NANJING UNIVERSITY · SOFTWARE INSTITUTE

南京大学 软件学院

Routing and Routers

CISCO SYSTEMS

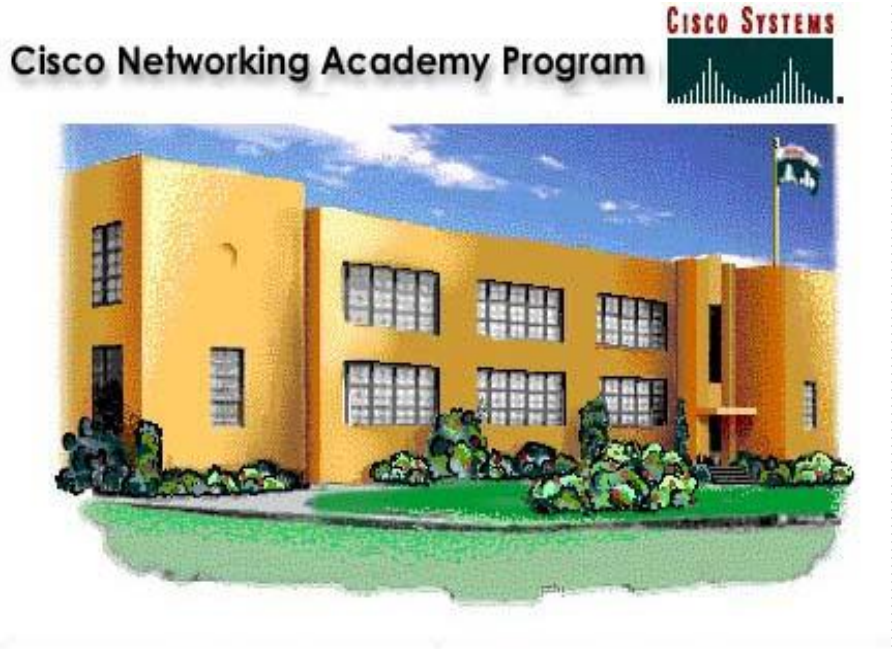
EMPOWERING THE INTERNET GENERATION℠

南京大學
NANJING UNIVERSITY

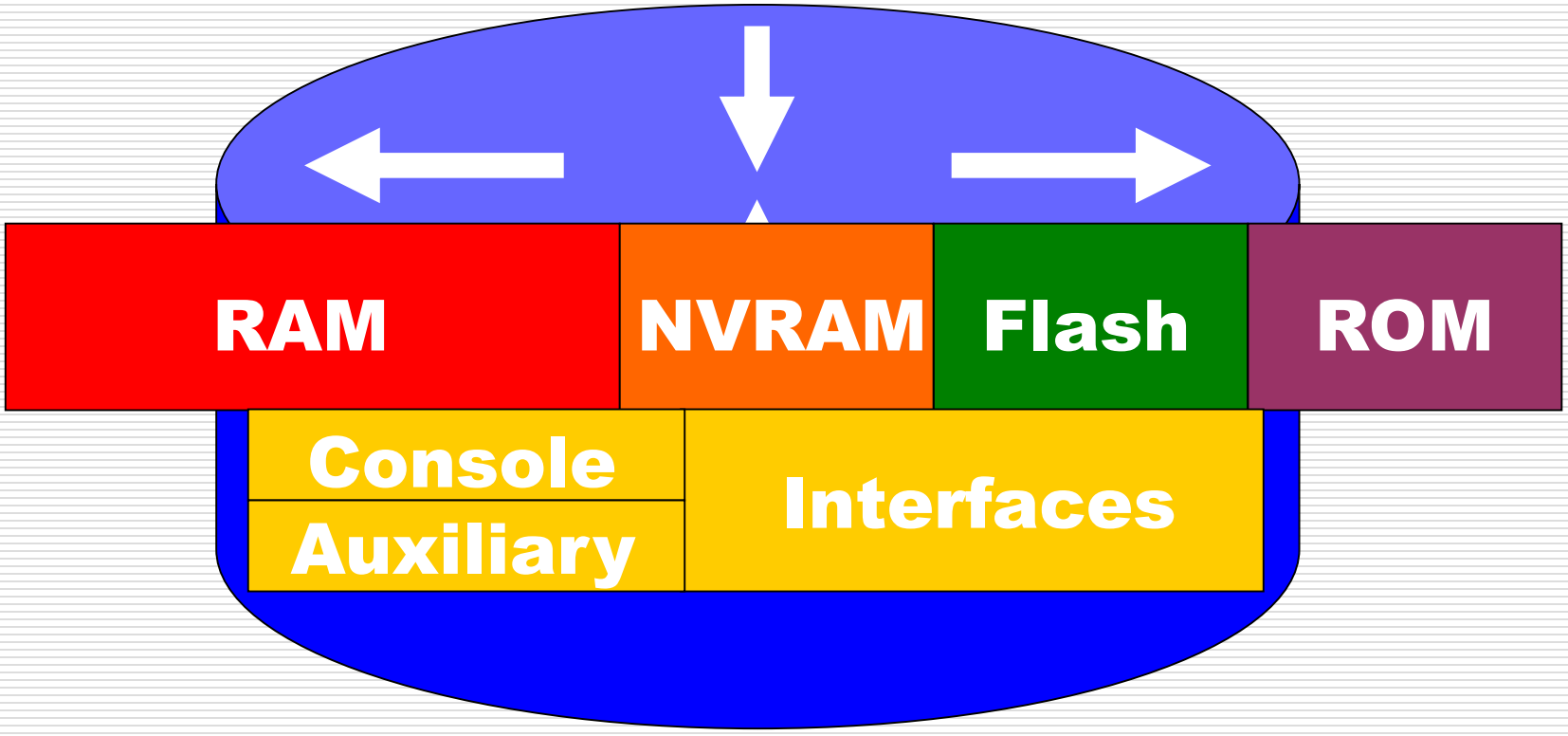
Routing and Routers

- Router Basics
- Router Startup procedure
- Routing
- Router configuration

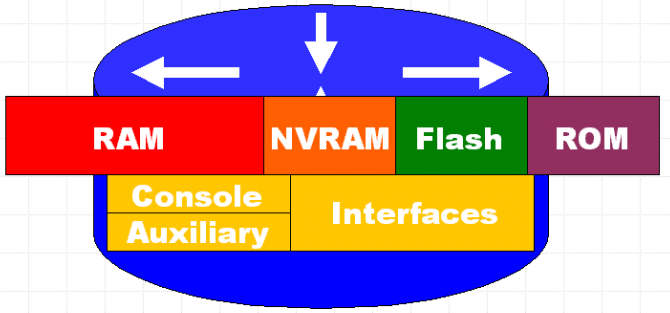
Router Basics



Internal Components

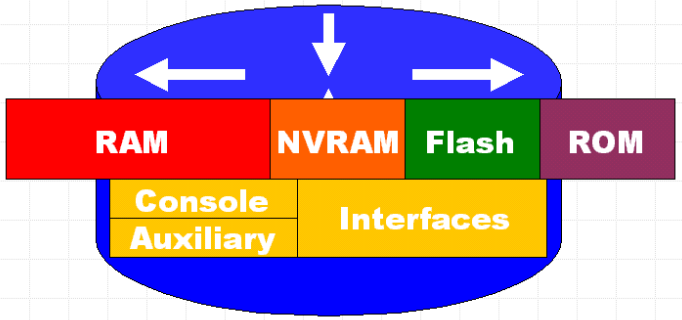


RAM



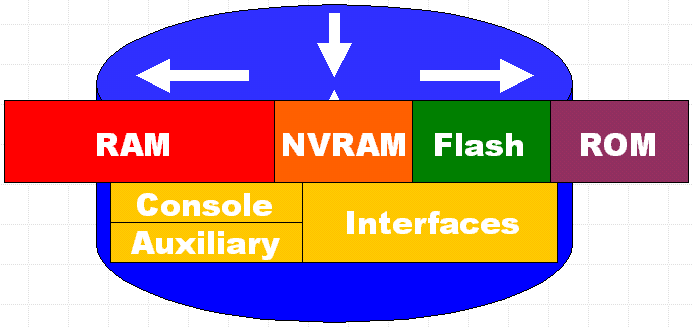
- Temporary storage for router configuration files
- RAM content is lost on power down or restart
- Stores...
  - Routing tables
  - ARP cache
  - Fast switching cache
  - Packet buffering
  - Packet hold queues

NVRAM



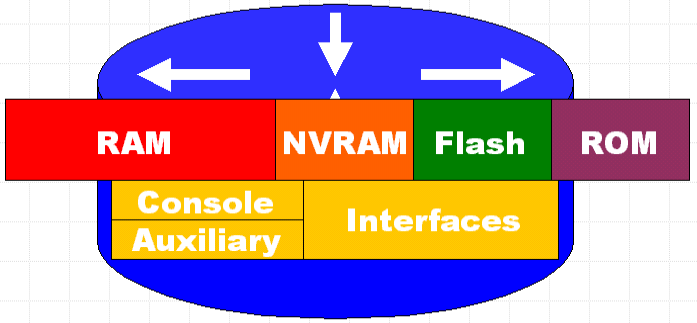
- Non-volatile RAM
- Stores backup/startup configuration files
- Content is not lost when router is powered down or restarted.

Flash



- EEPROM (Electronically Erasable Programmable Read-Only Memory)
- Holds the Cisco IOS (Internet Operating System)
- Allows updating of software without replacing the Flash chip
- Multiple versions of IOS can be stored
- Retained on power down

