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Chapter 1: Routing Services

CCNP ROUTE: Implementing IP Routing

Chapter 1 Objectives

- Describe common enterprise traffic requirements and network design models.
- Describe how to create a plan for implementing routing services in an enterprise network.
- Review the fundamentals of routing and compare various routing protocols.

COMPLEX ENTERPRISE NETWORK FRAMEWORKS, ARCHITECTURES, AND MODELS

Traffic Conditions in a Converged Network

- Modern networks must support various types of traffic:
  - Voice and video traffic
  - Voice applications traffic
  - Mission-critical traffic
  - Transactional traffic
  - Network management traffic
  - Routing protocol traffic
- This mix of traffic greatly impacts the network requirements such as security and performance.
- To help enterprises, Cisco has developed the Intelligent Information Network (IIN).

Cisco Intelligent Information Network

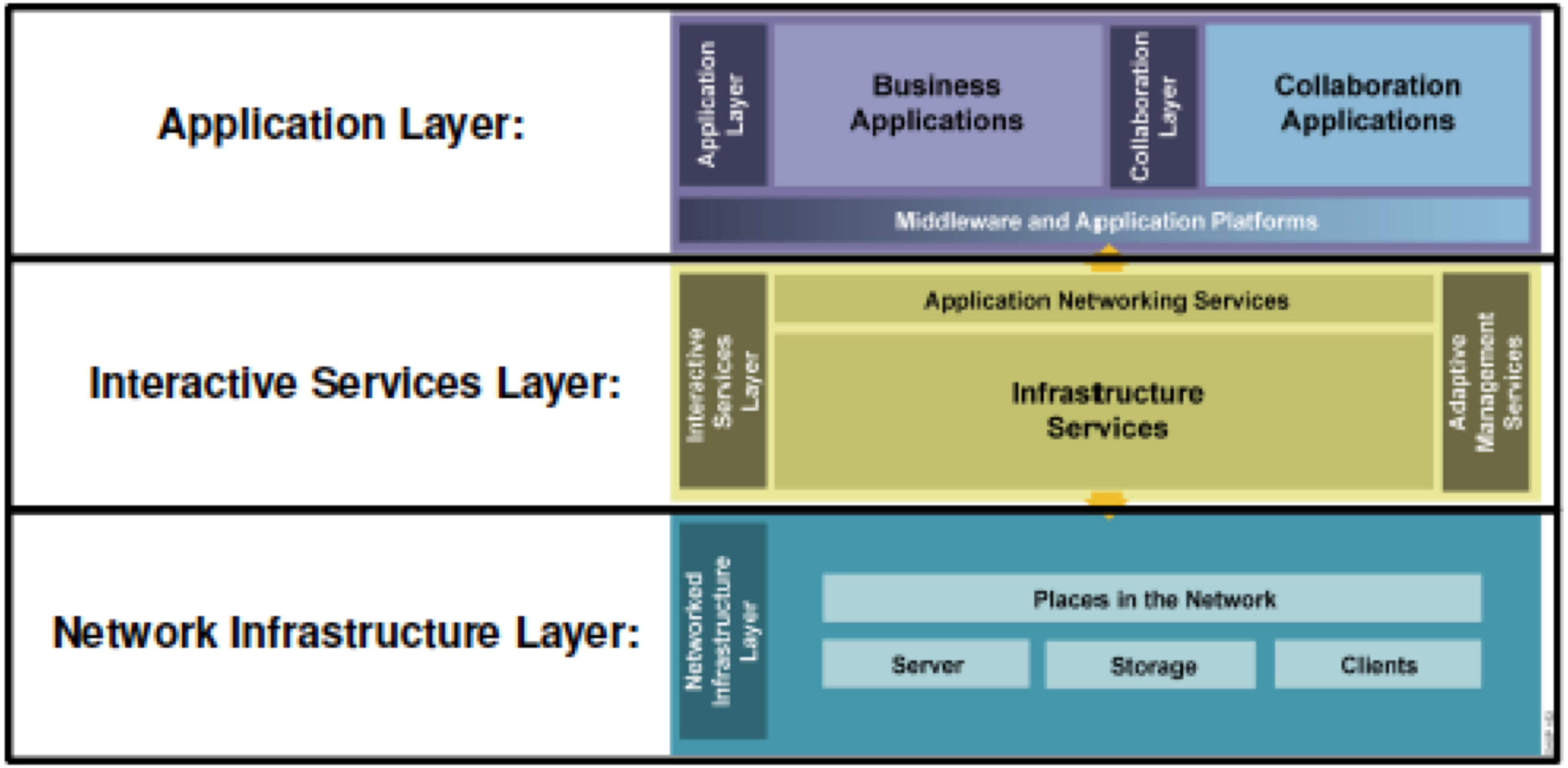
- The Intelligent Information Network (IIN):
  - Integrates networked resources and information assets.
  - Extends intelligence across multiple products and infrastructure layers.
  - Actively participates in the delivery of services and applications.
- The IIN technology vision consists of 3 three phases in which functionality can be added to the infrastructure as required:
  - Integrated transport
  - Integrated services
  - Integrated applications

Cisco SONA Framework

- The Cisco Service-Oriented Network Architecture (SONA) is an architectural framework to create a dynamic, flexible architecture and provide operational efficiency through standardization and virtualization.
  - SONA provides guidance, best practices, and blueprints for connecting network services and applications to enable business solutions.
  - In this framework, the network is the common element that connects and enables all components of the IT infrastructure.
- SONA help enterprises achieve their goals by leveraging:
  - The extensive Cisco product-line services
  - The proven Cisco architectures
  - The experience of Cisco and its partners

