows a network device to send event notifications to a syslog server.
- Use the **logging** command to identify a syslog server host to receive logging messages.
- NetFlow provides statistics on packets flowing through the routing devices in the network.
- The configuration part of NetFlow consists of configuring data capture and configuring data export.

Managing Cisco Devices

Network Device Management

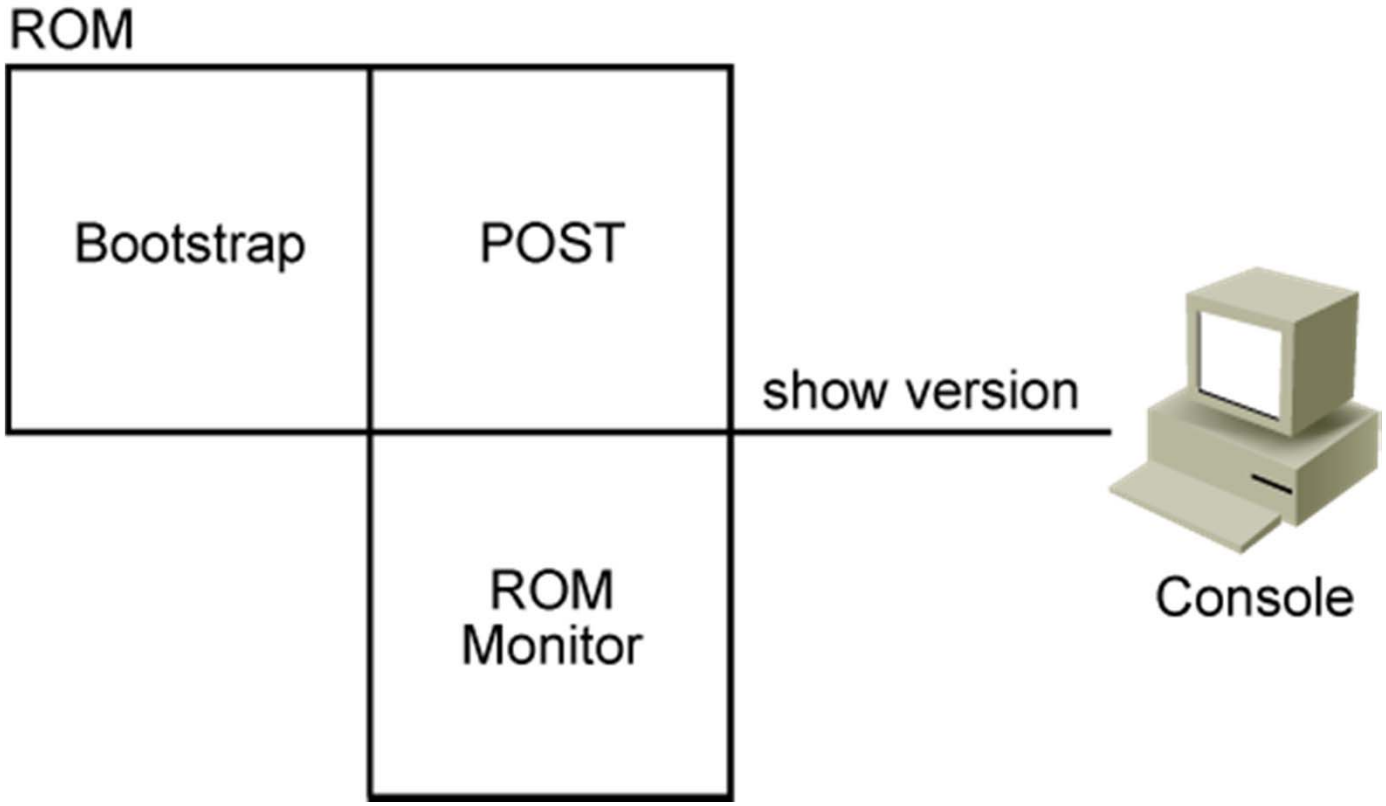
Router Internal Components Overview

Logical diagram of the internal hardware components of a Cisco router

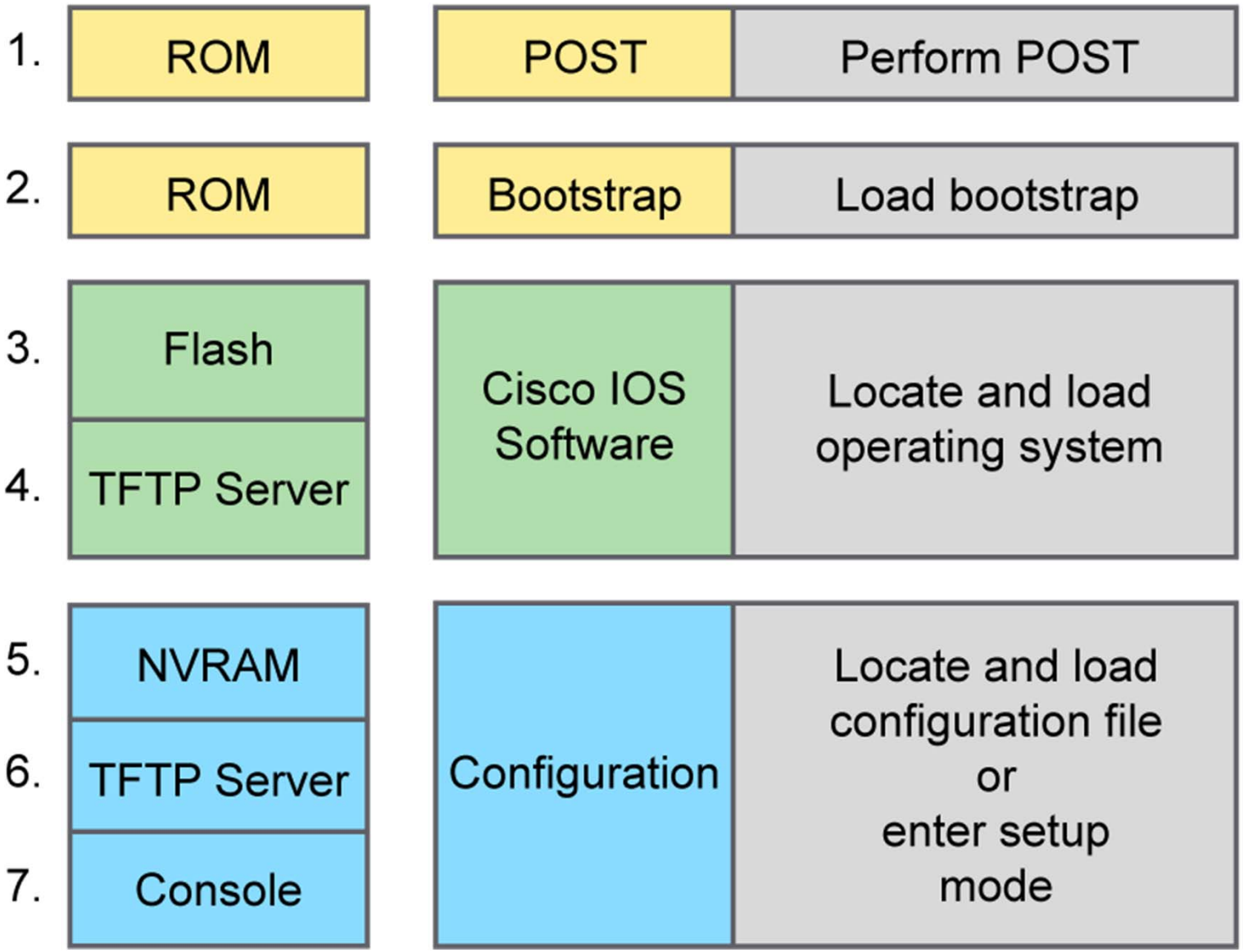


ROM Functions

ROM contains microcode for basic functions.