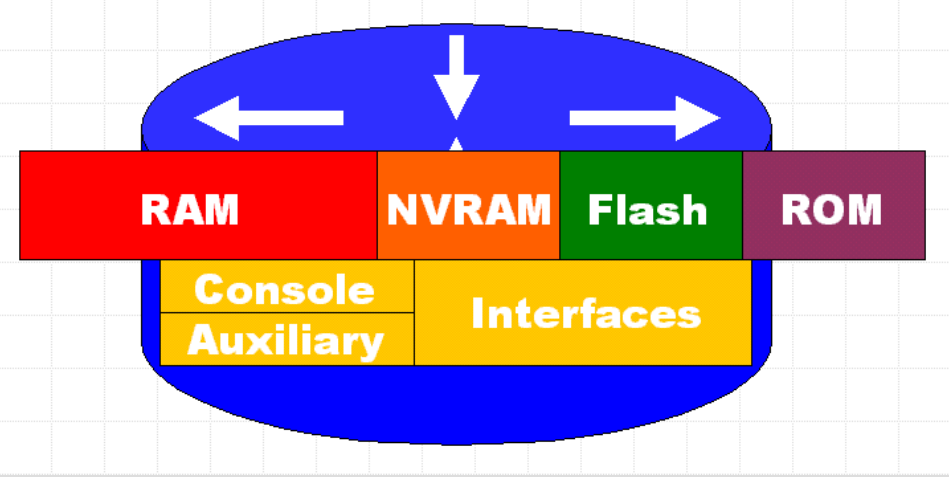
ROM



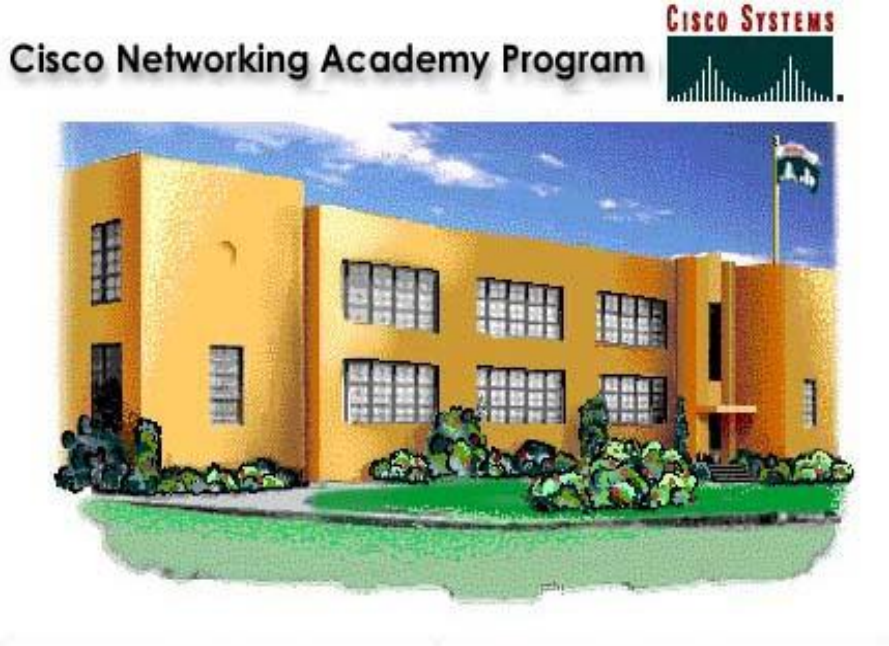
- Contains POST (Power On Self Test)
- A bootstrap program (loads the Cisco IOS)
- And operating system software
  - Backup, trimmed down version of the IOS
  - Upgrades require installing new chip set

Interfaces

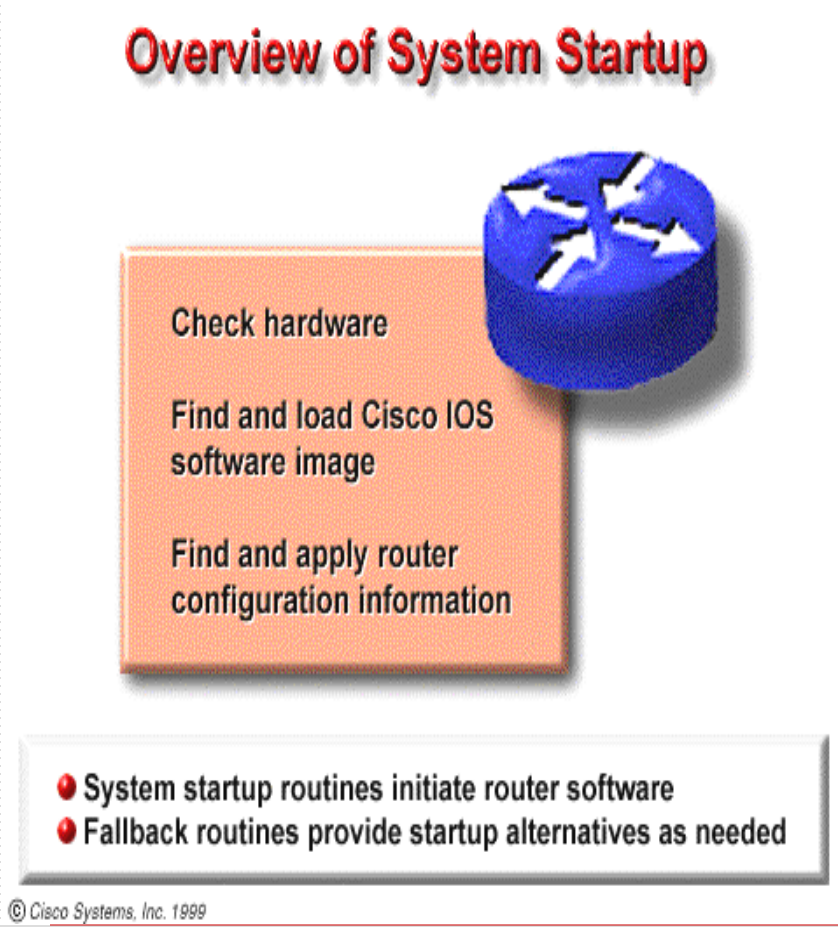
- Network connections through which packets enter and exit the router
- Attached to the motherboard or as separate modules.



Router Startup Procedure



System Startup Procedure

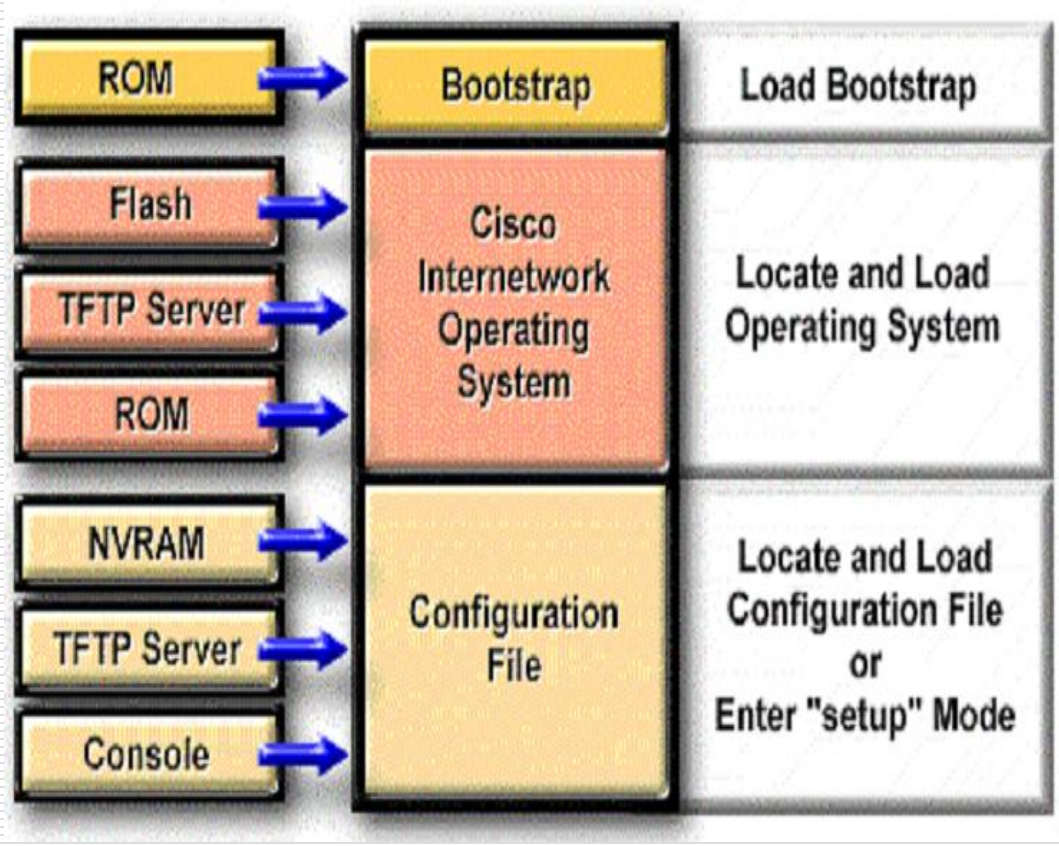


1. Perform a power-up self test(POST):During this self test, the router executes diagnostics from ROM on all hardware modules.
2. Verify the basic operation of CPU, memory, and network interface ports.
3. Software initialization.

Software Startup Procedure

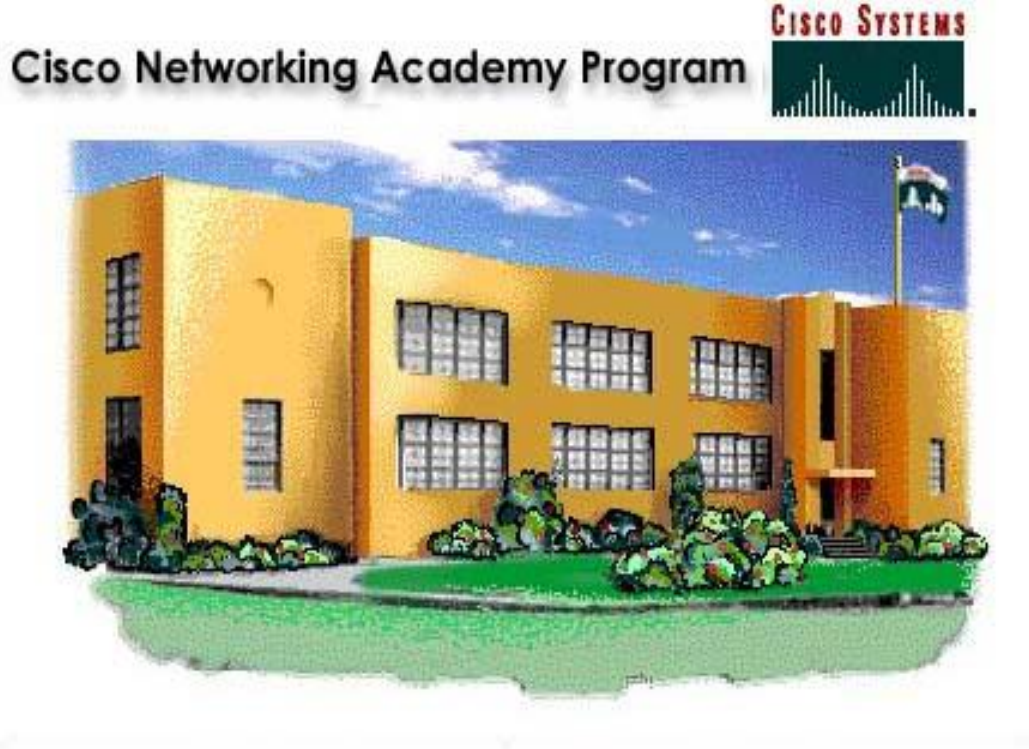
- Step 1 - The generic bootstrap loader, in ROM, executes on the CPU card.
- Step 2 - The operating system (Cisco IOS) can be found in one of several places. The location is disclosed in the boot field of the configuration register.
- Step 3 - The operating system image is loaded.
- Step 4 - The configuration file saved in NVRAM is loaded into main memory and executed one line at a time.
- Step 5 - If no valid configuration file in NVRAM, then executes a question-driven initial configuration routine referred to as the system configuration dialog, also called the ***setup mode***.