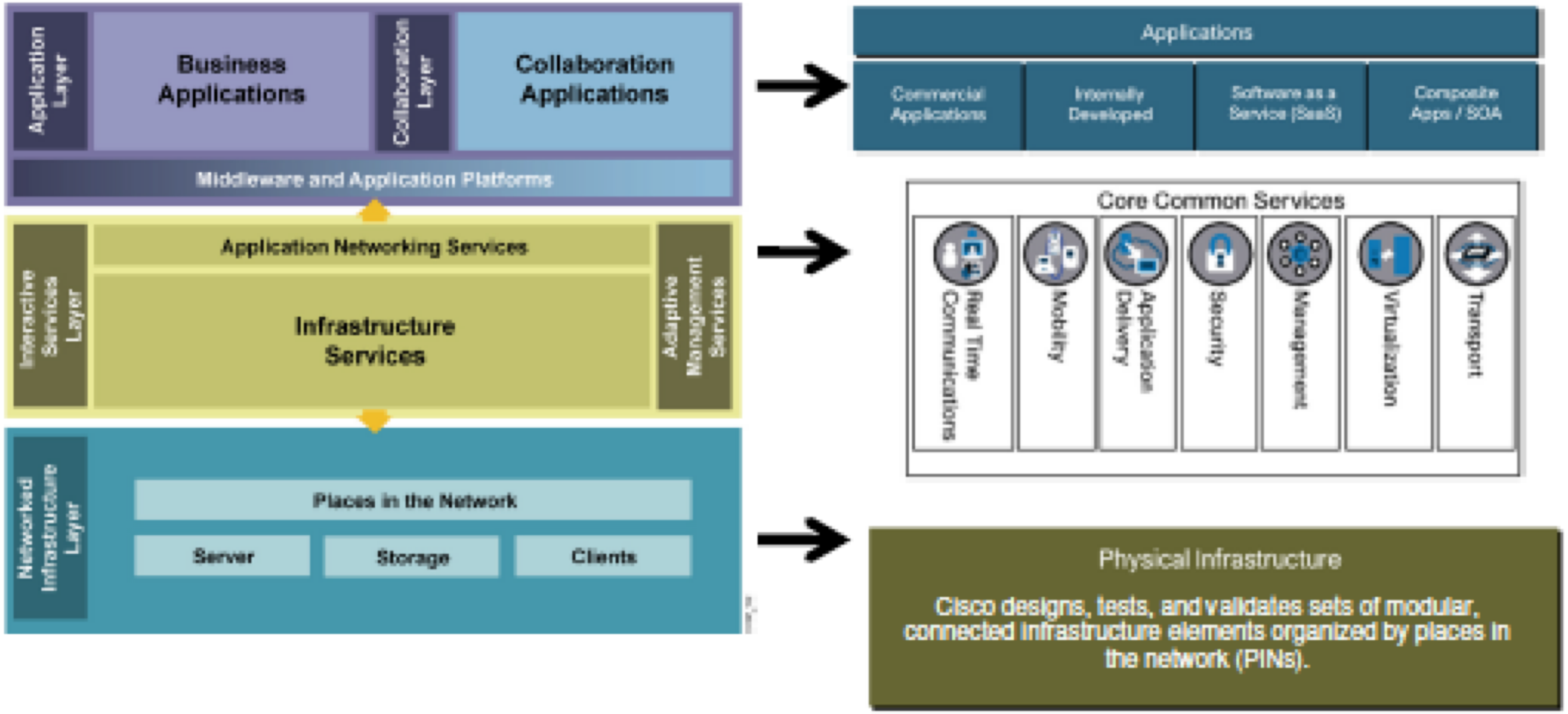
Cisco SONA Framework Layers

The SONA framework outlines three layers:



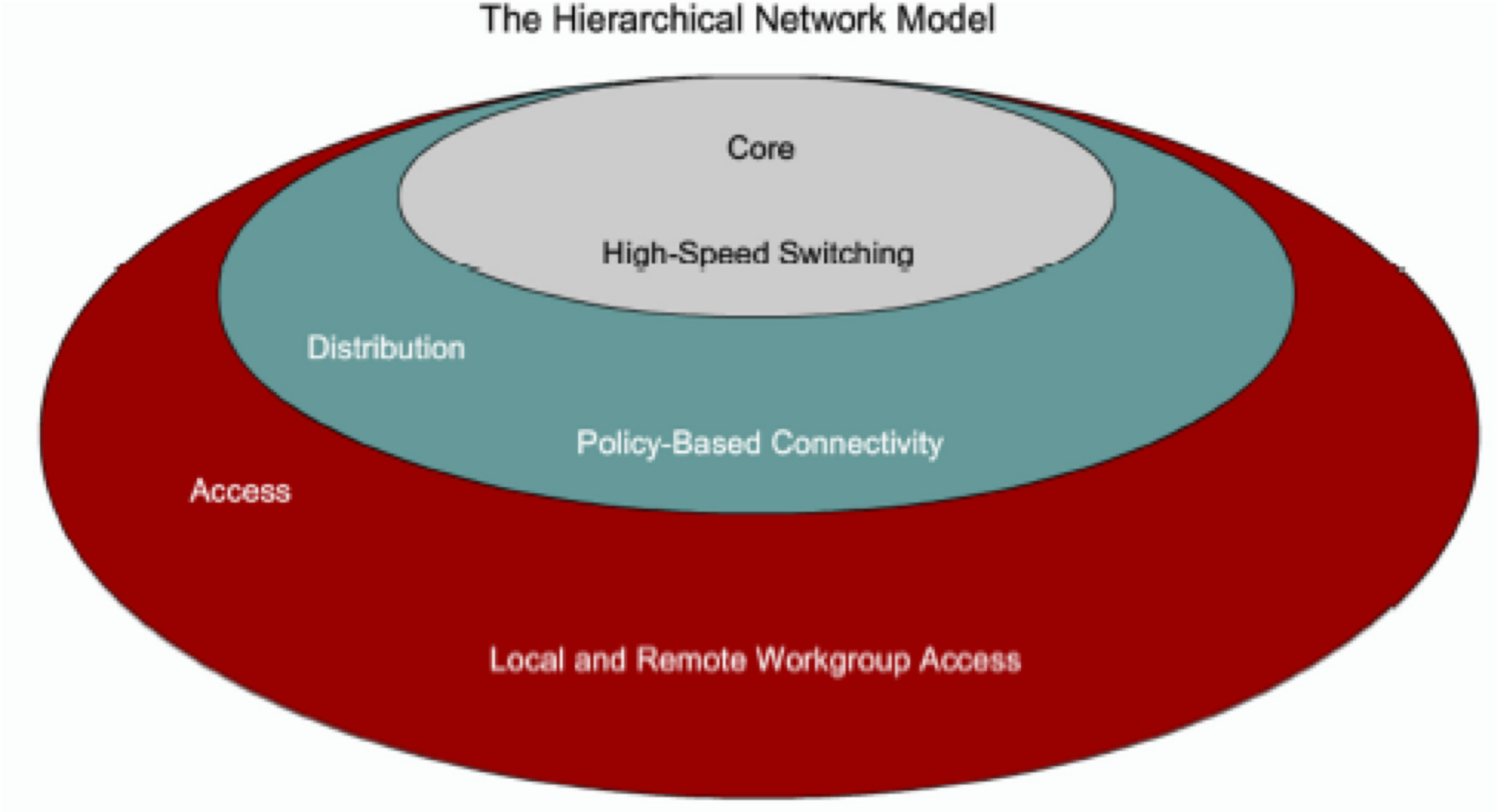
Updated SONA Framework

Cisco Systems has recently updated the SONA framework:

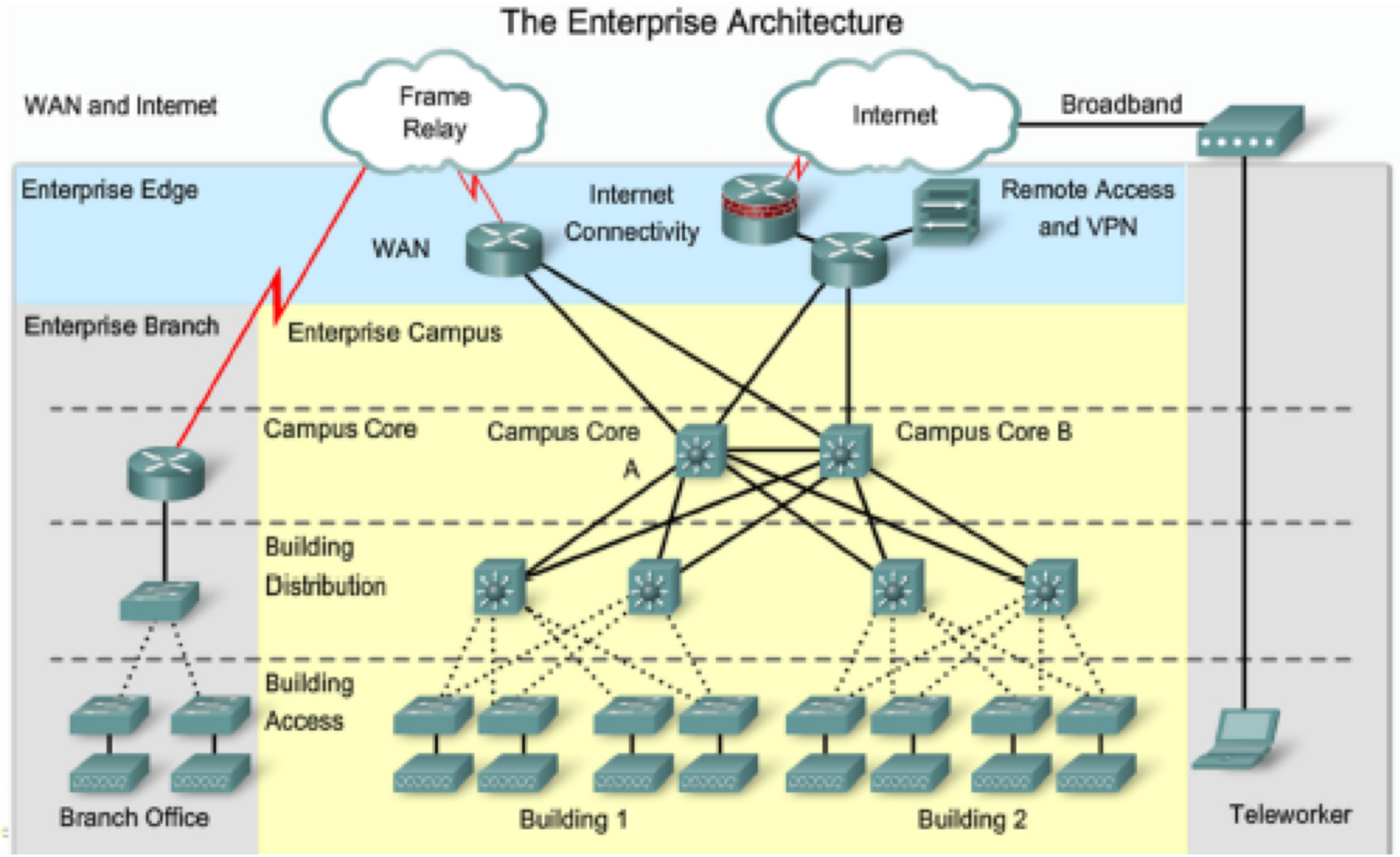


Hierarchical Model

The places in the network in the SONA Network Infrastructure Layer have been identified as follows:



Enterprise Composite Network Model



CREATING, DOCUMENTING, AND EXECUTING AN IMPLEMENTATION PLAN

Creating an Implementation Plan

- An effective, documented, implementation plan is a result of good processes and procedures during network design, implementation, and performance testing.
- There are two approaches to implementing changes to a network.
  - Ad-hoc approach
  - Structured approach

Ad-hoc Approach

- The many tasks such as deploying new equipment, connectivity, addressing, routing, and security are implemented and configured as required without planning any of the tasks.
- With such an approach, it is more likely that scalability issues, suboptimal routing, and security issues can occur.
- A good implementation plan is required to avoid such difficulties.

