Al-Mustaqbal Univerity

College of Science

Intelligent Medical Systems Departement

Computer Networks - 3rd Class

جامـــــعة المـــــستقبل
AL MUSTAQBAL UNIVERSITY

Lecture 6 and 7:
TCP/IP Protocol Suite, Addressing

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Hierarchical Addressing

** Each IP address is divided into a prefix and a suffix.

- **Prefix** identifies network to which computer is attached

- **Suffix** identifies computer within that network

** Address format makes routing efficient

Hierarchical Addressing

The IP addressing scheme is hierarchical, and IP routers make hierarchical decisions.

Recall that an IP address comprises a prefix part and a host part (suffix).

A router has to know only how to reach the next hop; it does not have to know the details of how to reach an end node that is not local.

Routers use the prefix to determine the path for a destination address that is not local. The host part is used to reach local hosts.

Route Summarization

With **route summarization**, also referred to as **route aggregation** or **supernetting**, one route in the routing table represents many other routes.

Summarizing routes reduces the routing update traffic and reduces the number of routes in the routing table and overall router overhead in the router receiving the routes.

In a hierarchical network design, effective use of route summarization can limit the impact of topology changes to the routers in one section of the network.

CIDR

Classless Inter-Domain Routing (CIDR) is a mechanism developed to help alleviate the problem of IP address exhaustion and growth of routing tables.

The idea behind CIDR is that blocks of multiple addresses (for example, blocks of Class C address) can be combined, or aggregated, to create a larger (that is, more hosts allowed) classless set of IP addresses. Blocks of Class C network numbers are allocated to each network service provider; organizations using the network service provider for Internet connectivity are allocated subsets of the service provider's address space as required. These multiple Class C addresses can then be summarized in routing tables, resulting in fewer route advertisements.

The CIDR mechanism can be applied to blocks of Class A, B, and C addresses; it is not restricted to Class C.)

Route Summarization

For summarization to work correctly, the following requirements must be met:

■ Multiple IP addresses must share the same leftmost bits.

■ Routers must base their routing decisions on a 32-bit IP address and a prefix length of up to 32 bits.

■ Routing protocols must carry the prefix length with the 32-bit IP address.

Route Summarization - Example

For example, assume that a router has the following networks behind it:

192.168.168.0/24

192.168.169.0/24

192.168.170.0/24

192.168.171.0/24

192.168.172.0/24

192.168.173.0/24

192.168.174.0/24

192.168.175.0/24

Each of these networks could be advertised separately; however, this would mean advertising eight routes. Instead, this router can summarize the eight routes into one route and advertise 192.168.168.0/21.

By advertising this one route, the router is saying, “Route packets to me if the destination has the first 21 bits the same as the first 21 bits of 192.168.168.0.”