Router Startup Procedure



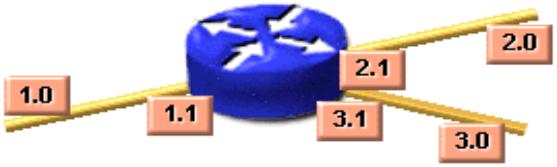
- Setup is not intended as the mode for entering complex protocol features in the router.
- You should use setup to bring up a minimal configuration, then use various configuration-mode commands, rather than setup, for most router configuration tasks

Routing



Routing Using Network Addressing

Destination Network	Direction and Router Port
1.0	1.1
2.0	2.1
3.0	3.1

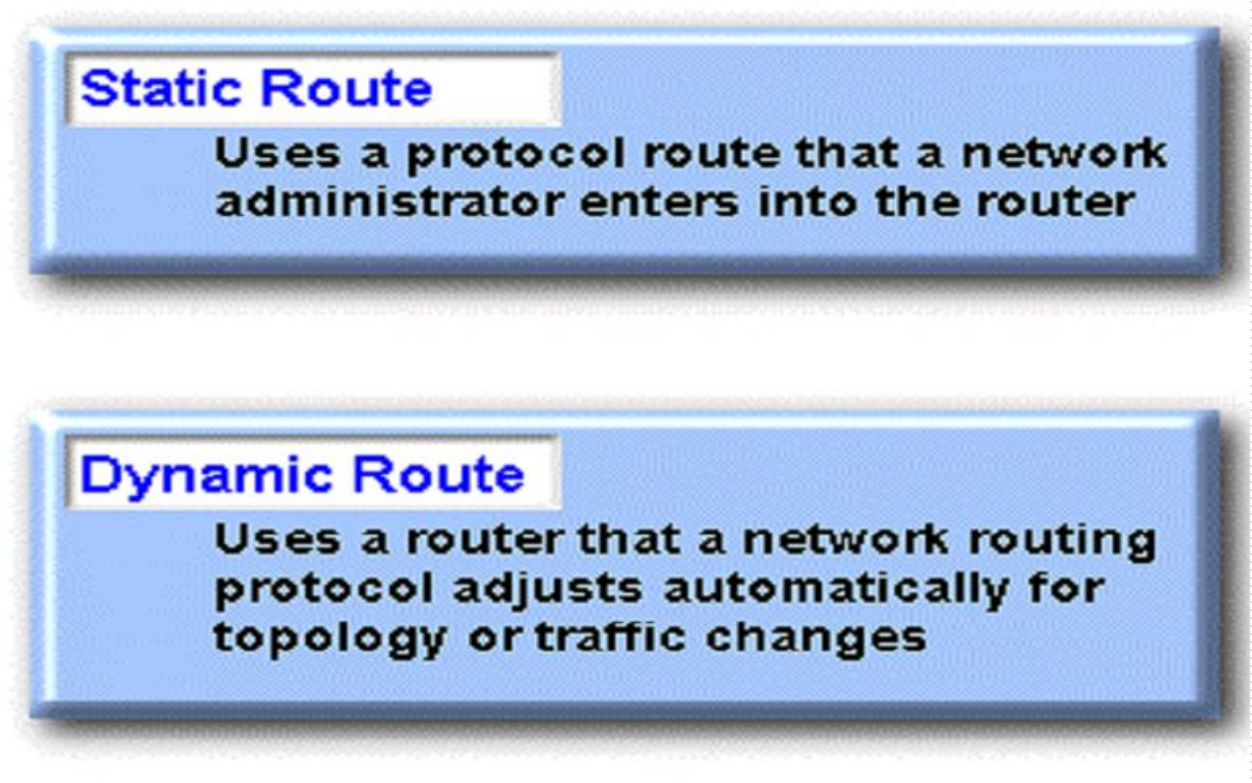


- Network portion of address used to make path selections
- Node portion of address refers to router port to the path

- A router generally relays a packet from one data link to another, using two basic functions, a *path determination* function and a *switching* function.

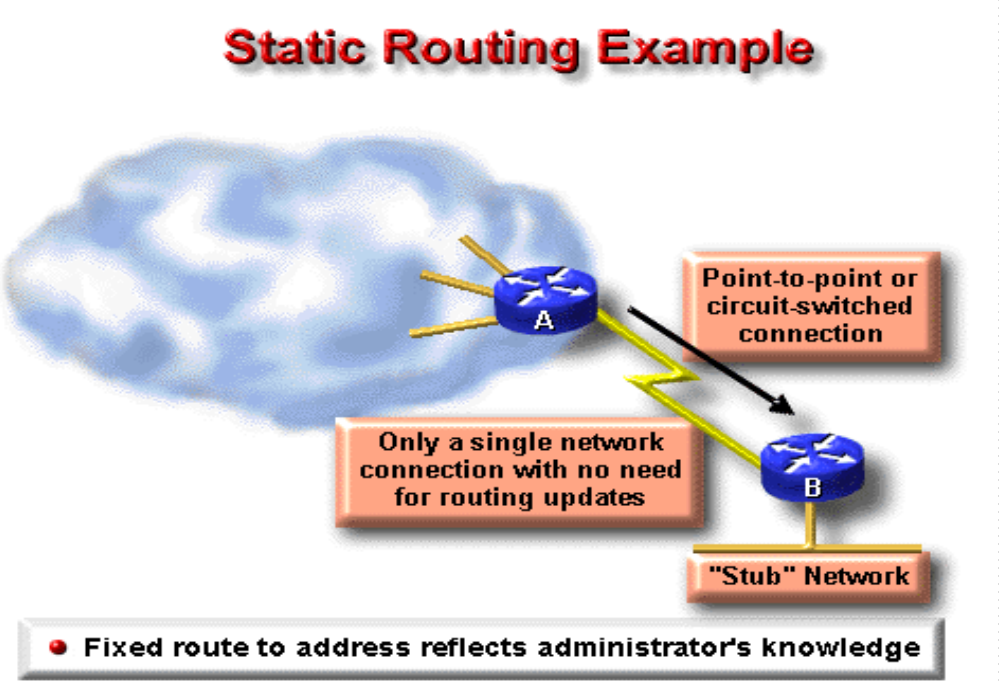
- The *switching function* allows a router to accept a packet on one interface and forward it through a second interface.
- The *path determination* function enables the router to select the most appropriate interface for forwarding a packet.
- The router uses the *network portion* of the address to make path selections to pass the packet to the next router
- The *node portion* of the address is used by the the router directly connected to the destination network to deliver the packet to the correct host.

Static and Dynamic Route



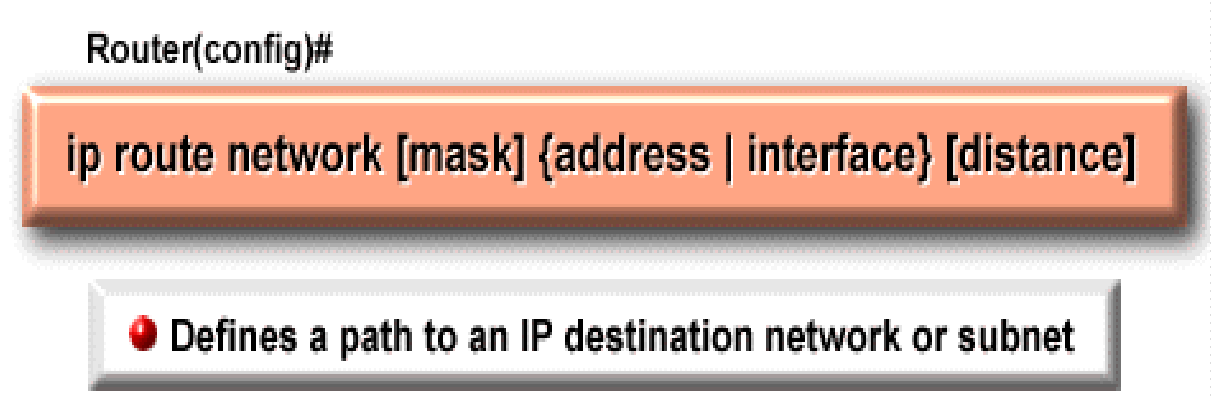
Static and Dynamic Route

- Whereas dynamic routing tends to reveal everything known about an internetwork, for security reasons, you may want to hide parts of an internetwork.



- When a network is accessible by only one path, a static route to the network can be sufficient.
- This type of partition is called a ***stub network***.

Static Route Configuration



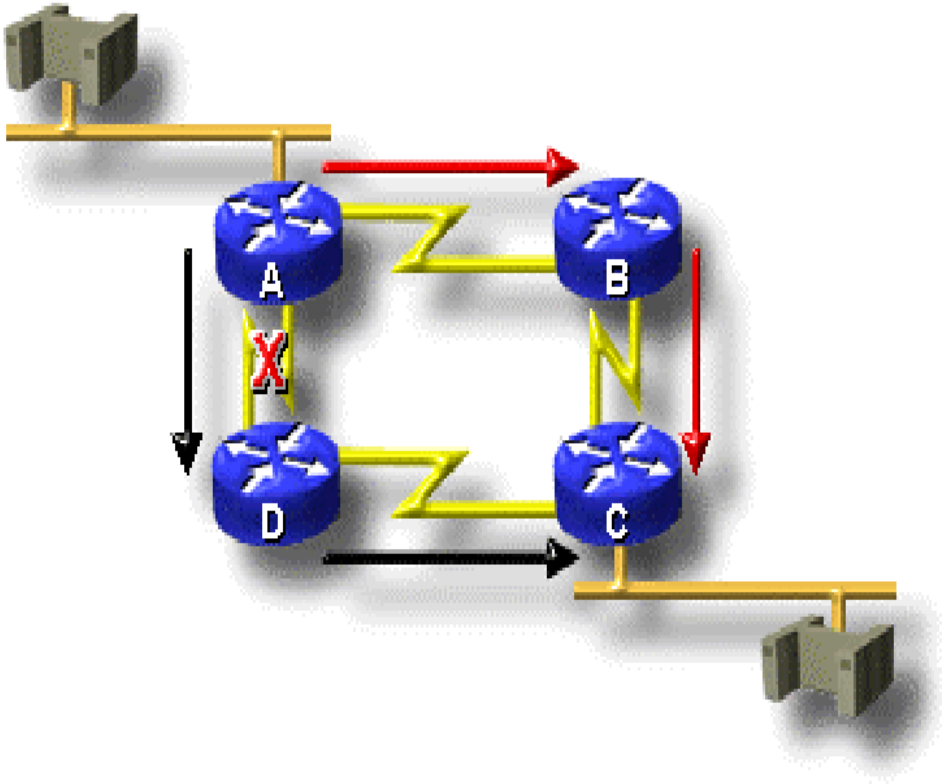
A static route allows manual configuration of the routing table.

ip route Command	Description
network	destination network or subnet
mask	subnet mask
address	IP address of the next-hop router
interface	the interface to use to get to the destination network
distance	administrative distance