Stages of the Router Power-On Boot Sequence



Configuration Register

- The configuration register is a 16-bit number that affects router behavior.
- The least-significant 4 bits of the configuration register are called the boot field.
- The boot field in the configuration register specifies how the router locates Cisco IOS Software.

Changing Configuration Register

```
Branch#show version
<output omitted>
Configuration register is 0x2102
```

- First, verify the current configuration register value.

```
Branch#configure terminal
Branch(config)#config-register 0x2101
Branch(config)#exit
Branch#copy running-config startup-config
```

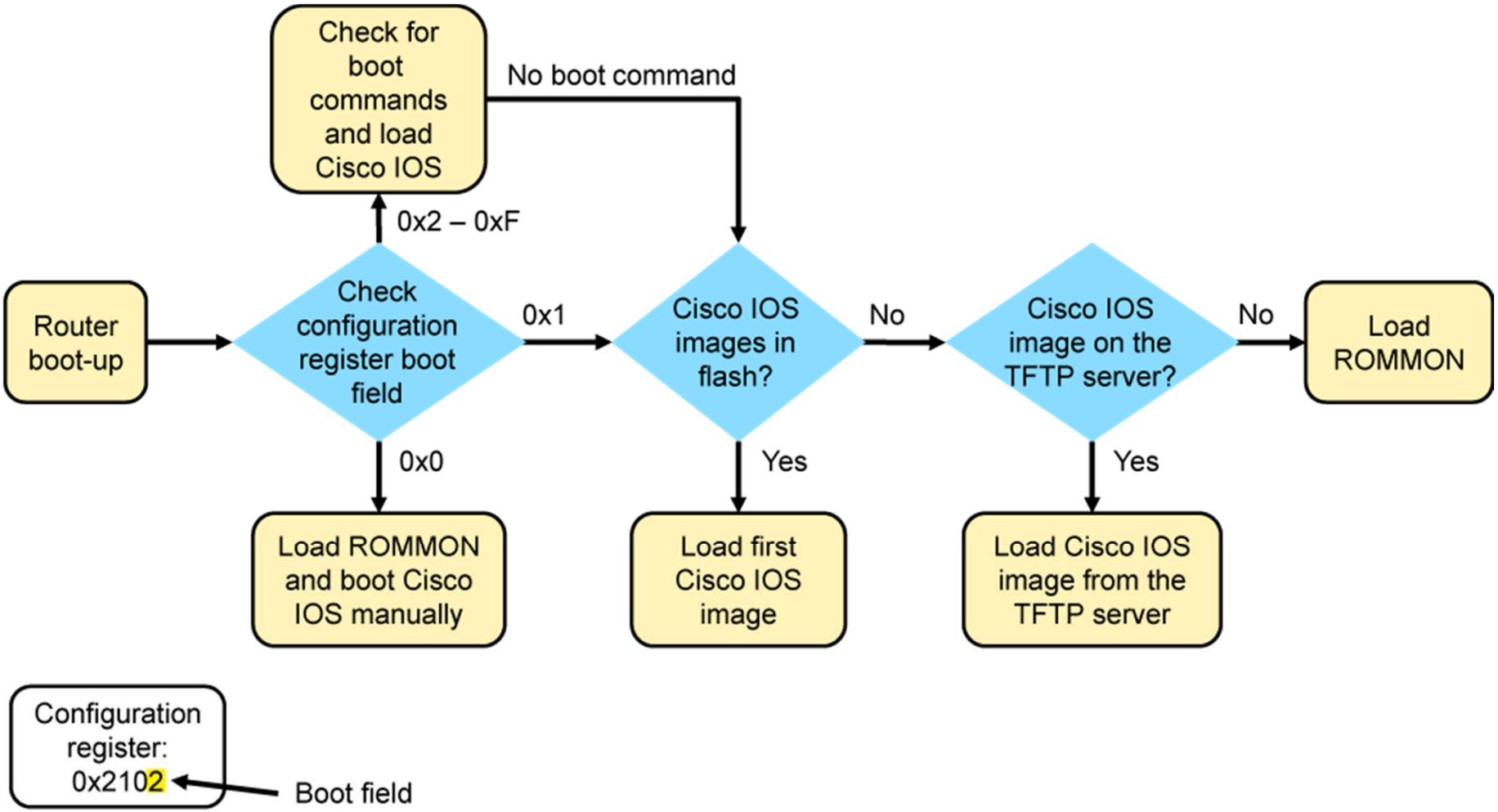
Set the configuration register value.

```
Branch#show version
<output omitted>
Configuration register is 0x2102 (will be 0x2101 at next reload)
```

- Verify the new configuration register value.

Locating Cisco IOS Image Files

Order of locating Cisco IOS image:



Loading Cisco IOS Image Files

```
System Bootstrap, Version 15.0(1r)M15, RELEASE SOFTWARE (fc1)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 2011 by cisco Systems, Inc.

Total memory size = 512 MB - On-board = 512 MB, DIMM0 = 0 MB
CISCO2901/K9 platform with 524288 Kbytes of main memory
Main memory is configured to 72/-1(On-board/DIMM0) bit mode with ECC
enabled
Readonly ROMMON initialized
program load complete, entry point: 0x80803000, size: 0x1b340
program load complete, entry point: 0x80803000, size: 0x1b340

IOS Image Load Test
___________________
Digitally Signed Release Software
program load complete, entry point: 0x81000000, size: 0x5d433c0
Self decompressing the image:
########################################################################
########################################[OK]
<output omitted>
```

- The Cisco IOS image file is decompressed and stored to RAM. The output shows the boot process on a router.

Loading Cisco IOS Image Files (Cont.)

```
Branch#show version
Cisco IOS Software, C2900 Software (C2900-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 20:54 by prod_rel_team
ROM: System Bootstrap, Version 15.0(1r)M15, RELEASE SOFTWARE (fc1)
Branch uptime is 39 minutes
System returned to ROM by reload at 11:39:24 UTC Tue Nov 20 2012
System image file is "flash0:c2900-universalk9-mz.SPA.152-4.M1.bin"
Last reload type: Normal Reload
Last reload reason: Reload Command
<output omitted>
```

(Continued in next figure)