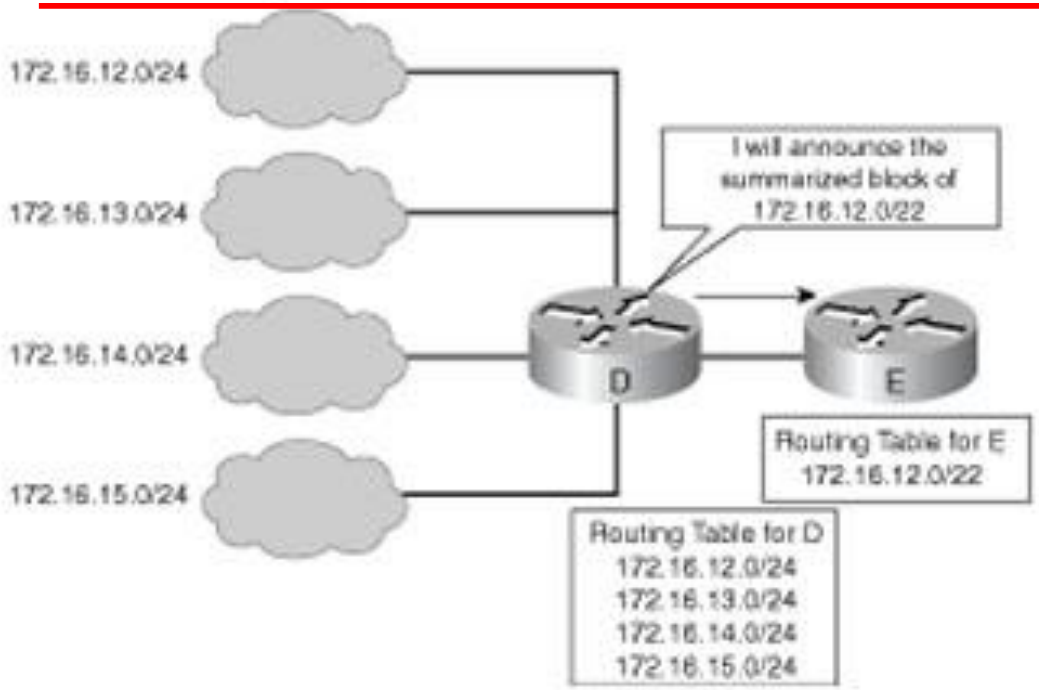
Route Summarization - Example

The following figure illustrates how this summary route is determined. The addresses all have the first 21 bits in common and include all the combinations of the other 3 bits in the network portion of the address; therefore, only the first 21 bits are needed to determine whether the router can route to one of these specific addresses.

192.168.168.0 =	11000000 10101000 10101	000	00000000
192.168.169.0 =	11000000 10101000 10101	001	00000000
192.168.170.0 =	11000000 10101000 10101	010	00000000
192.168.171.0 =	11000000 10101000 10101	011	00000000
192.168.172.0 =	11000000 10101000 10101	100	00000000
192.168.173.0 =	11000000 10101000 10101	101	00000000
192.168.174.0 =	11000000 10101000 10101	110	00000000
192.168.175.0 =	11000000 10101000 10101	111	00000000

Number of Common Bits = 21
Number of Non-Common Network Bits = **3**
Number of Host Bits = **8**

Route Summarization - Example



Router D can either send four routing update entries or summarize the four addresses into a single network number. If router D summarizes the information into a single network number entry, the following things happen:

** Bandwidth is saved on the link between routers D and E.

** Router E needs to maintain only one route and therefore saves memory.

** Router E also saves CPU resources, because it evaluates packets against fewer entries in its routing table.

Benefits of Hierarchical Addressing

A network designer decides how to implement the IP addressing hierarchy based on the network's size, geography, and topology. In large networks, hierarchy within the IP addressing plan is mandatory for a stable network (including stable routing tables). For the following reasons, a planned, hierarchical IP addressing structure, with room for growth, is recommended for networks of all sizes:

1- Influence of IP addressing on routing: An IP addressing plan influences the network's overall routing. Before allocating blocks of IP addresses to various parts of the network and assigning IP addresses to devices, consider the criteria for an appropriate and effective IP addressing scheme. Routing stability, service availability , and network scalability are some crucial and preferred network characteristics and are directly affected by IP address allocation and deployment.