Administrative Distance

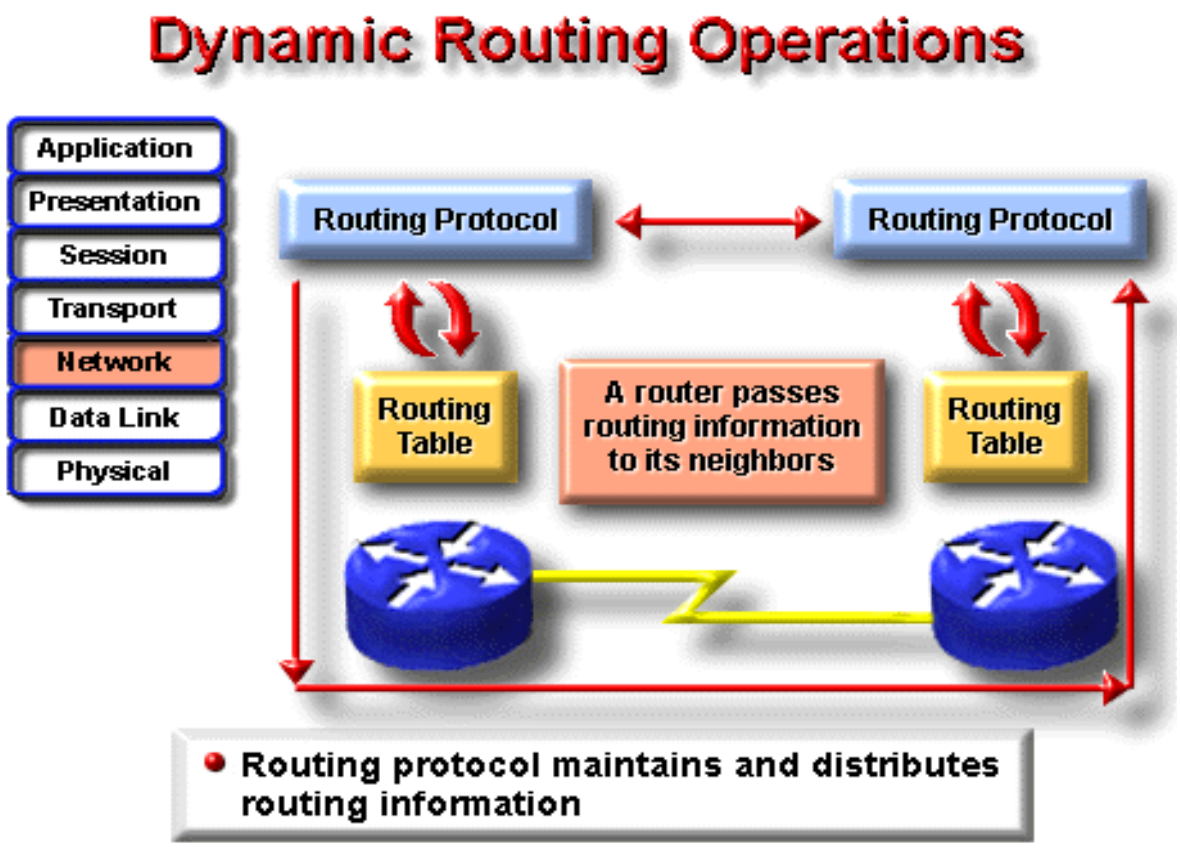
- The *administrative distance* is a rating of the trustworthiness of a routing information source, expressed as a numeric value from 0 to 255.
- The higher the number, the lower the trustworthiness rating.
- So the administrative distance of static routes is often low.(1 is the default)

Dynamic Routing



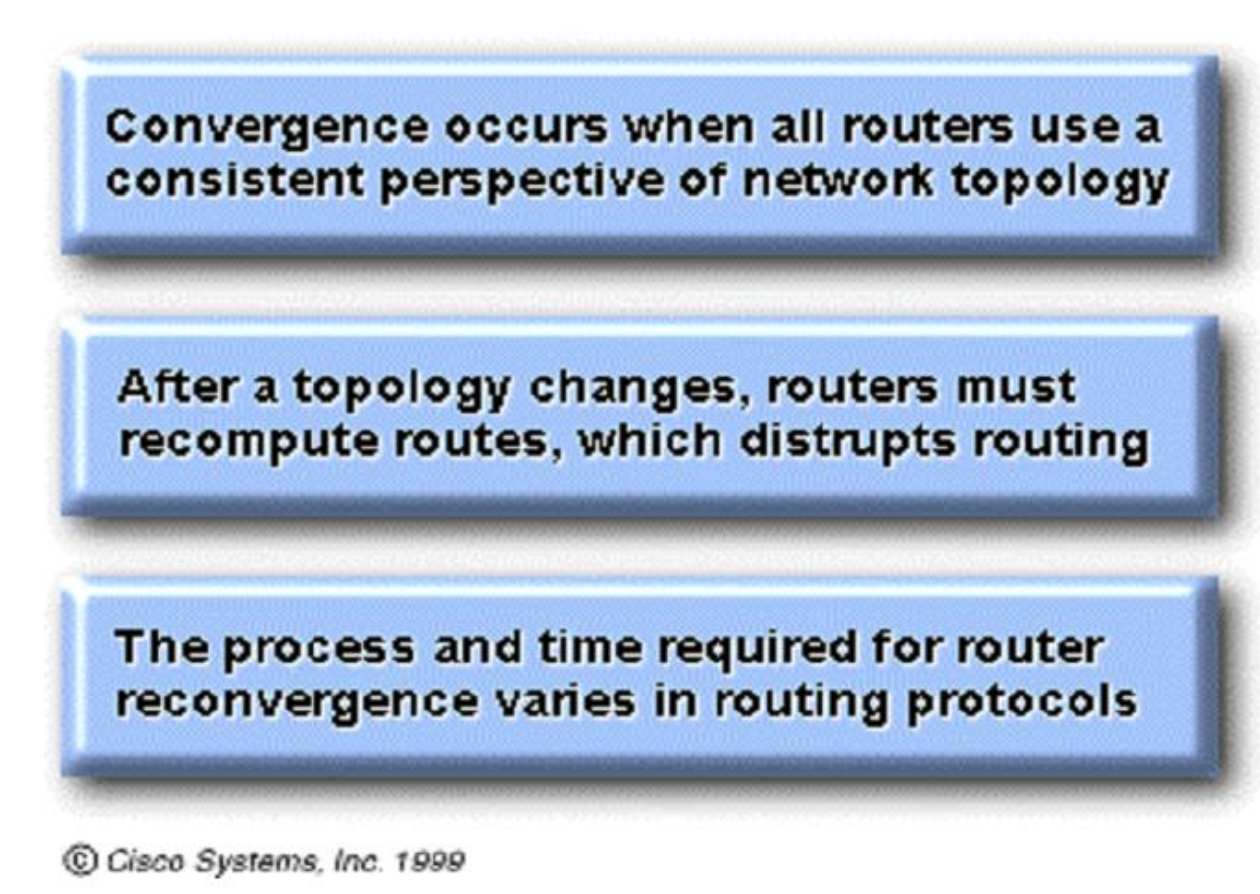
Dynamic routing protocols can also redirect traffic (or loadshare) between different paths in a network

Dynamic routing

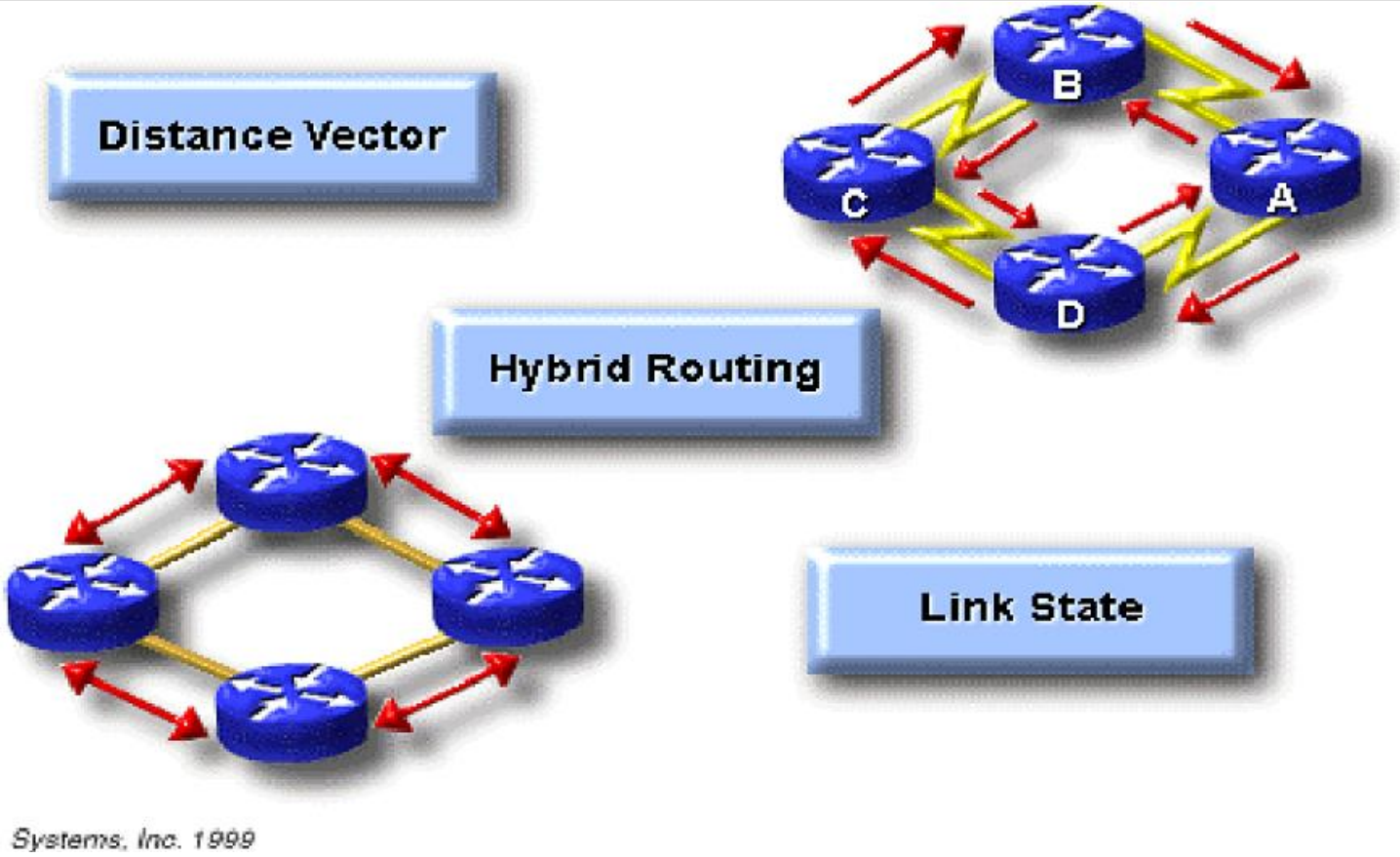


- Dynamic routing relies on a routing protocol to share knowledge among routers.
- The dynamic routing depends on two basic router functions:
  - maintenance of a routing table
  - distribution of knowledge to other routers