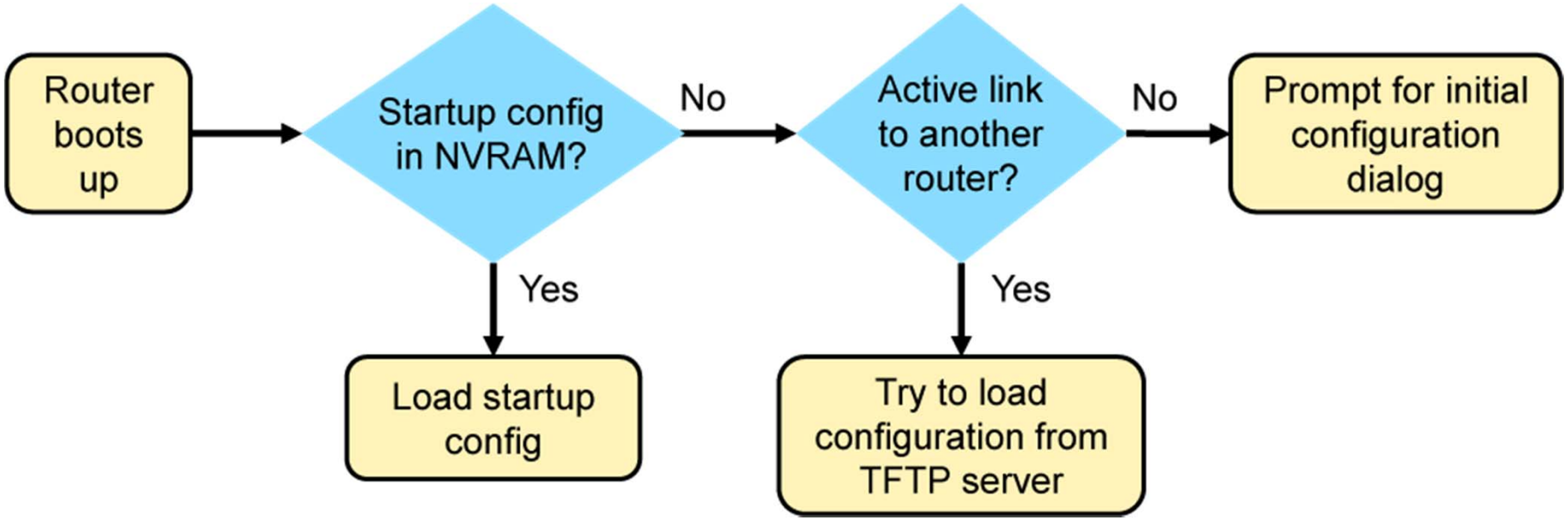
Loading Cisco IOS Image Files (Cont.)

```
Cisco CISCO2901/K9 (revision 1.0) with 483328K/40960K bytes of memory.
Processor board ID FCZ1642C5XJ
2 Gigabit Ethernet interfaces
1 Serial(sync/async) interface
1 terminal line
DRAM configuration is 64 bits wide with parity enabled.
255K bytes of non-volatile configuration memory.
250880K bytes of ATA System CompactFlash 0 (Read/Write)
<output omitted>
Configuration register is 0x2102
```

- Displays information about the currently loaded software, as well as hardware and device information.

Loading Cisco IOS Configuration Files

Load and execute the configuration from NVRAM. If no configuration is present in NVRAM, prompt for an initial configuration dialog.



Loading Cisco IOS Configuration Files (Cont.)

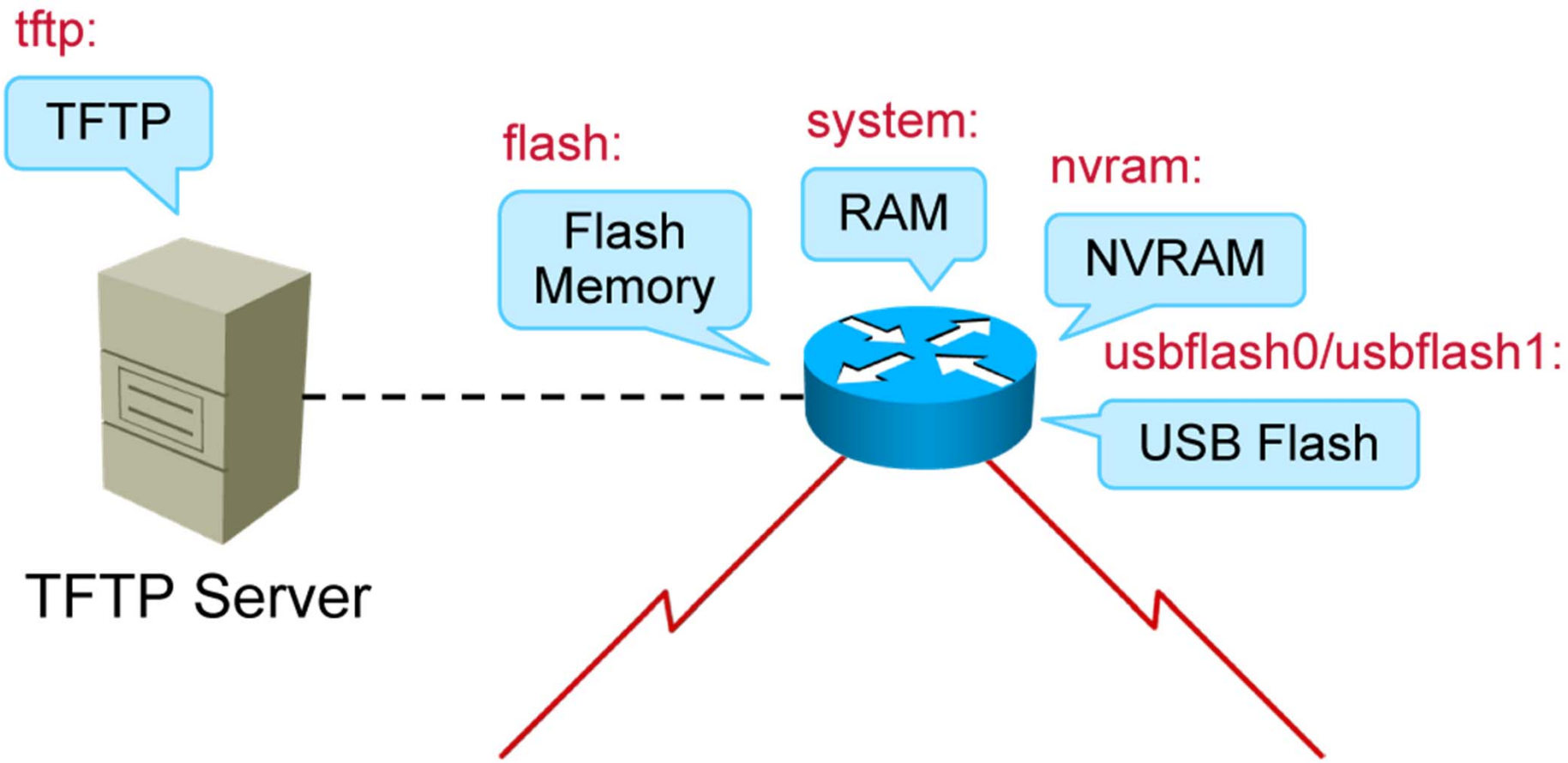
```
Branch#show running-config
Building configuration...
Current configuration : 1318 bytes
!
! Last configuration change at 13:11:38 UTC Tue Nov 20 2012
! NVRAM config last updated at 13:11:38 UTC Tue Nov 20 2012
! NVRAM config last updated at 13:11:38 UTC Tue Nov 20 2012
version 15.2
<output omitted>
```

- Displays the current configuration

```
Branch#show startup-config
Using 1318 out of 262136 bytes
!
! Last configuration change at 13:11:38 UTC Tue Nov 20 2012
! NVRAM config last updated at 13:11:38 UTC Tue Nov 20 2012
! NVRAM config last updated at 13:11:38 UTC Tue Nov 20 2012
version 15.2
<output omitted>
```