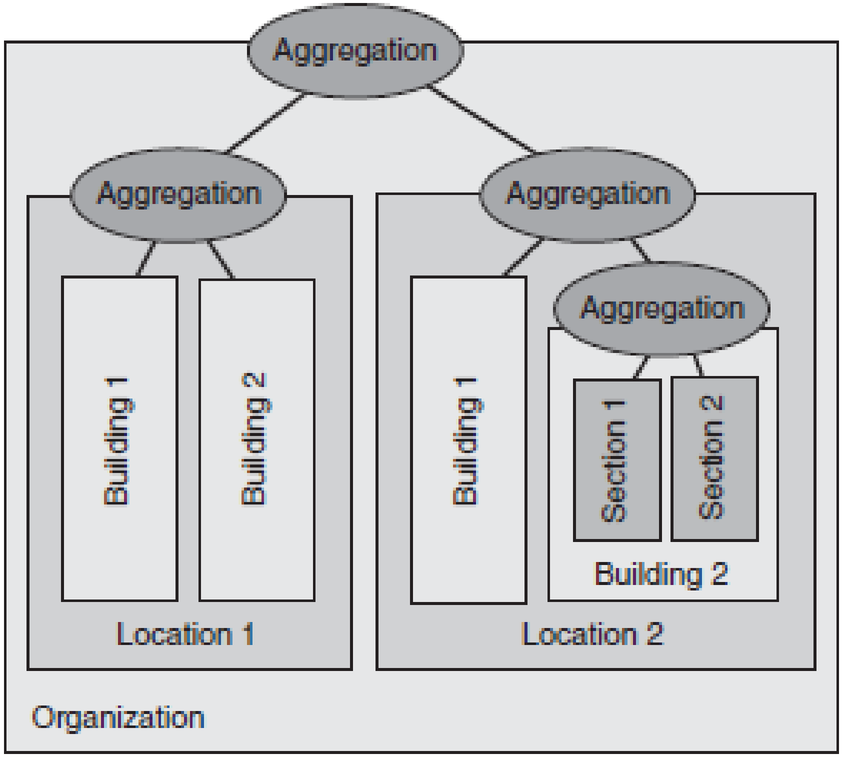
Benefits of Hierarchical Addressing

2- Modular design and scalable solutions: Whether building a new network or adding a new service on top of an existing infrastructure, a modular design helps to deliver a long-term, scalable solution. IP addressing modularity allows the aggregation of routing information on a hierarchical basis.

3- Route aggregation: Route aggregation is used to reduce routing overhead and improve routing stability and scalability. However, to implement route aggregation, a designer must be able to divide a network into contiguous IP address areas and must have a solid understanding of IP address assignment, route aggregation, and hierarchical routing.

Summarization Groups

To reduce the routing overhead in a large network, a multilevel hierarchy might be required. The depth of hierarchy depends on the network size and the size of the highest-level summarization group. The following figure shows an example of a network hierarchy.



Summarization Groups

A typical organization has up to three levels of hierarchy:

■ **First level: Network locations** typically represent the first level of hierarchy in enterprise networks. Each location typically represents a group of summarized subnets, known as a summarization group.

■ **Second level:** A second level of hierarchy can be done within first-level summarization groups. For example, a large location can be divided into smaller summarization groups that represent the **buildings within that location.** Not all first-level summarization groups require a second level of hierarchy.

■ **Third level:** To further minimize the potential routing overhead and instability, a third level of hierarchy can exist within the second-level summarization group. For example, **sections or floors within individual buildings** can represent the third-level summarization group.