Structured Approach

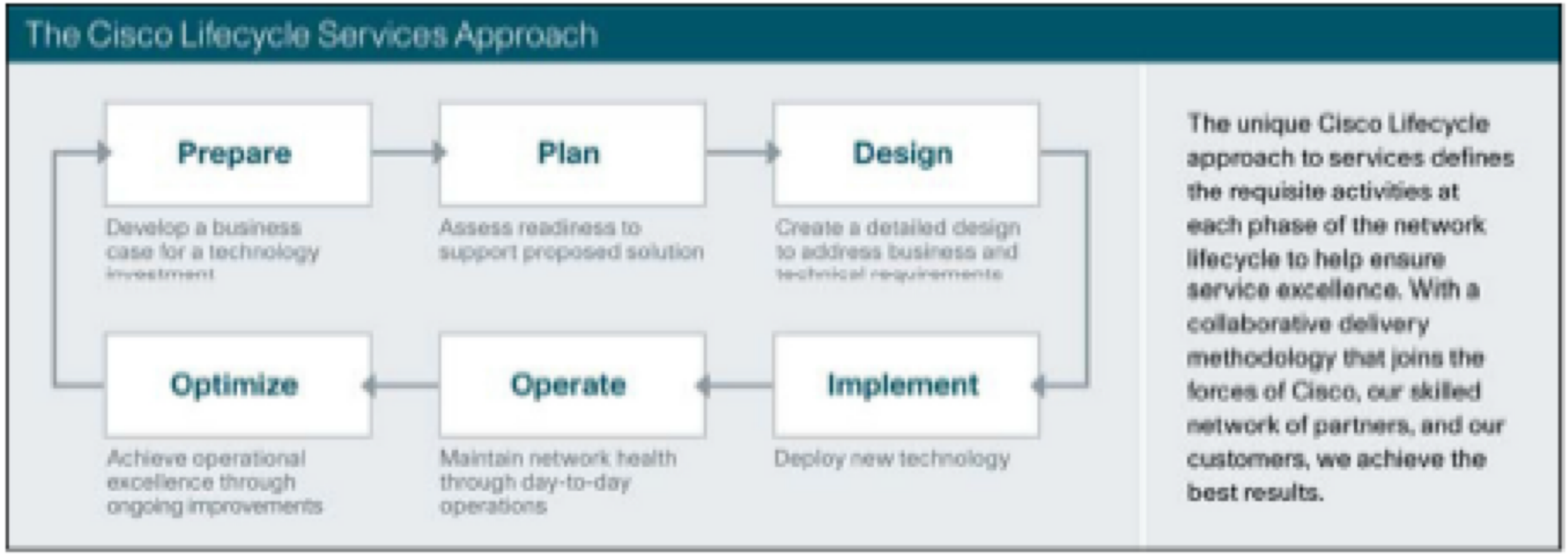
- Prior to implementing a change many considerations are taken into account.
- The design and implementation plan are completed, and may include a new topology, an IP addressing plan, a solution to scalability issues, a link utilization upgrade, remote network connectivity, and changes to other network parameters.
- The design and implementation plan must meet both technical and business requirements.
- All details are documented in the implementation plan prior to the implementation.
  - After the successful implementation, the documentation is updated to include the tools and resources used, and the implementation results.

Models and Methodologies

- Luckily there are there are many models and methodologies used in IT that define a lifecycle approach using various processes to help provide high quality IT services.
  - No need to reinvent the wheel.
- Examples of these models:
  - The Cisco Lifecycle Services (PPDIOO) model
  - IT Infrastructure Library (ITIL)
  - The Fault, Configuration, Accounting, Performance, and Security (FCAPS) model
    - International Organization for Standardization (ISO)
  - The Telecommunications Management Network (TMN) model
    - Telecommunications Standardization Sector (ITU-T)

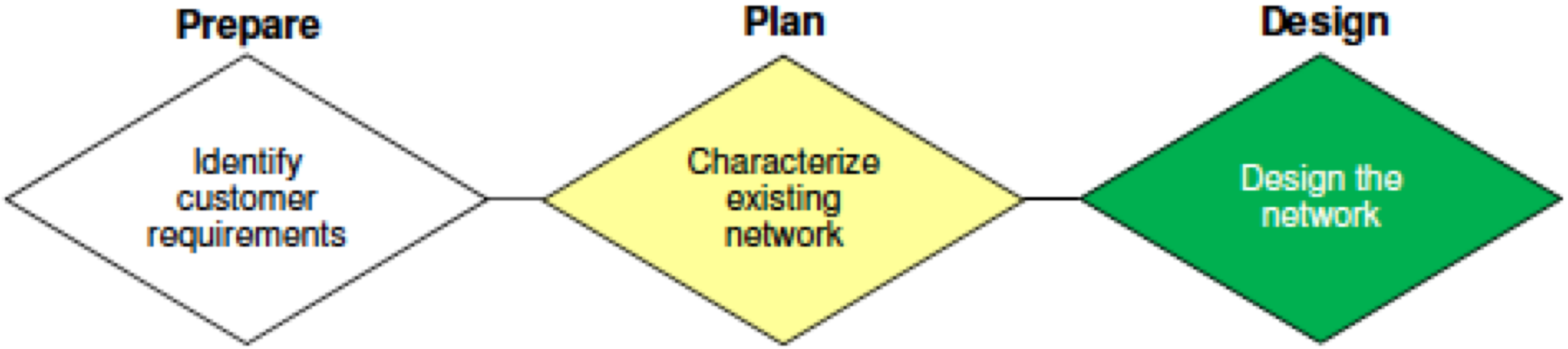
Cisco Lifecycle Services (PPDIOO) Model

The Cisco Lifecycle Services approach defines six phases in the network lifecycle and is referred to as the PPDIOO model:



PPDIOO – Prepare, Plan, and Design

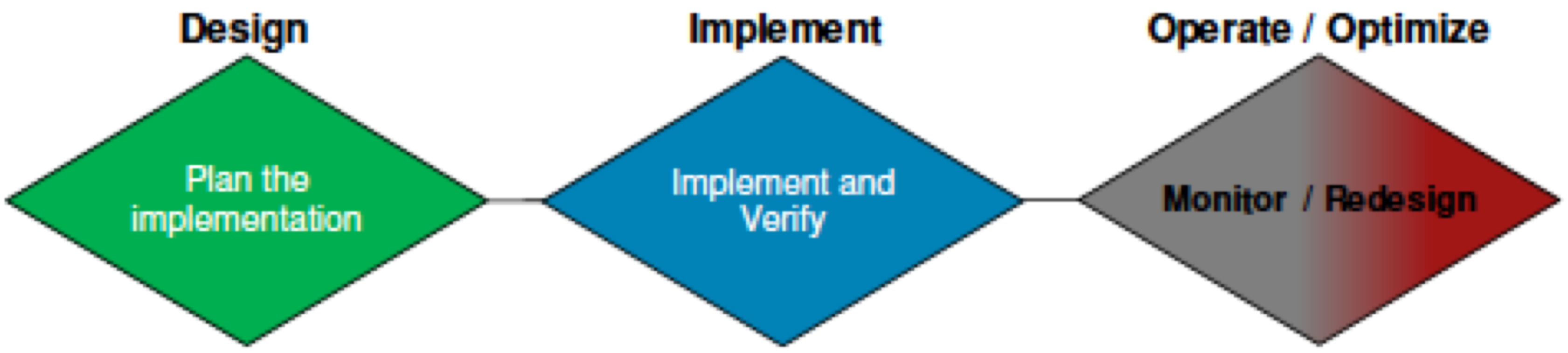
- The PPDIOO methodology begins with these three basic steps:
  - **Step 1 Identify customer requirements**
  - **Step 2 Characterize the existing network and sites**
  - **Step 3 Design the network topology and solutions**



- Once the design is defined, the implementation plan can be executed.