- Displays the saved configuration

Cisco IOS Integrated File System and Devices

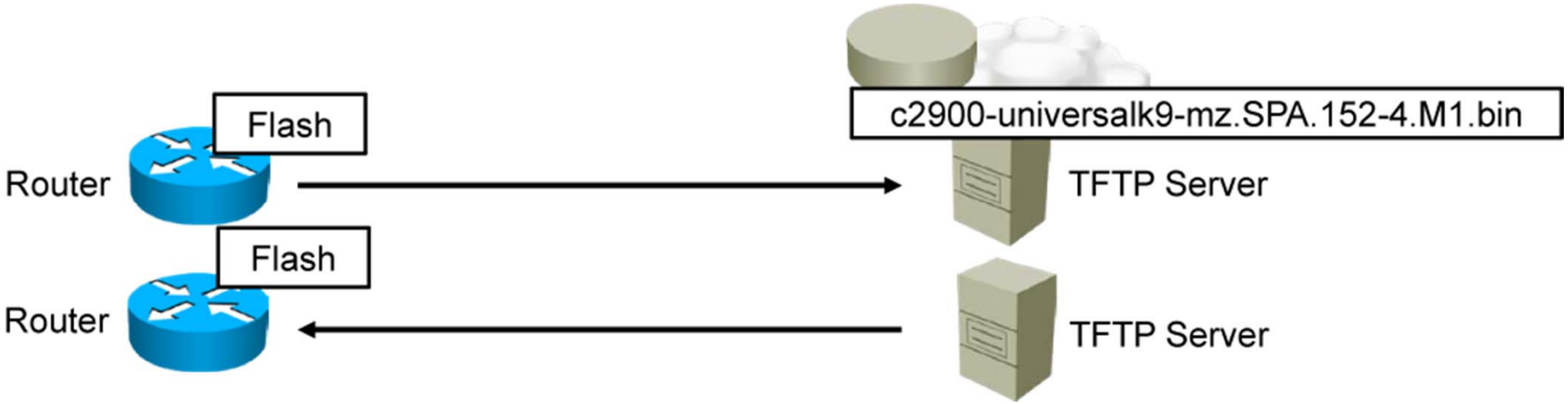


Cisco IOS Integrated File System and Devices (Cont.)

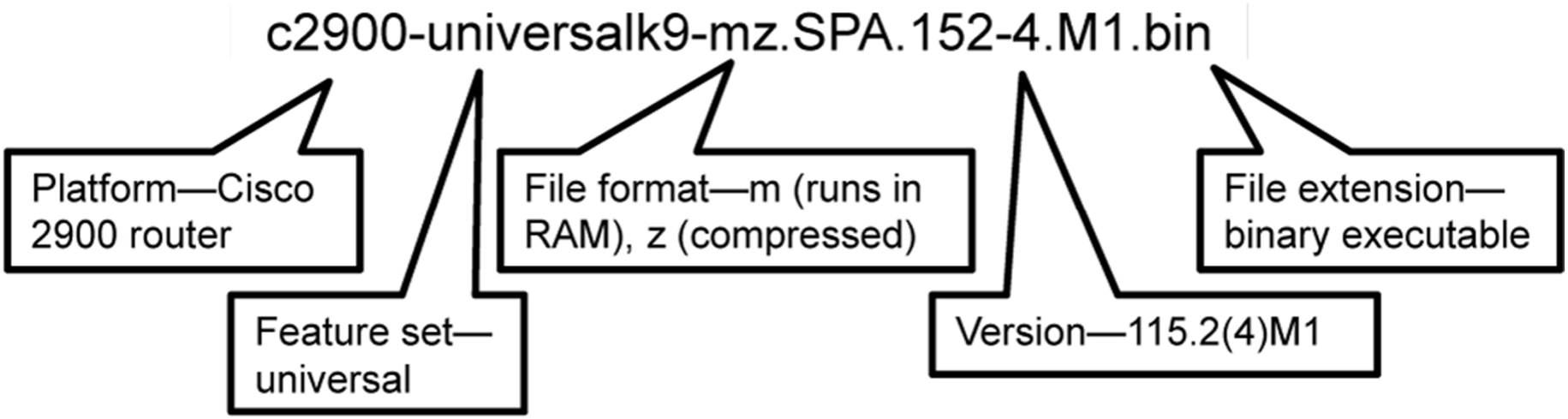
```
Branch#show file systems
File Systems:
       Size(b)       Free(b)      Type  Flags  Prefixes
             -             -    opaque     rw   archive:
             -             -    opaque     rw   system:
             -             -    opaque     rw   tmpsys:
             -             -    opaque     rw   null:
             -             -   network     rw   tftp:
*    256610304     153710592      disk     rw   flash0: flash:#
             -             -      disk     rw   flash1:
        262136        255626     nvram     rw   nvram:
             -             -    opaque     wo   syslog:
             -             -    opaque     rw   xmodem:
             -             -    opaque     rw   ymodem:
             -             -   network     rw   rcp:
             -             -   network     rw   http:
             -             -   network     rw   ftp:
             -             -   network     rw   scp:
             -             -    opaque     ro   tar:
             -             -   network     rw   https:
             -             -    opaque     ro   cns:
```

- Lists all of the available file systems

Managing Cisco IOS Images



Deciphering IOS Image Filenames



Creating the Cisco IOS Image Backup

- Verify connectivity to the server
- Verify that the TFTP server has sufficient disk space
- Copy the Cisco IOS file to the TFTP server

Creating the Cisco IOS Image Backup (Cont.)

```
Branch#ping 172.16.1.100
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.100, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
```

Verify connectivity to the server.

```
Branch#show flash0:
-#- --length-- -----date/time------ path
1     97794040 Nov 30 1983 00:00:00 +00:00 c2900-universalk9-mz.SPA.152-
4.M1.bin
<output omitted>
```

Verify Cisco IOS image size.

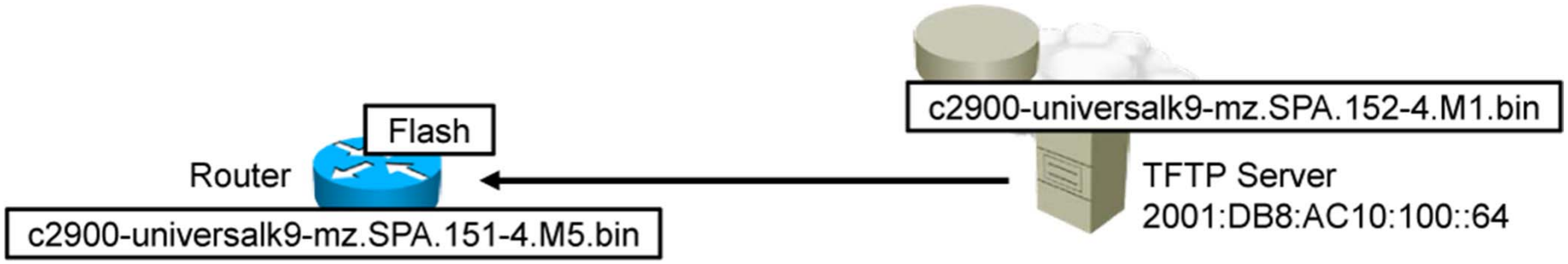
Creating the Cisco IOS Image Backup (Cont.)

```
Branch#copy flash0: tftp:
Source filename []? c2900-universalk9-mz.SPA.152-4.M1.bin
Address or name of remote host []? 172.16.1.100
Destination filename []? c2900-universalk9-mz.SPA.152-4.M1.bin
!!!!!!!!!!!!!!!!!!
<output omitted>
97794040 bytes copied in 363.468 secs (269058 bytes/sec)
```

Copy image to the TFTP server

Upgrading Cisco IOS Images

- Select and download a new image file.
- Verify connectivity to the server.
- Verify that the router has sufficient flash memory space.
- Copy the Cisco IOS file from the TFTP server.
- Configure the router to boot the new Cisco IOS image.
- Reload the router.