Time to Convergence

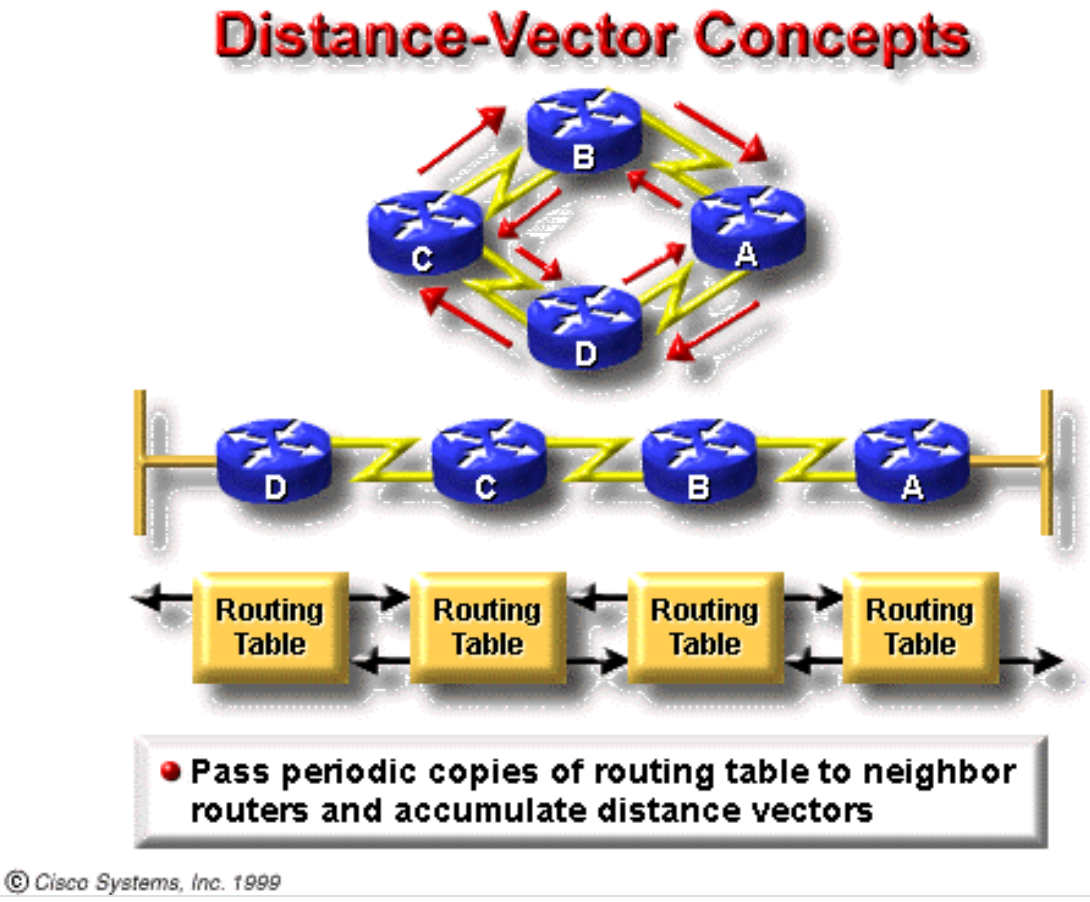


Classification of Routing Protocols

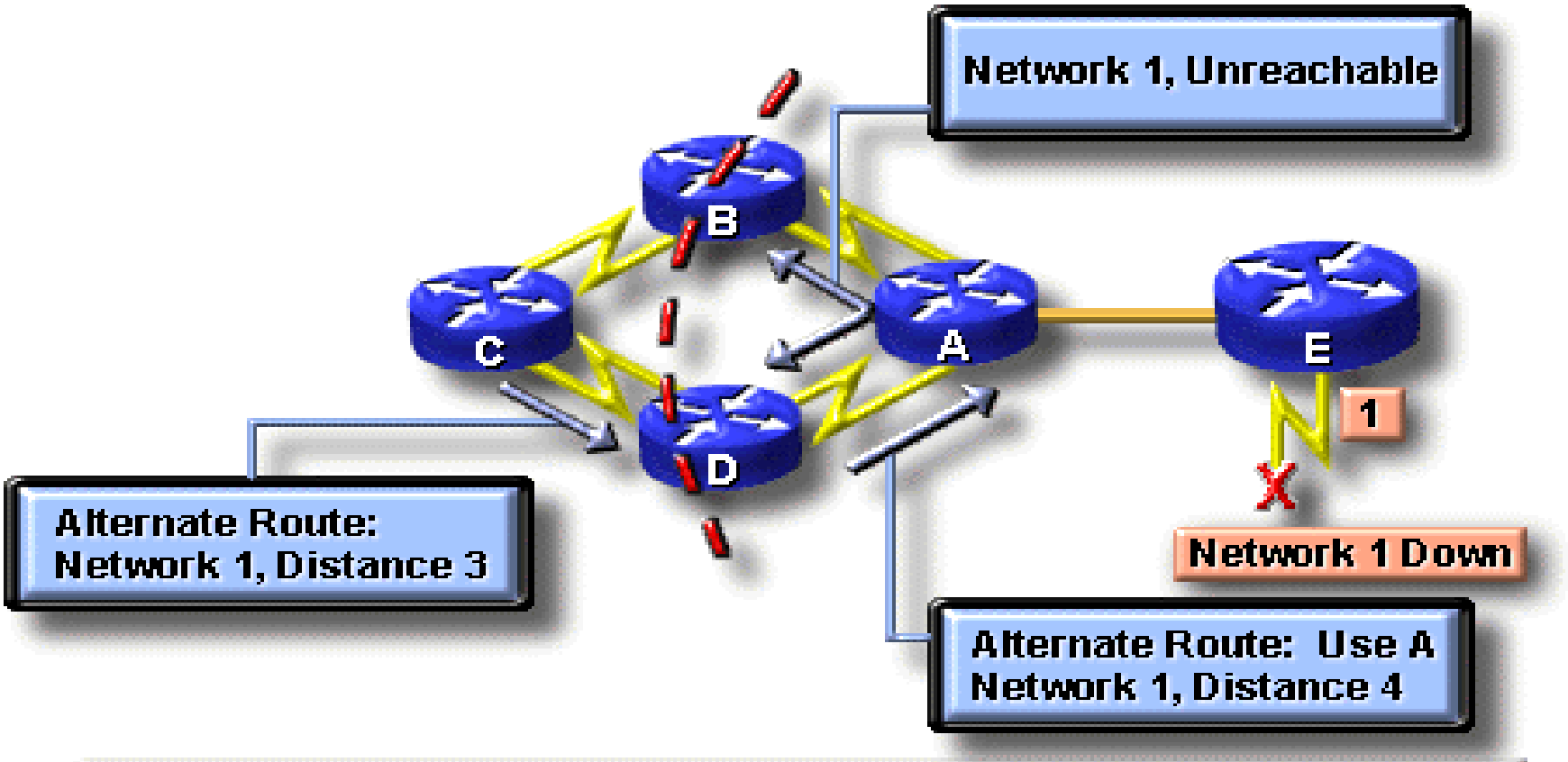


Distance-Vector Protocol

- Distance-vector algorithms do not allow a router to know the exact topology of an internetwork
- Distance-vector-based routing algorithms (also known as ***Bellman-Ford algorithms***) pass periodic copies of a routing table from router to router.