PPDIOO – Implement, Operate, Optimize

- The next three steps include:
  - **Step 4 Plan the implementation:**
  - **Step 5 Implement and verify the design:**
  - **Step 6 Monitor and optionally redesign:**



Implementation Plan documentation

- The implementation plan documentation should include the following:
  - Network information
  - Tools required
  - Resources required
  - Implementation plan tasks
  - Verification tasks
  - Performance measurement and results
  - Screen shoots and photos, as appropriate
- The documentation creation process is not finished until the end of the project, when the verification information is added to it.

DOCUMENTATION IS VERY IMPORTANT

IP ROUTING OVERVIEW

IP protocol version 4

Currently in use is IP protocol version 4 (RFC 791)

IP protocol is used for:
- logical addressing (32 bits long identificator)
- best effort delivery (end-to-end)

Routing is based on prefixes (longest prefix match)

Networks (remote prefixes) can be set:
- statically *(static routes)*
- learned by dynamic routing protocols *(IGP and EGP protocols)*

Route Lookup process

Router locally search for the best route

Considerations, when installing to routing table:
- administrative distance
- metric

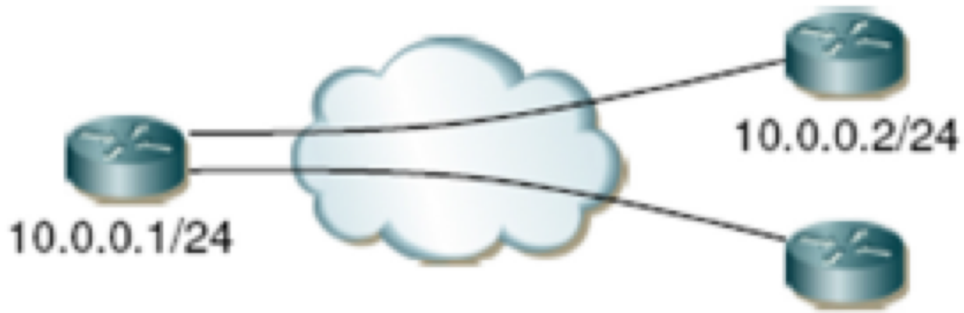
Next-hop IP addressess are used for L2 lookup
(ARP, InvARP, Dialer map, frame-relay map)

It is possible to use outgoing interface but only in special cases (point-to-point links)

NBMA networks

In NBMA it is necessary to consider, who can communicate with who

NBMA networks needs split-horizon correction or dynamic routing protocol correction



ip route Command

- To configure a static route use the **`ip route`** command.

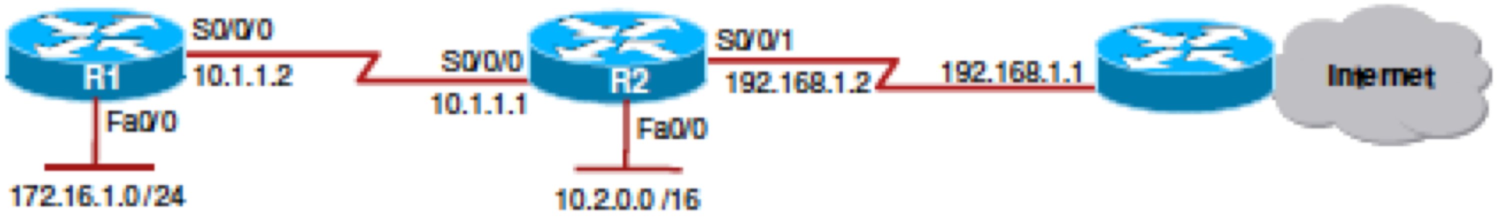
```
Router(config)# ip route prefix mask {address | interface [address]}
  [dhcp] [distance] [name next-hop-name] [permanent | track number] [tag
  tag]
```

`ip route` **Command**	**Description**
prefix mask	The IP network and subnet mask for the remote network to be entered into the IP routing table.
address	The IP address of the next hop that can be used to reach the destination network.
interface	The local router outbound interface to be used to reach the destination network.
dhcp	(Optional) Enables a Dynamic Host Configuration Protocol (DHCP) server to assign a static route to a default gateway (option 3).
distance	(Optional) The administrative distance to be assigned to this route.
name *next-hop-name*	(Optional) Applies a name to the specified route.
permanent	(Optional) Specifies that the route will not be removed from the routing table even if the interface associated with the route goes down.
track *number*	(Optional) Associates a track object with this route. Valid values for the number argument range from 1 to 500.
tag *tag*	(Optional) A value that can be used as a match value in route maps.

Configuring a Default Static Route

- R2 is configured with a static route to the R1 LAN and a default static route to the Internet.
- R1 is configured with a default static route.

```
R2(config)# ip route 172.16.1.0 255.255.255.0 S0/0/0
R2(config)# ip route 0.0.0.0 0.0.0.0 192.168.1.1
```




```
R1(config)# ip route 0.0.0.0 0.0.0.0 10.1.1.1
R1(config)# exit
R1# show ip route
<output omitted>

Gateway of last resort is not set
C    172.16.1.0 is directly connected, FastEthernet0/0
C    10.1.1.0 is directly connected, Serial0/0/0
S*   0.0.0.0/0 [1/0] via 10.1.1.1
R1#
```