Upgrading Cisco IOS Images (Cont.)

```
Branch#ping 2001:DB8:AC10:100::64
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:AC10:100::64, timeout is 2
seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
```

Verify connectivity to the server

```
Branch#show flash0:
-#- --length-- -----date/time------ path
<output omitted>
6      3000320 Nov 20 2012 10:03:30 +00:00 cpexpress.tar
7         1038 Nov 20 2012 10:03:36 +00:00 home.shtml

153710592 bytes available (102899712 bytes used)
```

Verify free flash memory space.

Upgrading Cisco IOS Image (Cont.)

```
Branch#copy tftp: flash0:
Address or name of remote host []? 2001:DB8:AC10:100::64
Source filename []? c2900-universalk9-mz.SPA.152-4.M1.bin
Destination filename []? c2900-universalk9-mz.SPA.152-4.M1.bin
Accessing tftp://2001:DB8:AC10:100::64/c2900-universalk9-mz.SPA.152-
4.M1.bin...

Loading c2900-universalk9-mz.SPA.152-4.M1.bin from 2001:DB8:AC10:100::64
(via GigabitEthernet0/0): !!!!!!!!!!!!!!!!!!!
<output omitted>
[OK - 97794040 bytes]
97794040 bytes copied in 368.128 secs (265652 bytes/sec)
```

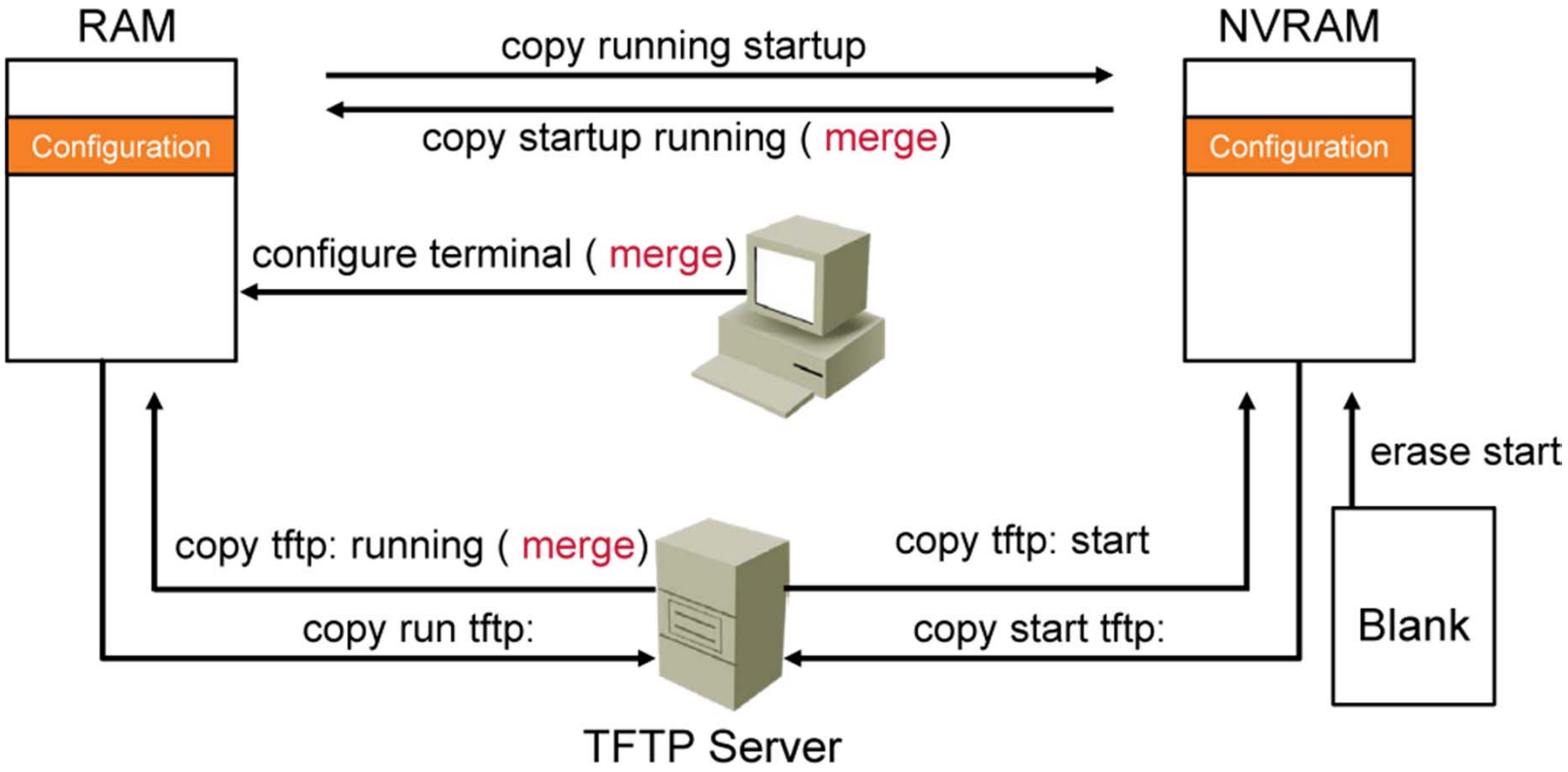
Copy the image from the TFTP server.

```
Branch#configure terminal
Branch(config)#boot system flash0://c2900-universalk9-mz.SPA.152-4.M1.bin
Branch#copy running-config startup-config
Branch#reload
```