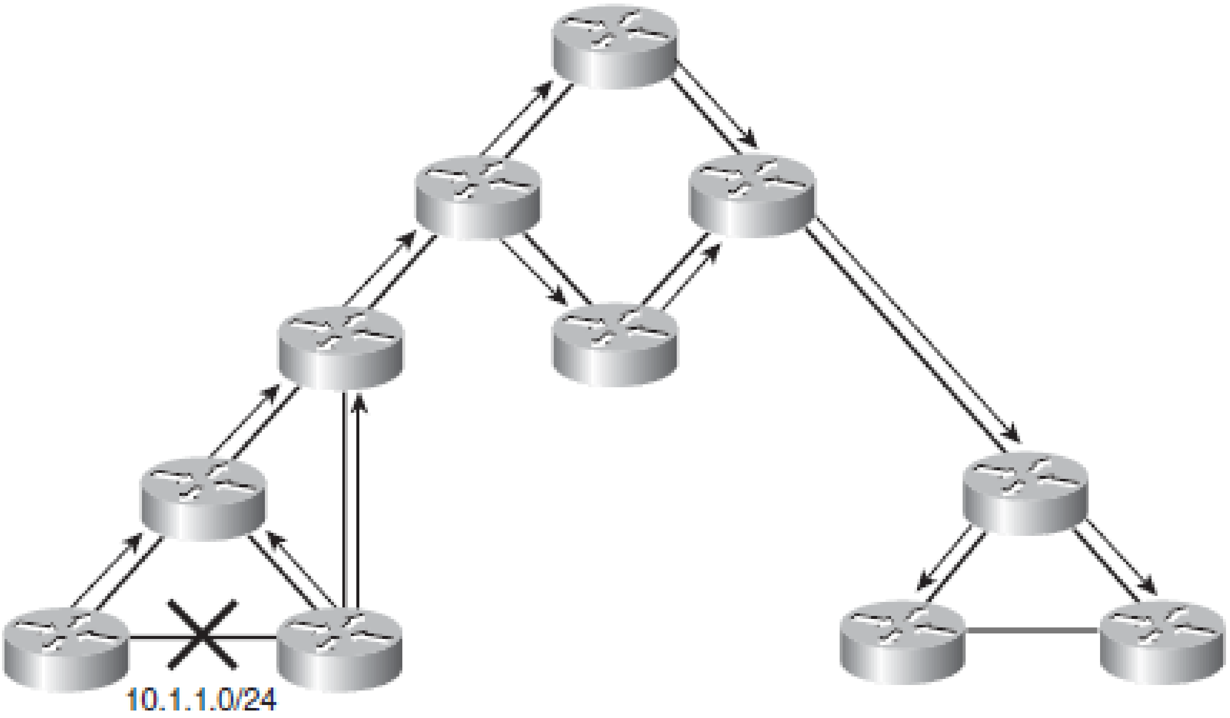
Impact of Poorly Designed IP Addressing

A poorly designed IP addressing scheme usually results in IP addresses that are randomly assigned on an as-needed basis. In this case, the IP addresses are most likely dispersed through the network with no thought as to whether they can be grouped or summarized. A poor design provides no opportunity for dividing the network into contiguous address areas, and therefore no means of implementing route summarization.

The next figure is a sample network with poorly designed IP addressing; it uses a dynamic routing protocol. Suppose that a link in the network is flapping (changing its state from UP to DOWN, and vice versa) ten times per minute. Because dynamic routing is used, the routers that detect the change send routing updates to their neighbors, those neighbors send it to their neighbors, and so on. Because aggregation is not possible, the routing update is propagated throughout the entire network, even if there is no need for a distant router to have detailed knowledge of that link.

Impact of Poorly Designed IP Addressing

A Poorly Designed IP Addressing Scheme Results in Excess Routing Traffic



Impact of Poorly Designed IP Addressing

Impacts of poorly designed IP addressing include the following:

■ **Excess routing traffic consumes bandwidth**: When any route changes, routers send routing updates. Without summarization, more updates are sent, and the routing traffic consumes more bandwidth.

■ **Increased routing table recalculation**: Routing updates require routing table recalculation, which affects the router's performance and ability to forward traffic.

■ **Possibility of routing loops**: When too many routing changes prevent routers from converging with their neighbors, routing loops might occur, which might have global consequences for an organization.

Benefits of Route Aggregation

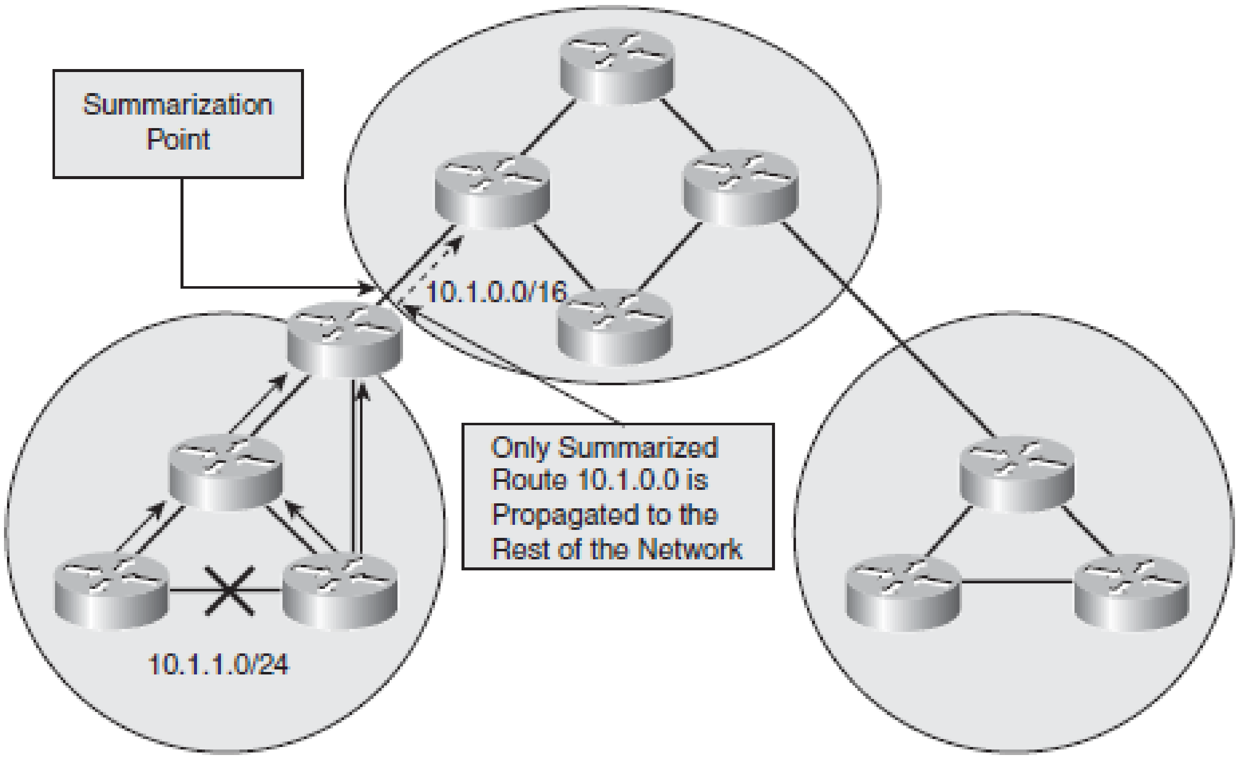
Implementing route aggregation on border routers between contiguously addressed areas controls routing table size.