IP unnumbered

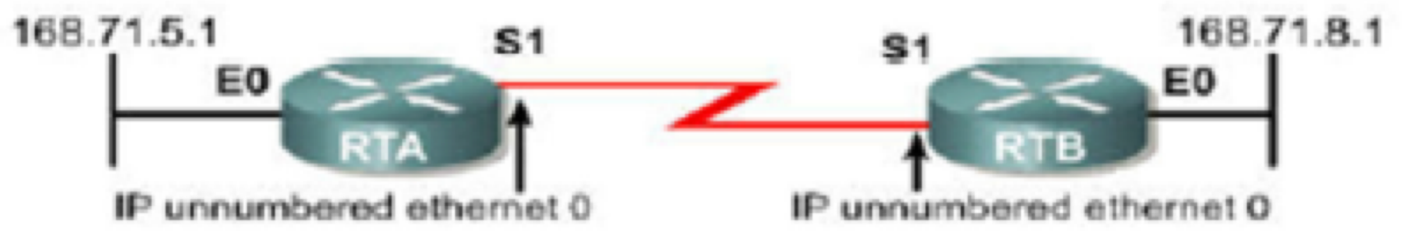
Document ID: 13786

Point-to-point interfaces has special behavior:
- Data receiver is known
- It seems that interface does not need IP address
  (it's tunnel that has only two ends)

IP unnumbered: possibility to borrow IP address from another working interface (e.g. loopback)

Configuration of IP unnumbered

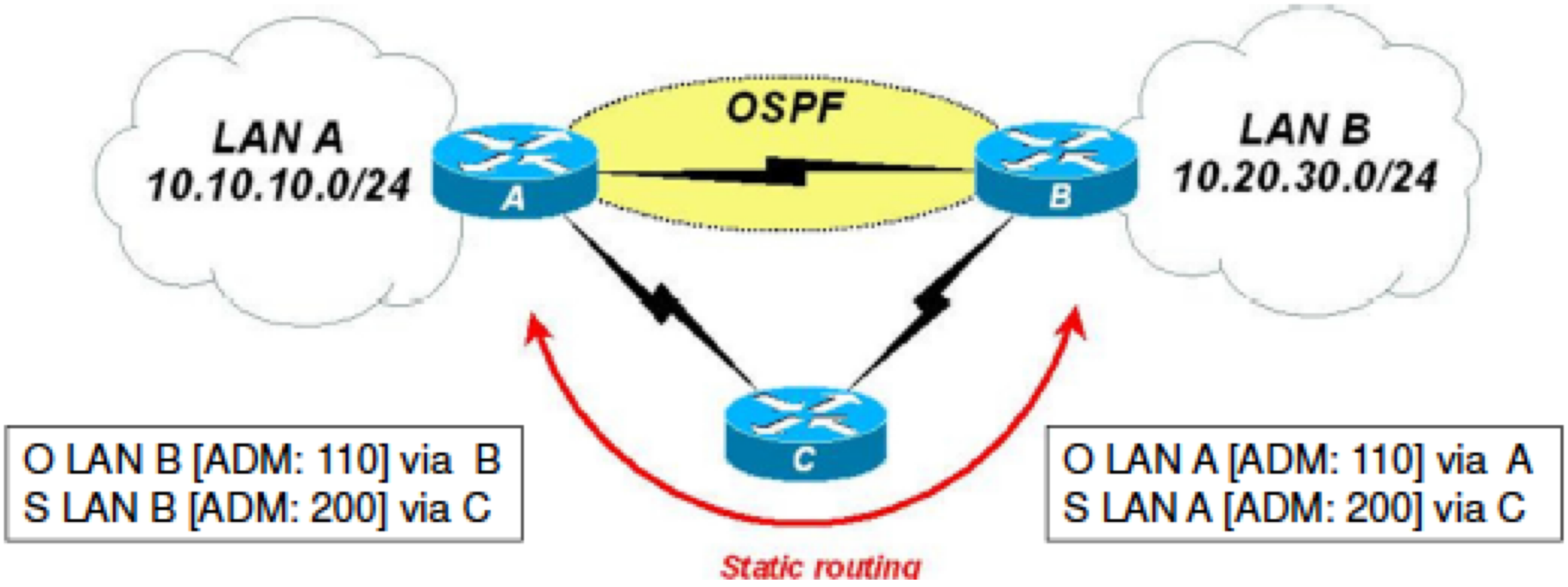
```
Router(config)# int e0
Router(config-if)# ip address 168.71.5.1 255.255.255.0
Router(config-if)# no shut
Router(config-if)# int s1
Router(config-if)# ip unnumbered e0
```



By using IP unnumbered, serial interfaces can "borrow" an IP address from another interface.

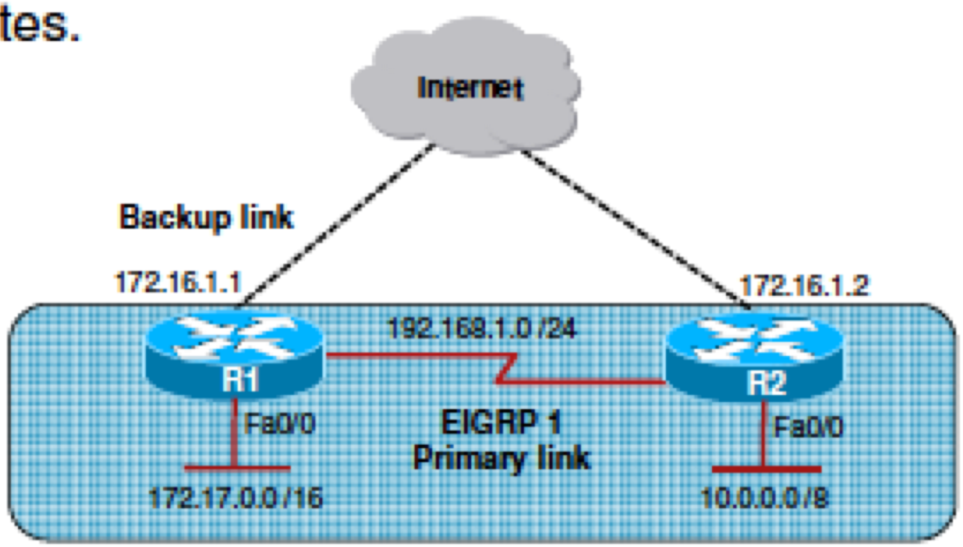
Floating static routes

Provides backup for networks with better administrative distance



Configuring a Floating Static Route

- Create floating static routes on R1 and R2 that floats above the EIGRP learned routes.