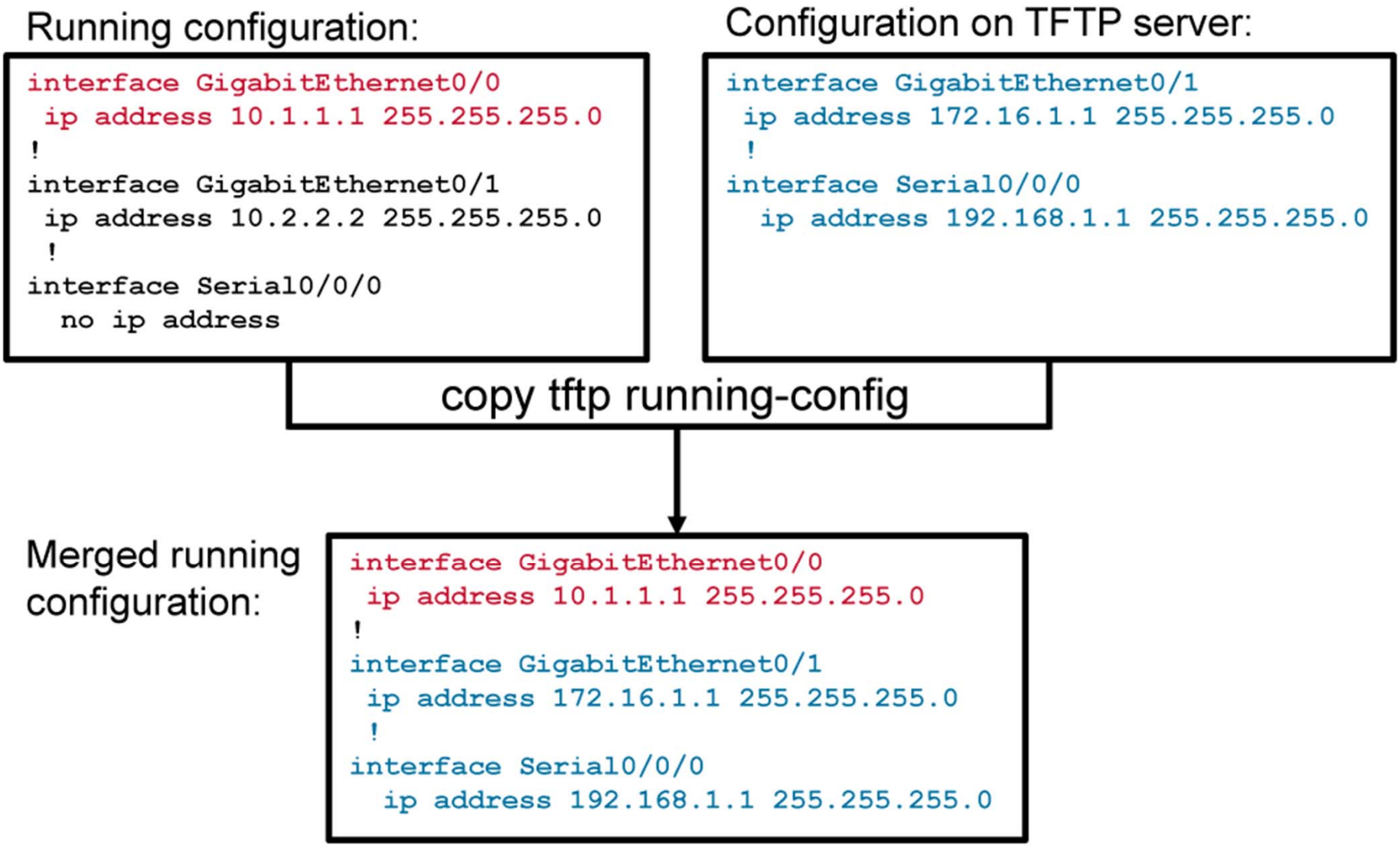
Set the image to boot and reload the router.

Device Configuration Sources

- NVRAM
- Terminal
- TFTP server



Managing Device Configuration Files



Managing Device Configuration Files (Cont.)

```
Branch#copy running-config tftp
Address or name of remote host []? 172.16.1.100
Destination filename [running-config]? config.cfg
.!!
1684 bytes copied in 13.300 secs (129 bytes/sec)
```

Upload and save the current configuration to a TFTP server.

```
Branch#copy tftp running-config
Address or name of remote host []? 2001:DB8:AC10:100::64
Source filename []? config.cfg
Destination filename [running-config]?
Accessing tftp://2001:DB8:AC10:100::64/config.cfg...
Loading config.cfg from 2001:DB8:AC10:100::64 (via GigabitEthernet0/0): !
[OK - 1684/3072 bytes]

1684 bytes copied in 17.692 secs (99 bytes/sec)
```

Merge a configuration file from the TFTP server with the running configuration of the RAM.

Password Recovery

The password recovery procedure differs for different router and switch platforms.

1. Switch off the router.
2. Switch on the router. Press **Break** to enter ROM monitor mode.
3. When the router is in ROM monitor mode, set the configuration register to 0x2142.

```
rommon 1>confreg 0x2142
```

4. Reset the router.

```
rommon 1>reset
```

5. Enter privileged EXEC mode.

```
Router>enable
```

Password Recovery (Cont.)

6. Copy "startup-config" to "running-config."

```
Router#copy startup-config running-config
```

7. Bring up interfaces.

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

8. Enter global configuration mode and change the enable password.

```
Router#configure terminal
Router(config)#enable secret newpassword
```

9. Change the configuration register back to the initial value.

```
Router(config)#config-register 0x2102
```

Password Recovery (Cont.)

10. Copy "running-config" to "startup-config"

```
Router#copy running-config startup-config
```

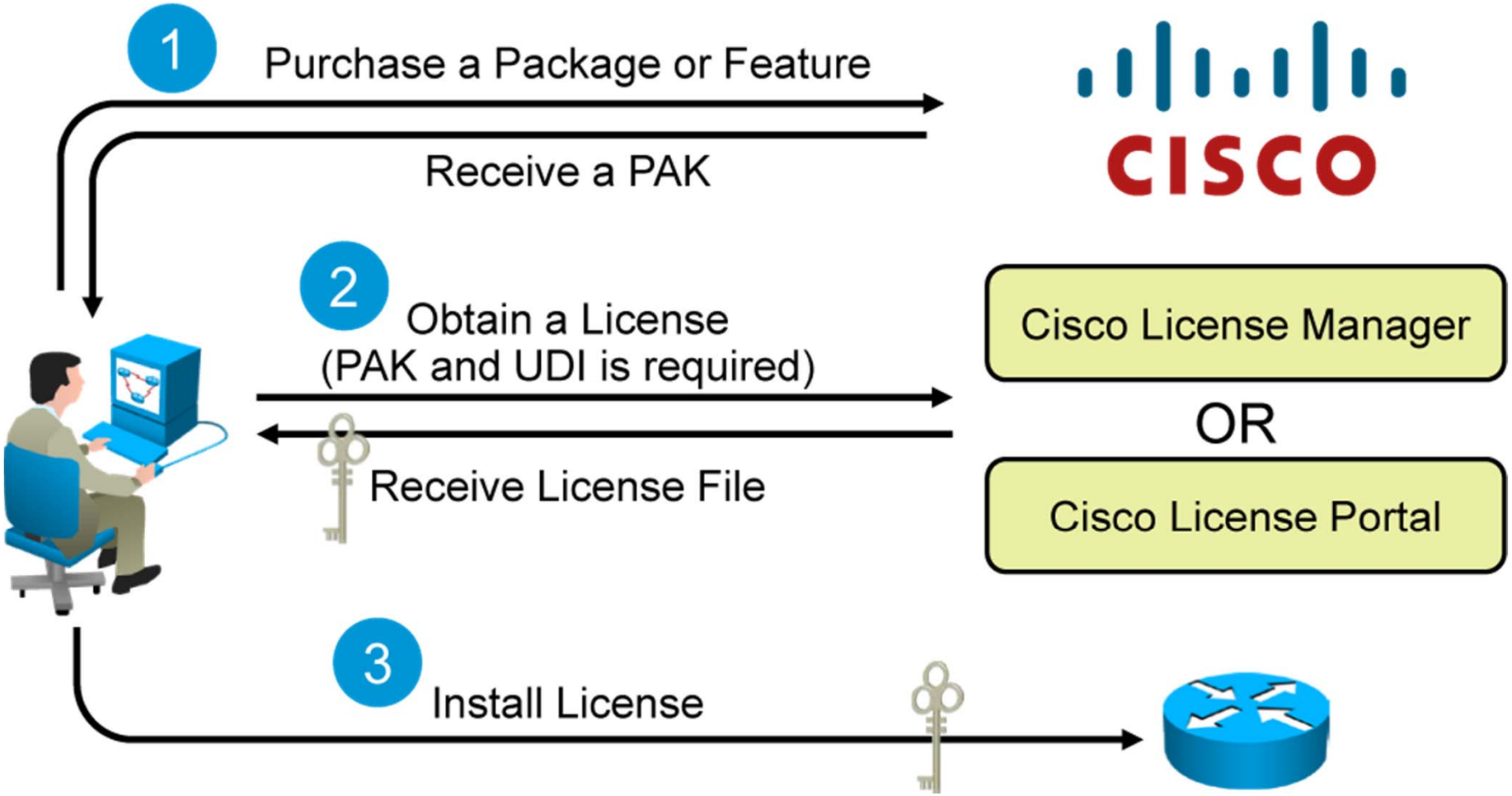
Summary

- The major components of a router are CPU, RAM, flash memory, ROM, NVRAM, and interfaces.
- A router first performs a POST test when booting.
- When a router boots, it searches for the Cisco IOS image in a specific sequence.
- When a router locates a valid Cisco IOS image in flash memory, the Cisco IOS image is loaded into RAM to run.
- After a router loads the Cisco IOS image, the router loads startup-config (if any startup-config is present on the router).
- The configuration register is a 16-bit number that affects router behavior, including locating a Cisco IOS image.
- You can use a TFTP server to store router configurations in a central place.