The following figure shows an example of implementing route summarization (aggregation) on the area borders in a sample network. If a link within an area fails, routing updates are not propagated to the rest of the network, because only the summarized route is sent to the rest of the network, and it has not changed; the route information about the failed link stays within the area. This reduces bandwidth consumption related to routing overhead and relieves routers from unnecessary routing table recalculation.

Efficient aggregation of routing advertisements narrows the scope of routing update propagation and significantly decreases the cumulative frequency of routing updates.

Benefits of Route Aggregation

- *A Hierarchical IP Addressing Plan Results in Reduced Routing Traffic*



Fixed- and Variable-Length Subnet Masks

*Another consideration when designing the IP addressing hierarchy is the subnet mask to use either the same mask for the entire major network or different masks for different parts of the major network.

*Some routing protocols require FLSM; others allow VLSM.

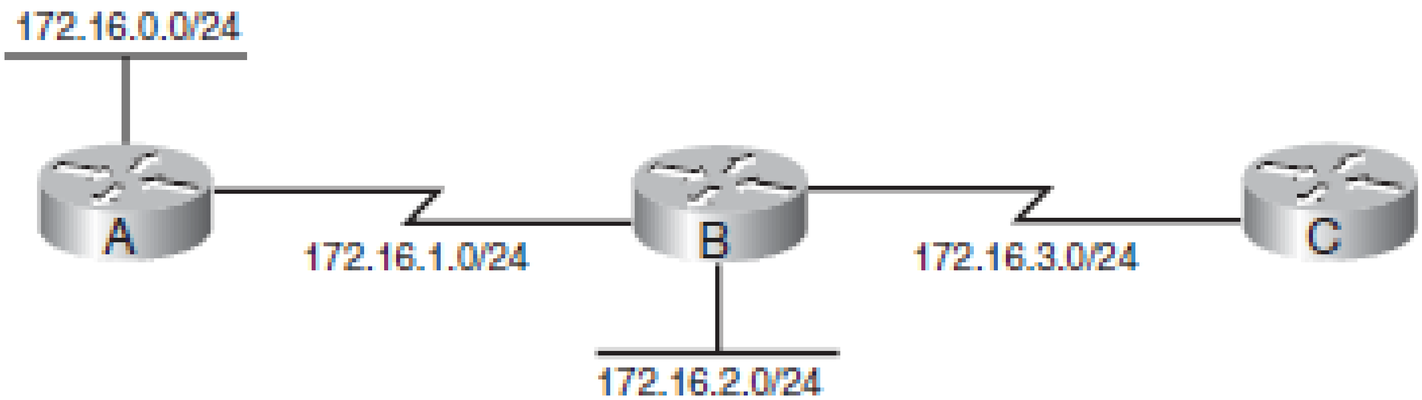
**A major network is a Class A, B, or C network.

**Fixed-Length Subnet Masking (FLSM) is when all subnet masks in a major network must be the same.

**Variable-Length Subnet Masking (VLSM) is when subnet masks within a major network can be different. In modern networks, VLSM should be used to conserve the IP addresses.