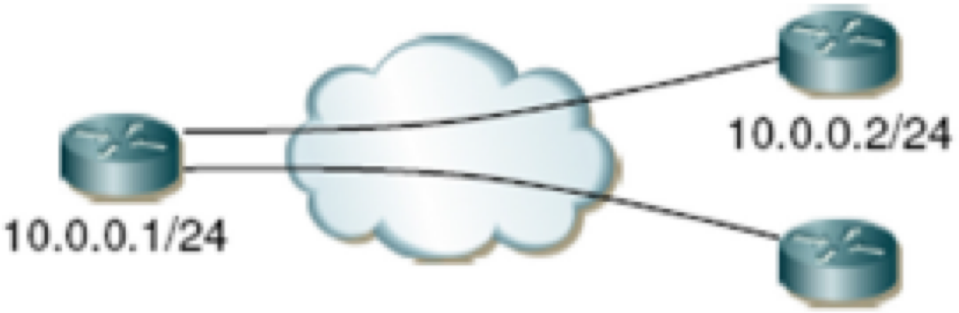



```
R1(config)# ip route 10.0.0.0 255.0.0.0 172.16.1.2 100
R1(config)# router eigrp 1
R1(config-router)# network 172.17.0.0
R1(config-router)# network 192.168.1.0
```

```
R2(config)# ip route 172.17.0.0 255.255.0.0 172.16.1.1 100
R2(config)# router eigrp 1
R2(config-router)# network 10.0.0.0
R2(config-router)# network 192.168.1.0
```

On-demand routing (ODR)

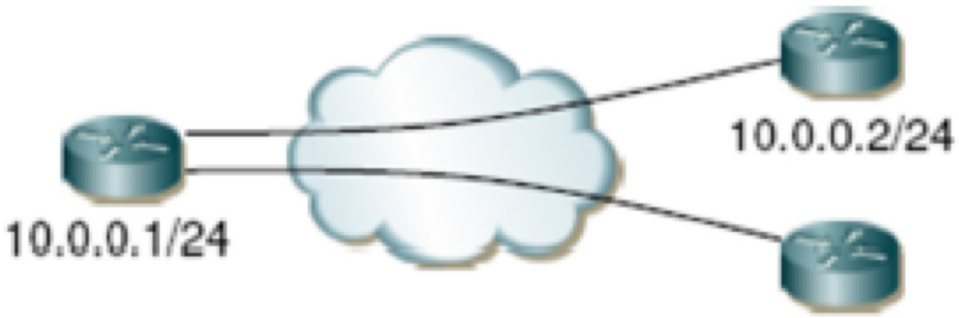
- Usually in hub-and-spoke topology
- There are STUB networks behind the SPOKE routers
- Spoke routers needs only default-route
- Hub router needs all spoke networks



On-Demand Routing

- Document ID: 13710, 13716

- CDP supports limited routing capabilities
- ODR is configured only on HUB router
- Spoke routers do not use dynamic routing protocol



Configuring ODR

Router(config)# **router odr**
Router(config-router)# **network ...**
Router(config-router)# **network ...**

Notes:

- You can't redistribute to ODR
- ODR is CDP dependent

Configuring ODR

- R1 is a hub router while R2 and R3 are stub routers.
- All routers have CDP enabled.


```
R1(config)# router odr
R1(config)# exit
R1# show ip route
<output omitted>

172.16.0.0/16 is subnetted, 2 subnets
o 172.16.1.0/24 [160/1] via 10.1.1.2, 00:00:23, Serial0/0/1
o 172.16.2.0/24 [160/1] via 10.2.2.2, 00:00:03, Serial0/0/2
<output omitted>
R1#
```

Additional ODR commands.

- ODR can also be tuned with optional commands, including:
  - a distribute list to filter routing updates
  - **`timers basic`** router configuration command to adjust ODR timers
  - **`cdp timer`** global configuration command to adjust the timers and improve convergence time (default is every 60 seconds).

Distance Vector Versus Link-State

- **Distance vector:**
  - All the routers periodically send their routing tables (or a portion of their tables) to only their neighboring routers.
  - Routers use the received information to determine whether any changes need to be made to their own routing table.
- **Link-state routing protocol:**
  - Each router sends the state of its own interfaces (links) to all other routers in an area only when there is a change.
  - Each router uses the received information to recalculate the best path to each network and then saves this information in its routing table.
- **Path-vector routing protocol:**
  - Every route in the routing table is connected to the list of attributes that can be used for route filtering/modifying, prioritizing and so..

Classful Versus Classless Routing

- **Classful Routing Protocol:**
  - Does not support VLSM.
  - Routing updates sent do not include the subnet mask.
  - Subnets are not advertised to a different major network.
  - Discontiguous subnets are not visible to each other.
  - RIP Version 1 (RIPv1) is a classful routing protocol.
- **Classless Routing Protocol:**
  - Supports VLSM.
  - Routing updates sent include the subnet mask.
  - Subnets are advertised to a different major network.
  - Discontiguous subnets are visible to each other.
  - RIPv2, EIGRP, OSPF, IS-IS, and BGP are classless routing protocols.

Routing Information Protocol

- Typical distance-vector protocol
- Currently, there are 3 versions:
  - RIPv1: Historical, classful, RFC1058
  - RIPv2: RFC 2453
  - RIPng: RFC 2080

- It is still in use because of its easyness

RIPv1 vs. RIPv2

- ***RIPv1 has the following features:***
  - Classful
  - Metric: hop count
  - UDP/520, updates sent periodically every 30 seconds as broadcasts
  - Maximal metric: 15 hops
  - Classful behavior: Document ID 13723
- ***RIPv2 differences:***
  - Classless
  - UDP/520, updates sent periodically every 30 seconds on multicast address 224.0.0.9
  - Supports authentication

RIP – basic configuration

Router(config)# router rip
Router(config-router)# version 2
Router(config-router)# network ...

What was the purpose of **network** statement?