Licensing

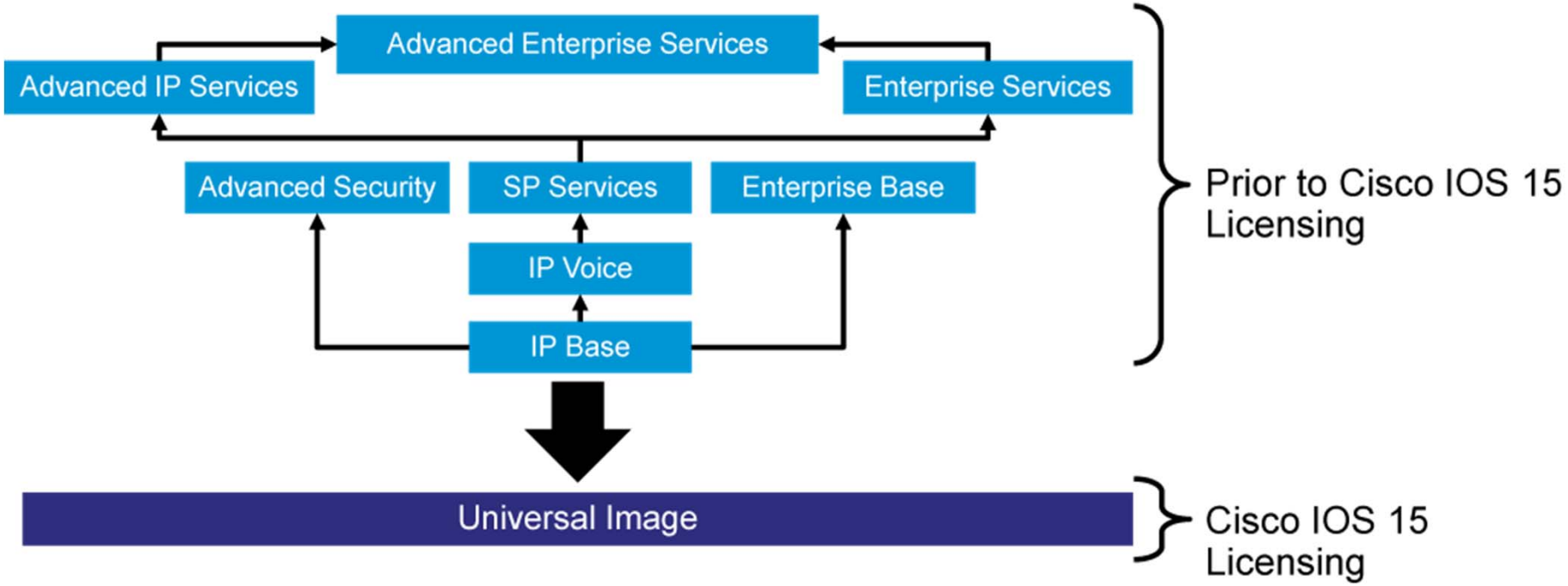
Network Device Management

Licensing Overview



Licensing Overview (Cont.)

- Prior to Cisco IOS Release 15.0, a software image was selected based on the required feature set of the customer.
- There were eight software packages (images) that satisfied requirements in different service categories.



Licensing Overview (Cont.)

- Since the introduction of Cisco IOS Software Release 15.0, the universal image contains all packages and features in *one* image.
- Multiple technology package licenses can be installed and activated on the Cisco 1900, 2900, and 3900 Series Integrated Services Router platforms.
- Individual features can be enabled or disabled by license keys.

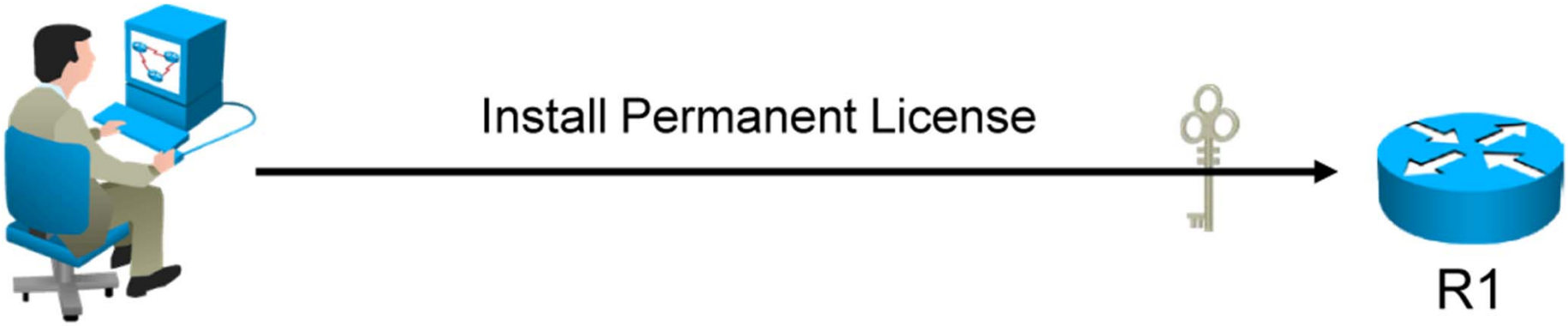
Technology Package License	Features
IP Base	Entry-level Cisco IOS functionality
DATA	MPLS, ATM, and multiprotocol support
Unified Communications	VoIP and IP telephony
Security	Cisco IOS Firewall, IPS, IPsec, 3DES, and VPN

Licensing Verification

```
Router#show license
Index 1 Feature: ipbasek9
        Period left: Life time
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
Index 2 Feature: securityk9
        Period left: Not Activated
        Period Used: 0  minute  0  second
        License Type: EvalRightToUse
        License State: Not in Use, EULA not accepted
        License Count: Non-Counted
        License Priority: None
<output omitted>
```