Problem: Routing Loops

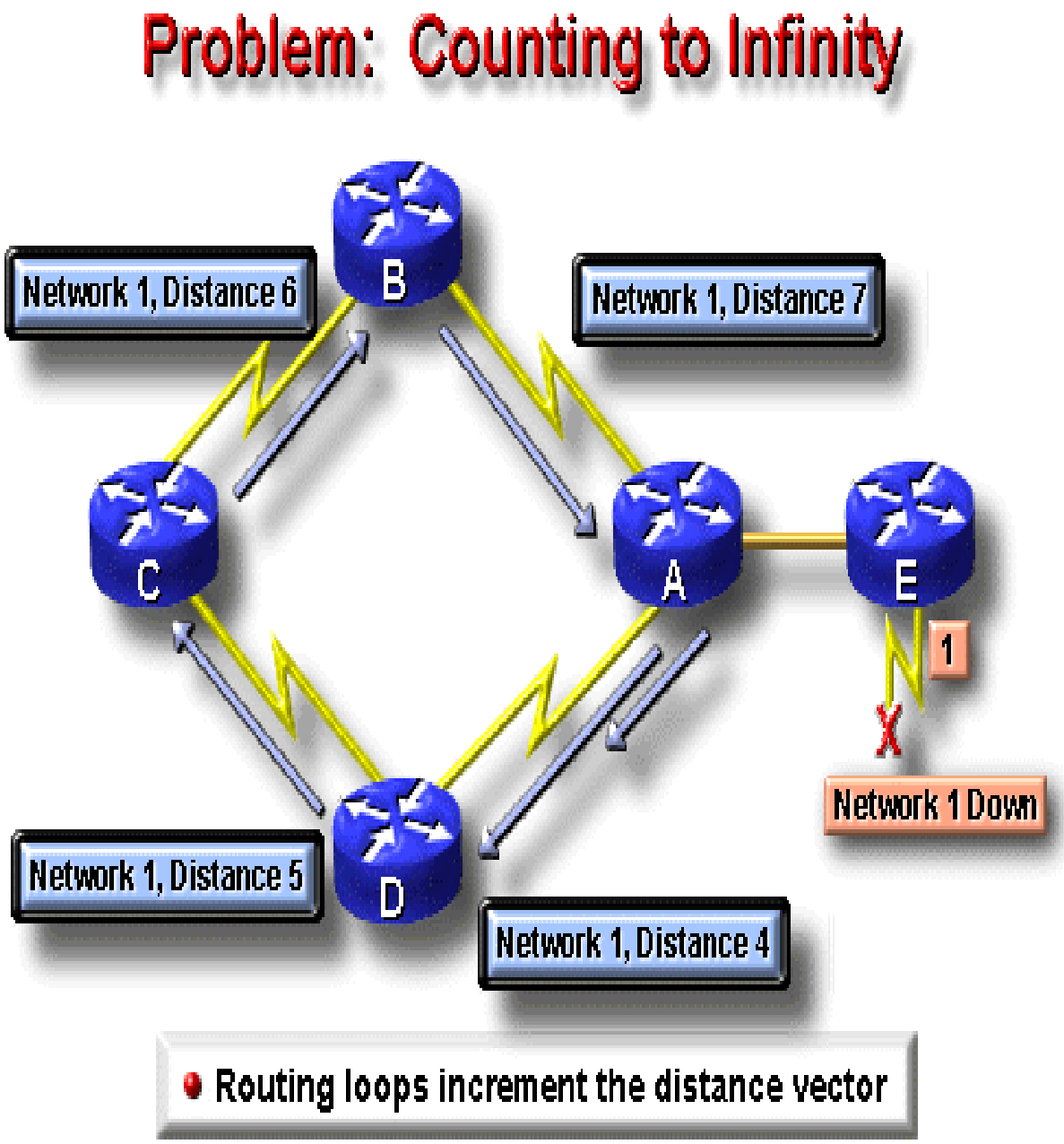


- Alternate routes, slow convergence, inconsistent routing

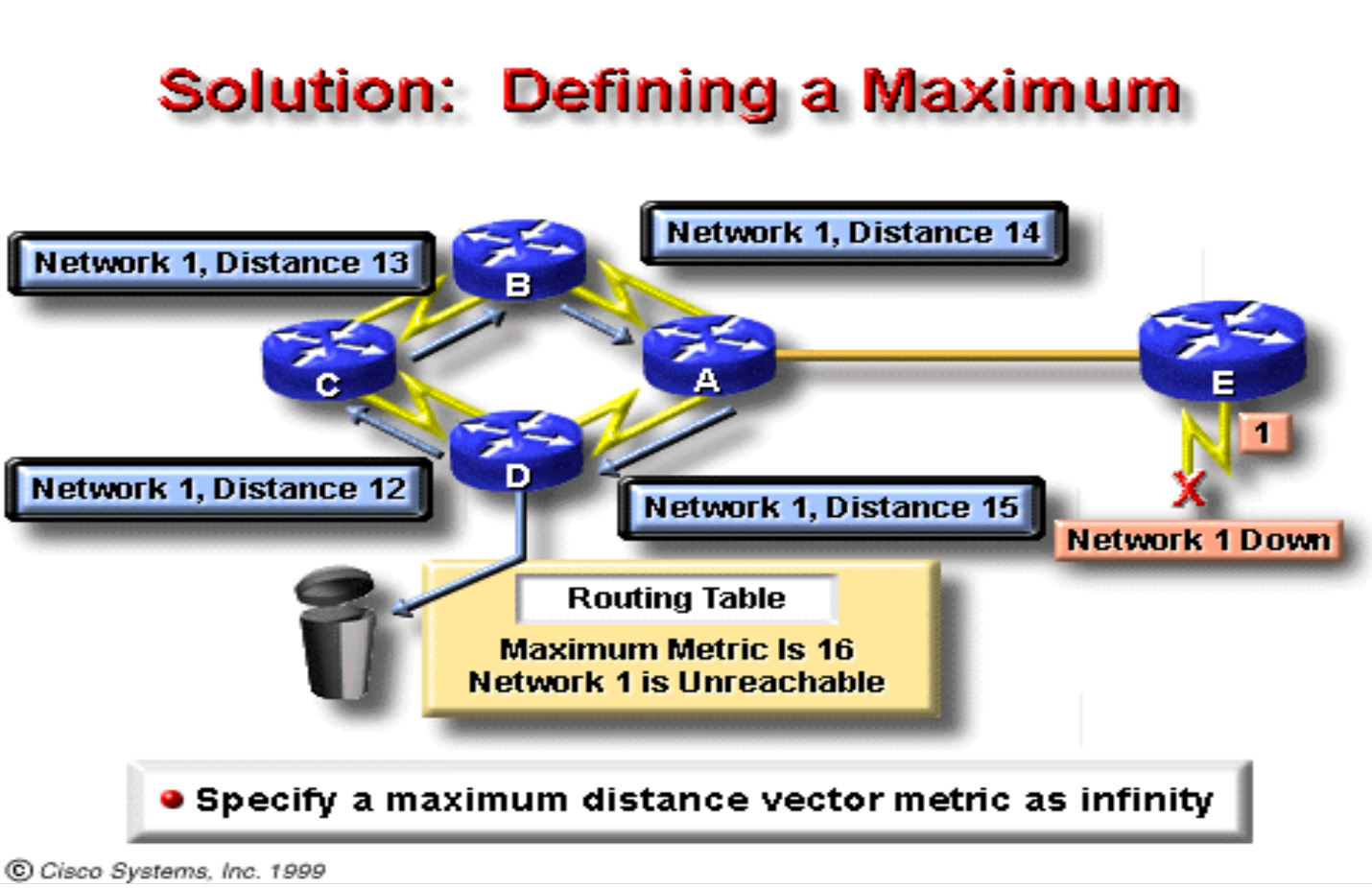
- The invalid updates of Network 1 will continue to loop until some other process stops the looping.

- This condition, called ***count to infinity***, loops packets continuously around the network in spite of the fundamental fact that the destination network, Network 1, is down.

- While the routers are counting to infinity, the invalid information allows a routing loop to exist.

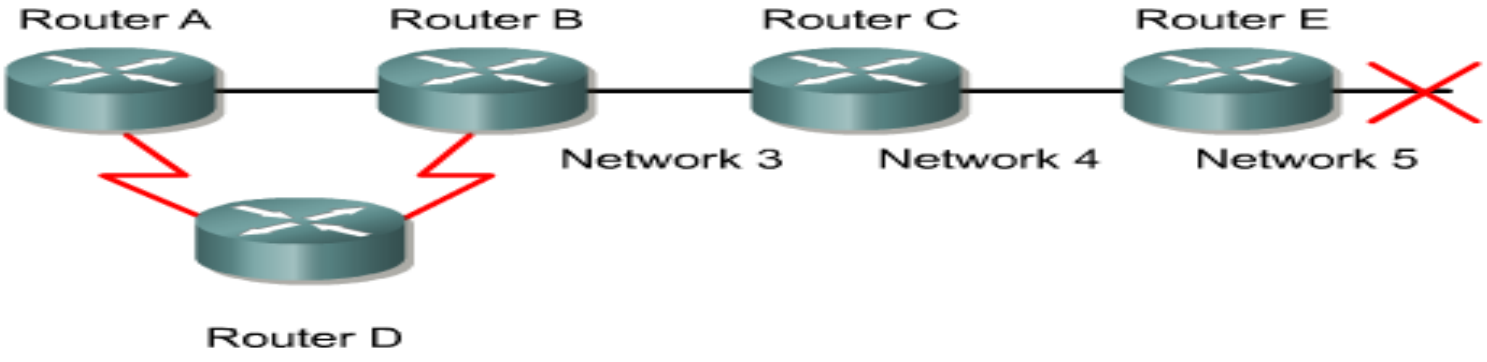


Solution: Defining a Maximum



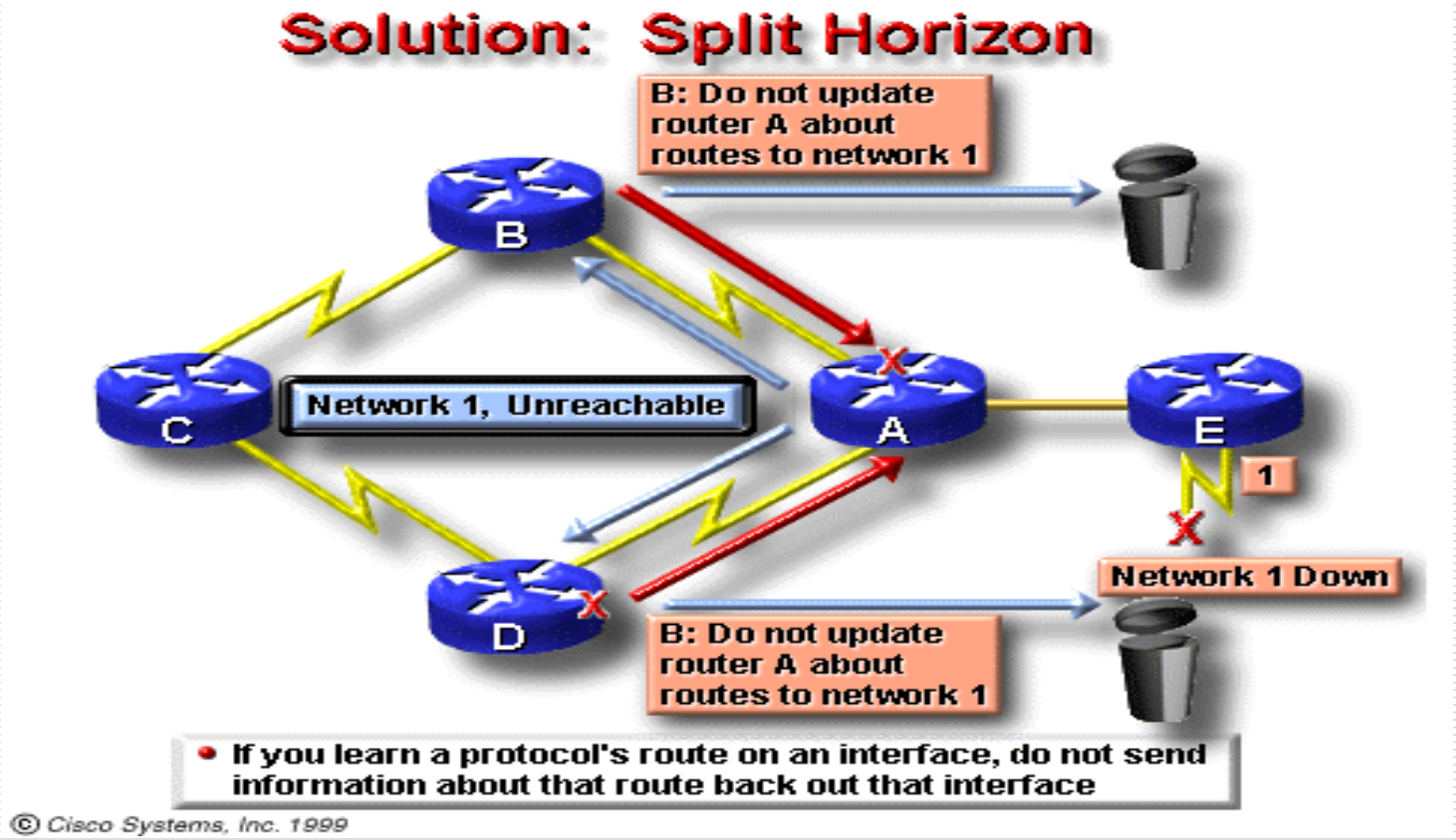
Solution: Route Poisoning

- When Network 5 goes down, Router E initiates route poisoning by making a table entry for Network 5 as 16, or unreachable.
- When Router C receives a route poisoning from Router E, it sends an update, called a poison reverse, back to Router E. This makes sure all routers on the segment have received the poisoned route information.