FLSM

FLSM requires that all subnets of a major network have the same subnet mask, which therefore results in less efficient address space allocation. For example, in the network shown in the following figure, network 172.16.0.0/16 is subnetted using FLSM. Each subnet is given a /24 mask. The network is composed of multiple LANs that are connected by point-to-point WAN links. Because FLSM is used, all subnets have the same subnet mask. This is inefficient, because even though only two addresses are needed on the point-to-point links, a /24 subnet mask with 254 available host addresses is used.

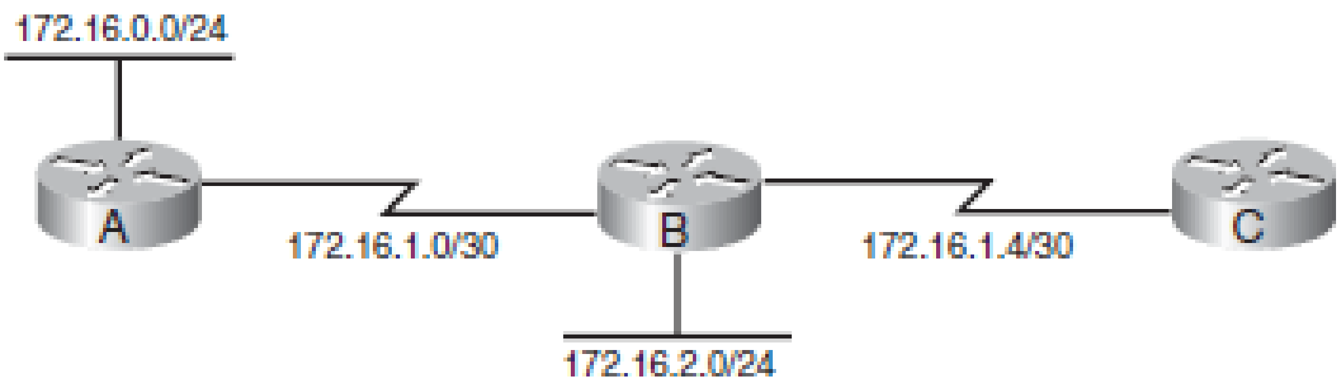


VLSM

VLSM makes it possible to subnet with different subnet masks and therefore results in more efficient address space allocation. VLSM also provides a greater capability to perform route summarization, because it allows more hierarchical levels within an addressing plan. VLSM requires prefix length information to be explicitly sent with each address advertised in a routing update.

VLSM

For example, in the network shown in the following figure, network 172.16.0.0/16 is subnetted using VLSM. The network is composed of multiple LANs that are connected by point-to-point WAN links. The point-to-point links have a subnet mask of /30, providing only two available host addresses, which is all that is needed on these links. The LANs have a subnet mask of /24 because they have more hosts that require addresses.



Routing Protocol Considerations

To use VLSM, the routing protocol in use must be classless.

Classful routing protocols permit only FLSM.

Classful Routing Protocols

The following rules apply when classful routing protocols are used:

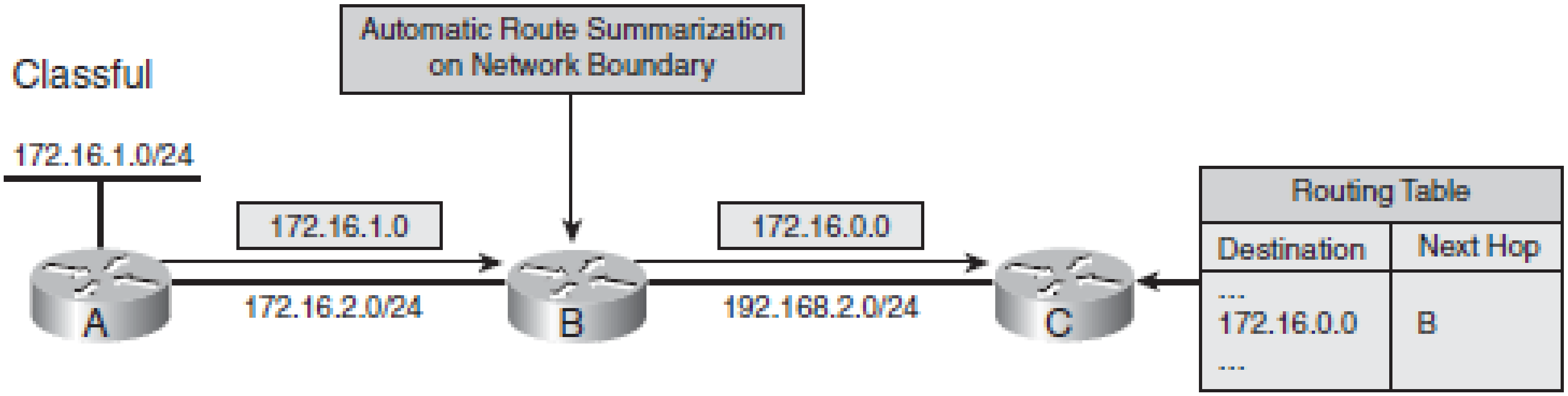
■ The routing updates do not include subnet masks.