- Displays information about all Cisco IOS Software licenses

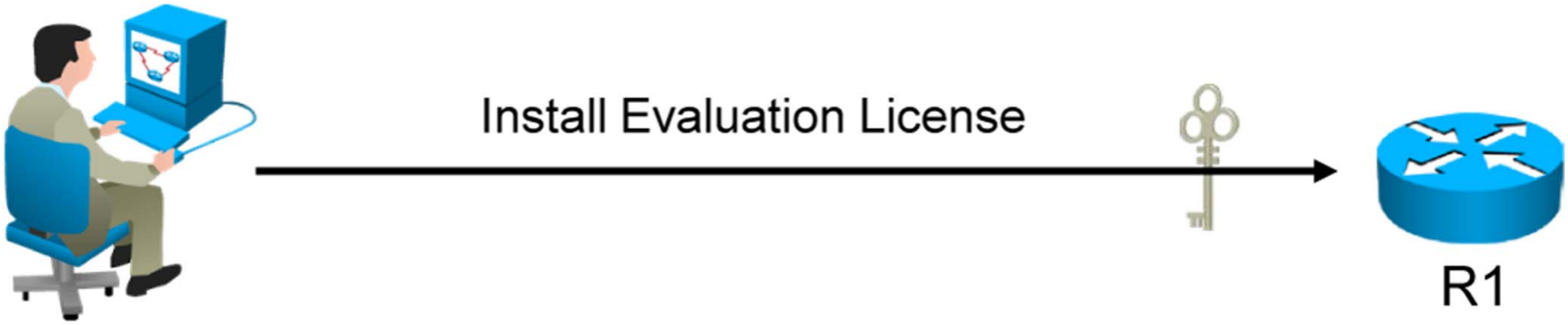
Permanent License Installation




```
R1#license install flash0:uck9-2900-SPE150_K9-FHH12250057.xml
R1#reload
```

- Installs a permanent Unified Communications license on the router

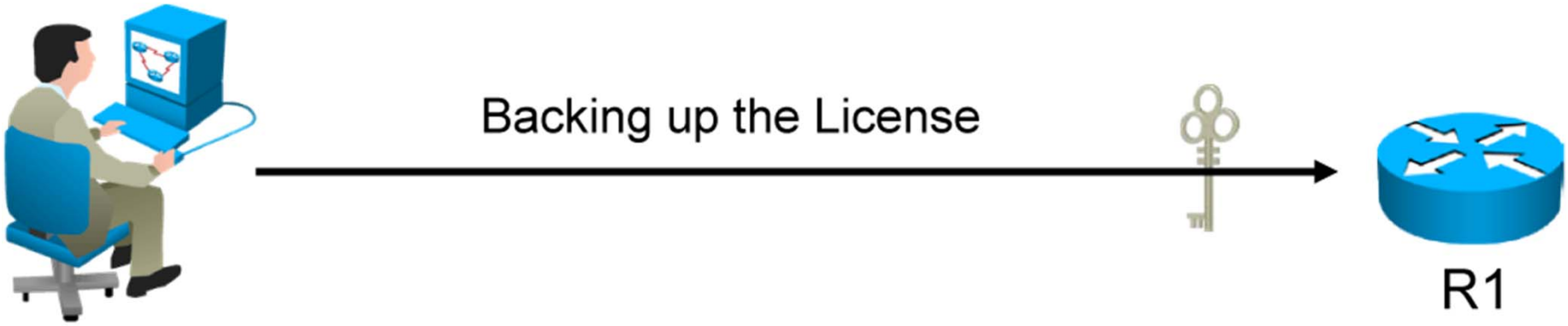
Evaluation License Installation




```
R1#license boot module c2900 technology-package uck9
R1#reload
```

- Installs a Unified Communications Evaluation license on the router

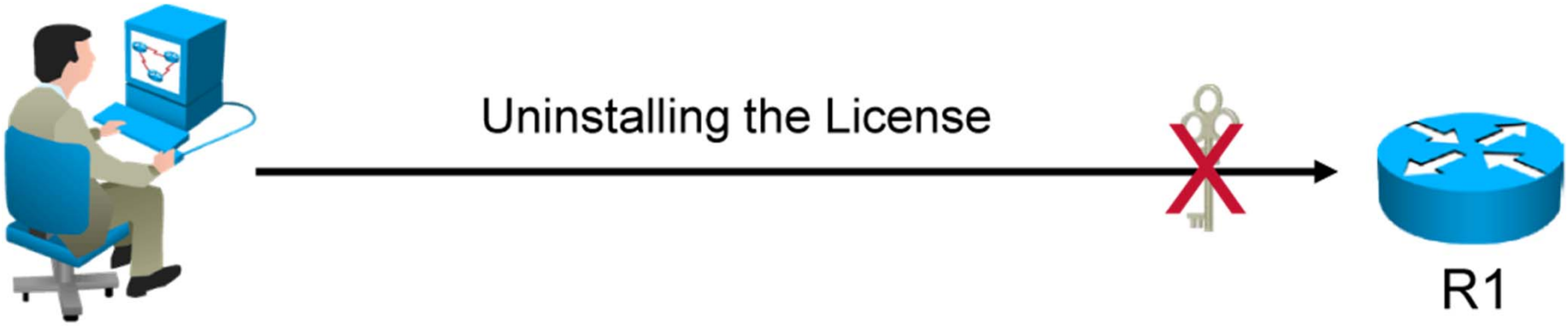
Backing up the License




```
R1#license save flash:all_licenses.lic
```

- Saves the license to the flash memory of the router

Uninstalling the License

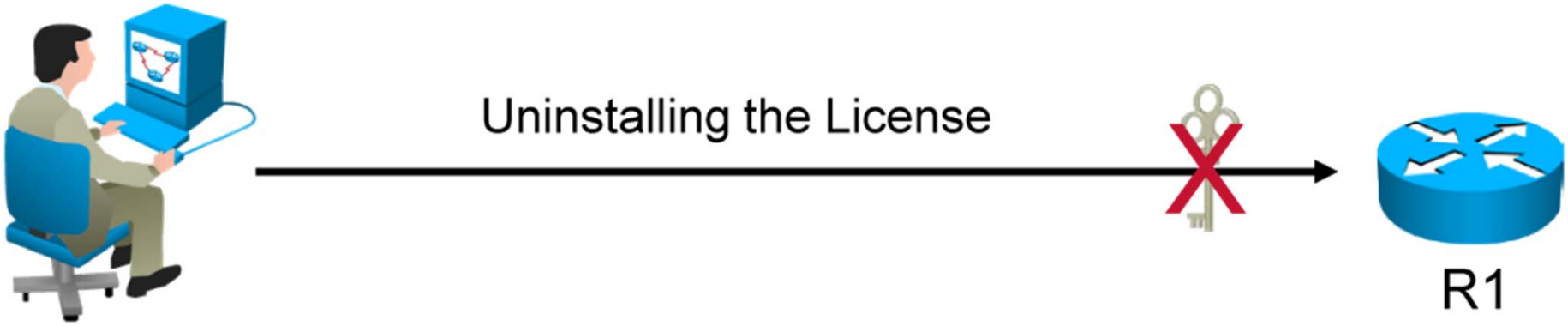


To clear an active permanent license from the router, perform the following tasks:

```
Router(config)#license boot module c3900 technology-package uck9 disable
Router(config)#exit
Router#reload
```

- Disable the technology package

Uninstalling the License (Cont.)




```
Router#license clear uck9
Router#configure terminal
Router(config)#no license boot module c3900 technology uck9 disable
Router(config)#exit
Router#reload
```

- Clear the license

Summary

- Obtain the license using Cisco License Manager or the Cisco License Registration Portal and use Cisco IOS commands to install the license.
- Use the **show license** command in privileged EXEC mode to see information about Cisco IOS Software licenses.
- Use the **license install** command to install the permanent license.
- Use the **license save** command to back up the license.
- Use the **license clear** command to remove the license.

Module Summary

- NetFlow provides statistics on packets flowing through the routing devices in the network, while SNMP provides many more statistics from networking devices.
- To maintain network operations with minimum downtime, it is necessary to have procedures in place for backing up Cisco IOS images.
- The universal images on the Cisco 1900, 2900, and 3900 Series Integrated Services Routers are a superset of Cisco IOS simplified technology packages; each package is a grouping of technology-specific features.