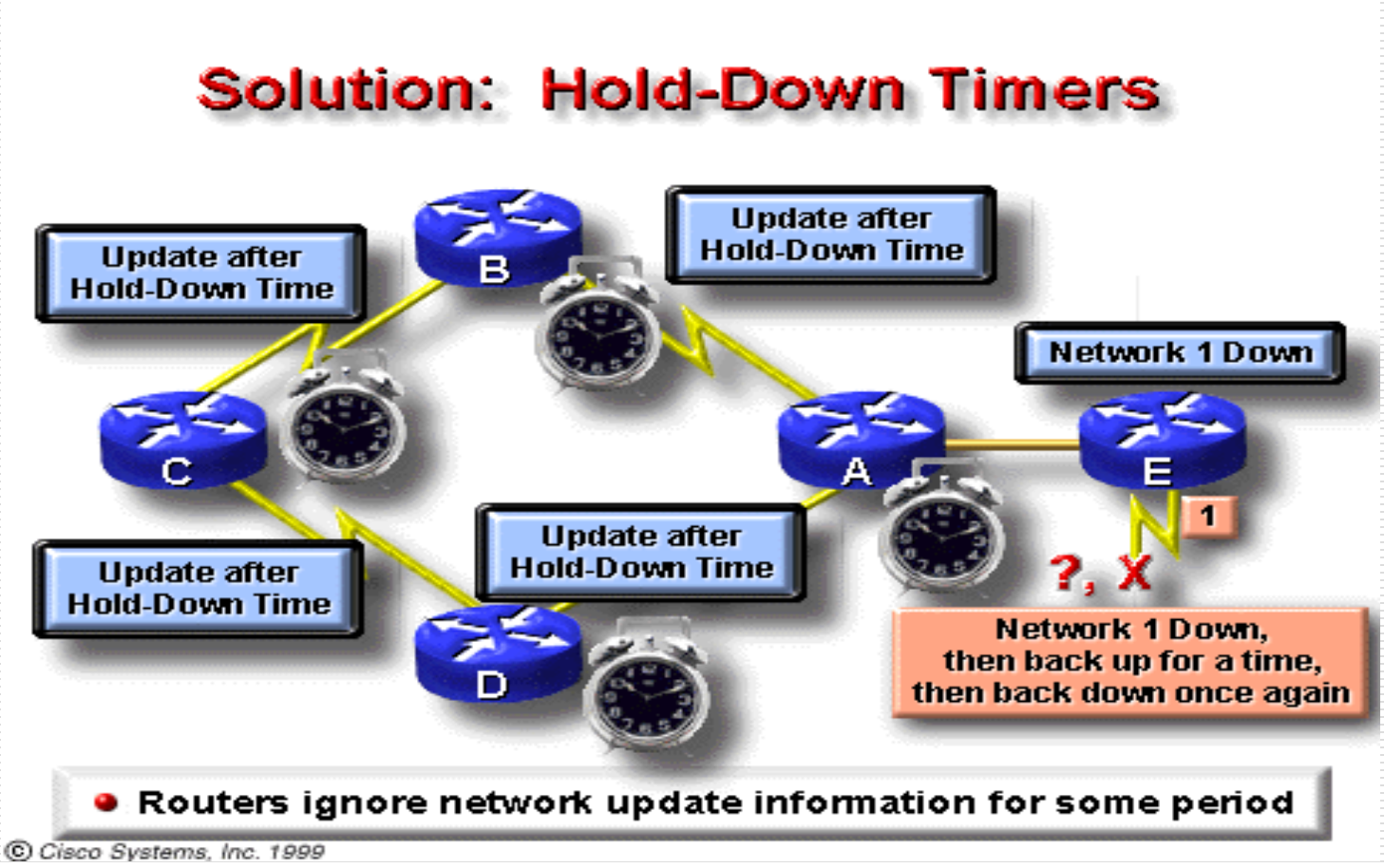


When Network 5 goes down, Router E initiates route poisoning by entering a table entry metric of 16 (unreachable).

Solution: Split Horizon



Solution: Hold-Down Timers



Prevent Sending Route update

- To prevent an interface from sending out any route update information,use the command:
  - Router(config-router)#Passive-interface f0/0
- It is valid only when using distance-vector routing protocols, because link-state routing protocols do not get the topology information directly from the routing table of its neighbors

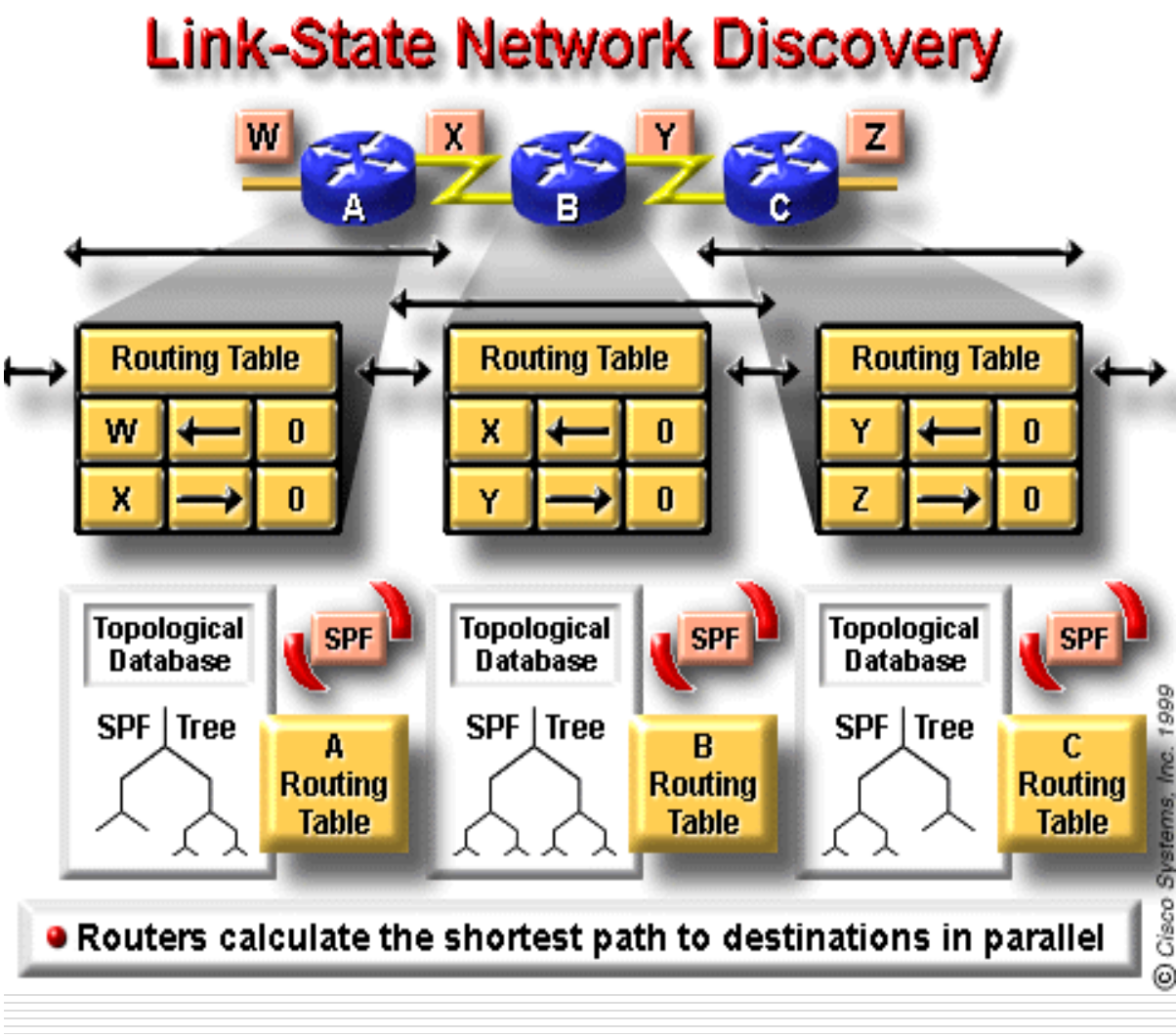
Link-state Protocol

- Link-state based routing algorithms also known as SPF (shortest path first) algorithms, maintain a complex database of topology information.
- Link-state routing uses:
  - link-state advertisements(LSAs)
  - a topological database
  - the SPF algorithm, and the resulting SPF tree
  - a routing table of paths and ports to each network
- RFC 1583 contains a description of OSPF link-state concepts and operations.

1. Routers ***exchange LSAs*** with each other. Each router begins with directly connected networks

2. Each router in parallel with the others ***constructs a topological database*** consisting of all the LSAs from the internetwork.

3. ***The SPF algorithm computes network reachability***. The router constructs this logical topology as a tree, with itself as root, consisting of all possible paths to each network in the link-state protocol internetwork. It then sorts these paths shortest path first (SPF).

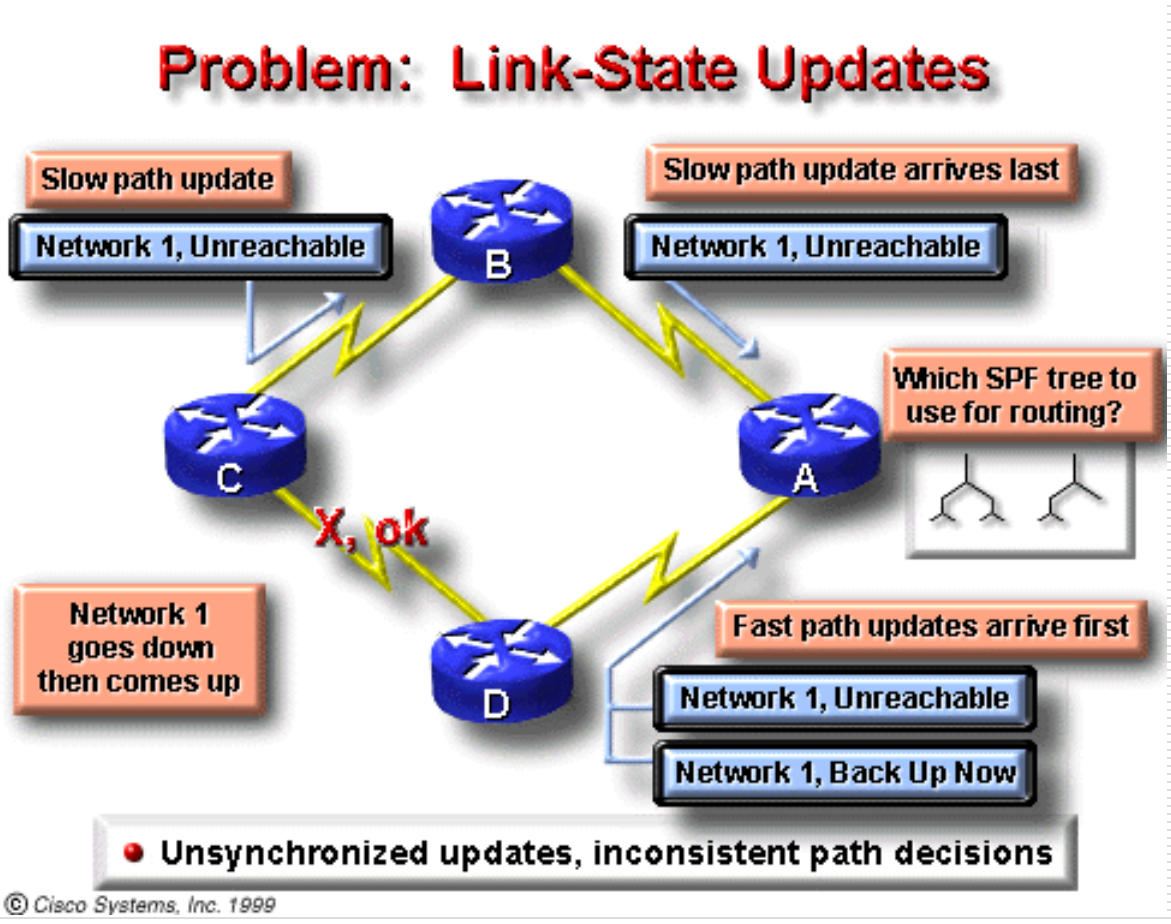


4. ***The router lists its best paths, and the ports to these destination networks, in the routing table***. It also maintains other databases of topology elements and status details.