■ When a routing update is received and the routing information is about one of the following:

— Routes within the same major network as configured on the receiving interface, the subnet mask configured on the receiving interface is assumed to apply to the received routes also. Therefore, the mask must be the same for all subnets of a major network. In other words, subnetting must be done with FLSM.

— Routes in a different major network than configured on the receiving interface, the default major network mask is assumed to apply to the received routes. Therefore, automatic route summarization is performed across major network (Class A, B, or C) boundaries, and subnetted networks must be contiguous.

Classful Routing Protocols



Classful Routing Protocols

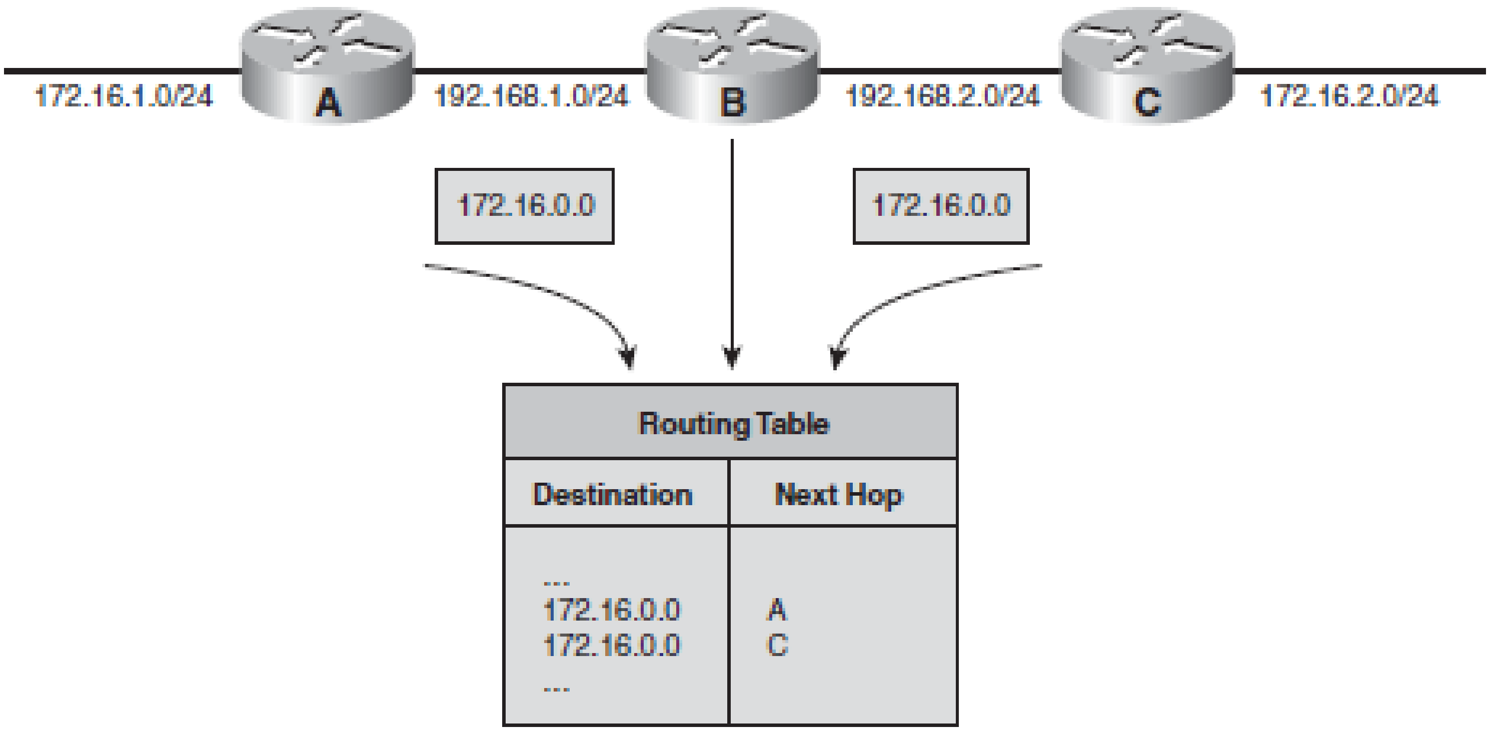
The following figure illustrates a sample network with a discontiguous 172.16.0.0 network that runs a classful routing protocol. Routers A and C automatically summarize across the major network boundary, so both send routing information about 172.16.0.0 rather than the individual subnets (172.16.1.0/24 and 172.16.2.0/24).