- To identify interface to which send updates
- To identify interface from which receive updates
- Which network we will advertise to neighbors

RIP – default route

It is possible to generate default route independently to Status of the router, whether it has its default route set…

```
Router(config)# router rip
Router(config-router)# default-information originate
```

Default behavior of RIP:

- without **version** command:
  - send version 1
  - receive version 1,2
- with **version** command
  - send or receive specified version

```
Router(config-if)# ip rip send version { 1 | 2 | 1 2 }
Router(config-if)# ip rip receive version { 1 | 2 | 1 2 }
```

RIP authentication

Key chain creation:

```
Router(config)# key chain NAME
Router(config-keychain)# key KEY_NUMBER
Router(config-keychain-key)# key-string PASSWORD
```

Defining authentication mode:

```
Router(config)# interface ...
Router(config-if)# ip rip authentication mode {md5 | text}
```

Activating key-chain:

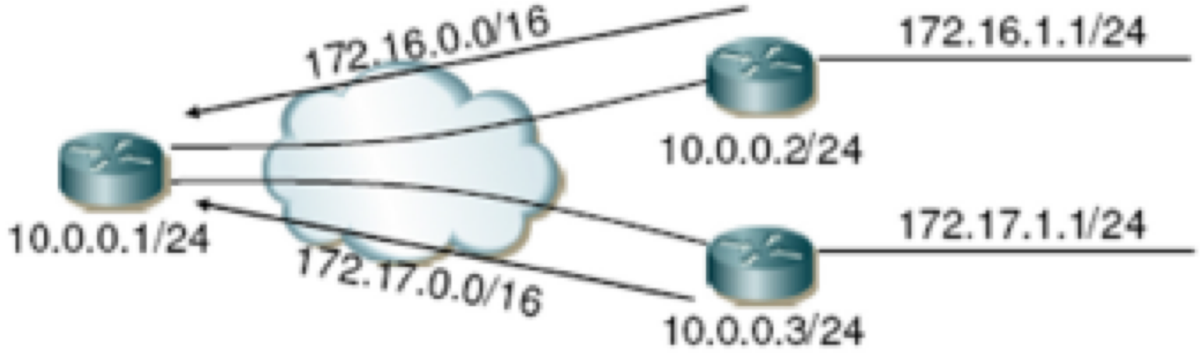
```
Router(config)# interface ...
Router(config-if)# ip rip authentication key-chain NAME
```

RIP – automatic summarization

Automatic summarization is in effect by default in RIP

```
Router(config-if)# ip summary-address rip NETWORK MASK

Router(config)# router rip
Router(config-router)# no auto-summary
```

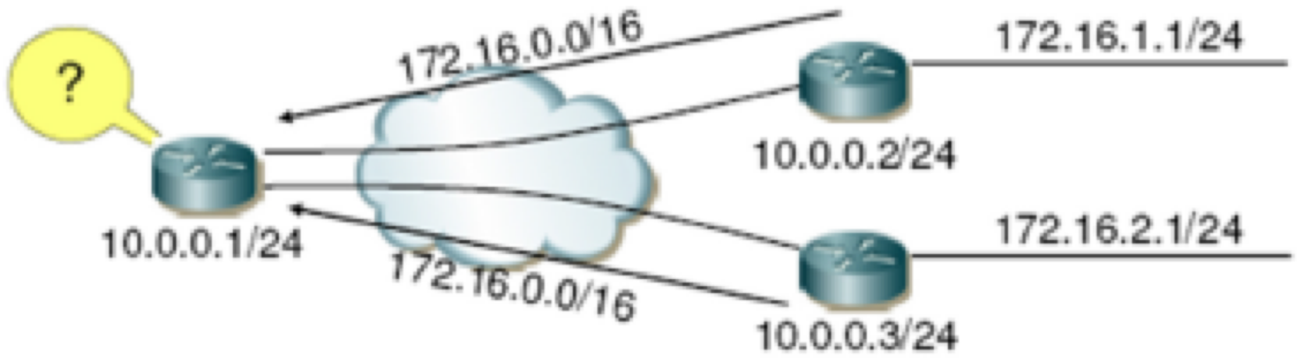


Discontiguous Subnets - Classful Routing

- Classful routing protocols do not support discontiguous networks.
- Discontiguous subnets are subnets of the same major network that are separated by a different major network.
  - For example, RIPv1 has been configured on all three routers.
  - Routers R2 and R3 advertise 172.16.0.0 to R1.
    - They cannot advertise the 172.16.1.0 /24 and 172.16.2.0 /24 subnets across a different major network because RIPv1 is classful.
  - R1 therefore receives routes about 172.16.0.0 /16 from two different directions and it might make an incorrect routing decision.

Network discontinuity

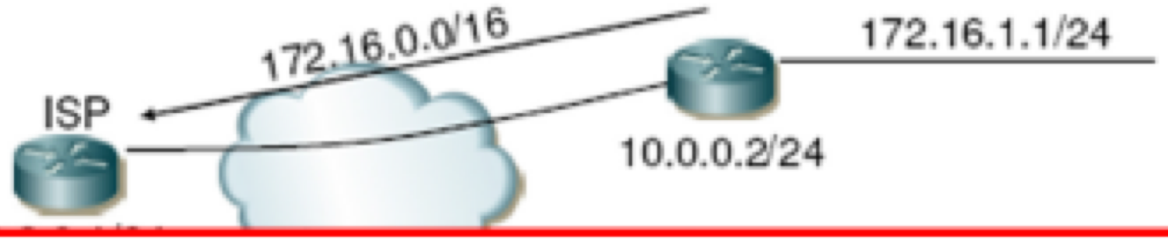
Incorrect summarization can cause networks discontinuity by putting incorrect information to routing table about the network, that has been divided by other major network.



Discard route

Router is sending to ISP summarized network 172.16.0.0/16, but one of the subnets of summarized networks is unavailable.

Border router is sending packets to ISP via default-route and ISP router returns packets back via summarized route causing routing loop



Router(config)# **ip route 172.16.0.0 255.255.0.0 Null0**

TCL Scripting

Tcl (original ... uage",
is a scripting ... Ousterhout.

Loopback 1: 10.1.1
Loopback 2: 10.1.2
Loopback 3: 10.1.3
Loopback 4: 10.1.4


```
Router# tclsh

Foreach address  {
10.2.1.1
10.2.2.1
10.2.3.1
} {
Ping $address
}

Router(tcl)# tclquit
```

ack 1: 10.2.1.1/30
ack 2: 10.2.2.1/30
ack 3: 10.2.3.1/30
ack 4: 10.2.4.1/30

Lab 1 ... on

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