Link-state Concerns

- **There are two link-state concerns:**
  - **Processing and memory requirements**
    - Running link-state routing protocols in most situations requires that routers use more memory and perform more processing than distance-vector routing protocols.
  - **Bandwidth requirements**
    - During Initial link-state packet flooding, all routers using link-state routing protocols send LSA packets to all other routers. This action floods the internetwork as routers make their demand for bandwidth, and temporarily reduce the bandwidth available for routed traffic that carries user data.

Problem: Link-state Updates



- **Link-state routing must make sure that all routers get all necessary LSA packets.**
- **Routers with different sets of LSAs calculate routes based on different topological data.**

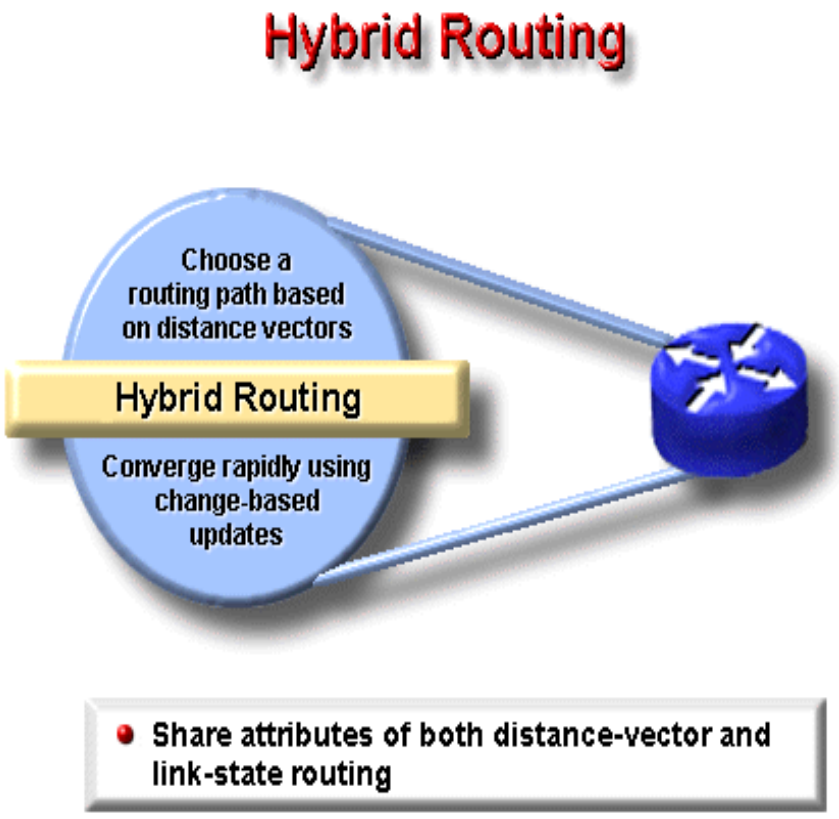
Comparing: Link-state and Distance-Vector

南京大學
NANJING UNIVERSITY

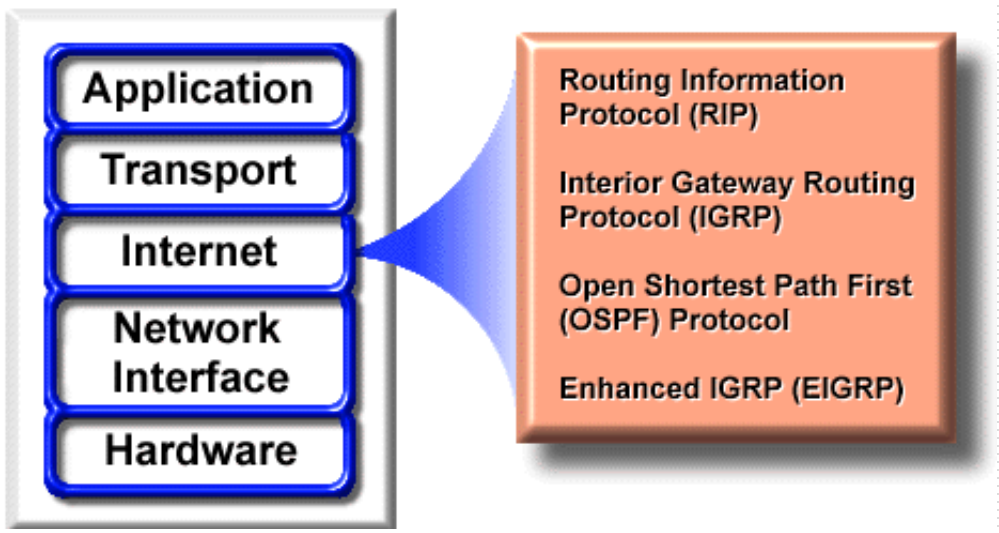
Distance-Vector	Link-State
View network topology from neighbor's perspective	Gets common view of entire network topology
Adds distance vectors from router to router	Calculates the shortest path to other routers
Frequent, periodic updates: slow convergence	Event-triggered updates: faster convergence
Passes copies of routing tables to neighbor routers	Passes link-state routing updates to other routers

Hybrid Protocols

- Examples of hybrid protocols:
  - OSI's ***IS-IS*** *(Intermediate System-to-Intermediate System)*
  - Cisco's ***EIGRP*** *(Enhanced Interior Gateway Routing Protocol).*



Routing Protocols



- Examples of IP routing protocols include:
  - RIP - a distance-vector routing protocol
  - IGRP - Cisco's distance-vector routing protocol
  - OSPF - a link-state routing protocol
  - EIGRP - a balanced hybrid routing protocol

Primary Goals of Routing Protocols

- Optimal Route—pick the best route
- Efficiency—minimal use of bandwidth and router processor resources
- Rapid Convergence—the faster, the better. Some are quicker at converging than others.
- Flexibility—can handle a wide variety of situations such as high usage and failed routes

Dynamic Routing Configuration

Router(config)#

router *protocol* [keyword]

- Defines an IP routing protocol

Router(config-router)#

network *network-number*

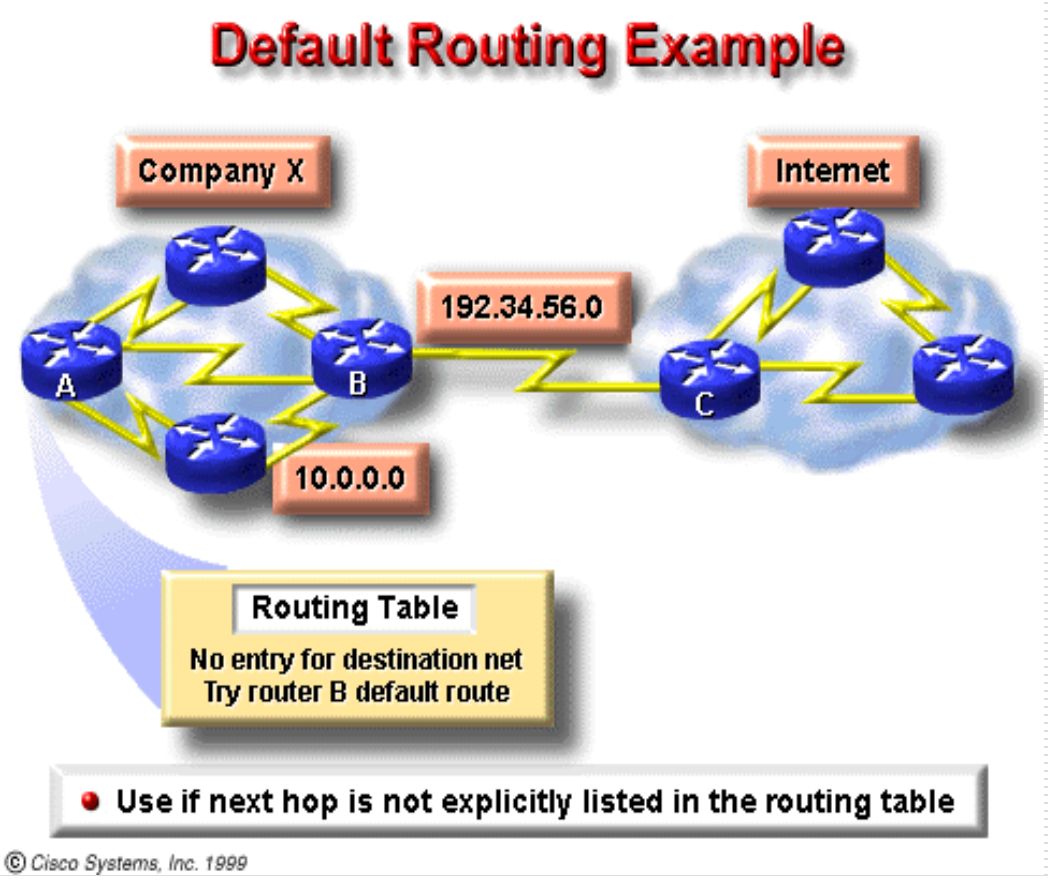
- The network subcommand is a mandatory configuration command for each IP routing process

Router Commands	Description
protocol	either RIP, IGRP, OSPF, or Enhanced IGRP.
options	such as autonomous system, which is used with protocols that require it, such as IGRP

Network Command	Description
network-number	specifies a directly-connected network

Define Default Route

- Default routes keep routing tables shorter.
- When an entry for a destination network does not exist in a routing table, the packet is sent to the default network.



Define Default Route(I)

- Define a default route using dynamic routing protocols
  - Router(config)# ip default-network [network-number]

ip default network Command	Description
network-number	IP network number or subnet number defined as the default

Define Default Route(II)

- Define a default route as a static route:
- Router(config)# ip route 0.0.0.0 0.0.0.0 [next-hop-ip-address| exit-interface]
- After configure a default route, use show ip route will display: (172.16.1.2 is the default next-hop address)
  - Gateway of last resort is 172.16.1.2 to network 0.0.0.0

谢 谢！