Consequently, Router B receives two entries for the major network 172.16.0.0, and it puts both entries into its routing table. Router B therefore might make incorrect routing decisions.

Because of these constraints, classful routing is not often used in modern networks. Routing Information Protocol (RIP) version 1 (RIPv1) is an example of a classful routing protocol.

Classful Routing Protocols

Classful Routing Protocols Do Not Send the Subnet Mask in the Routing Update



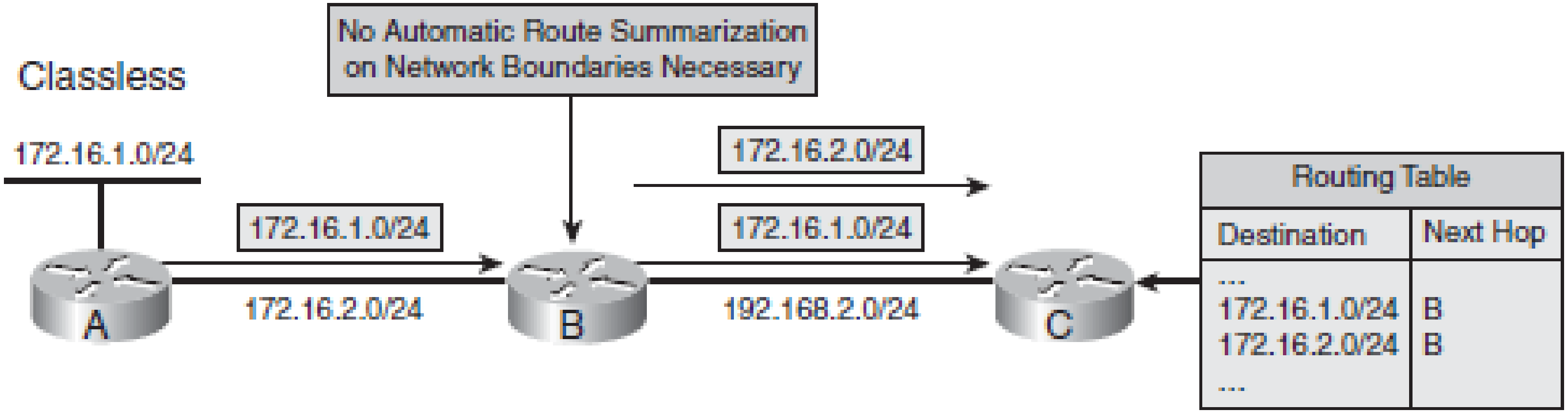
Classless Routing Protocols

The following rules apply when classless routing protocols are used:

■ The routing updates include subnet masks.
■ VLSM is supported.
■ Automatic route summarization at the major network boundary is not required, and route summarization can be manually configured.
■ Subnetted networks can be discontiguous.

Consequently, all modern networks should use classless routing. Examples of classless routing protocols include RIP version 2 (RIPv2), Enhanced Interior Gateway Routing Protocol (EIGRP), and Border Gateway Protocol (BGP).

Classless Routing Protocols



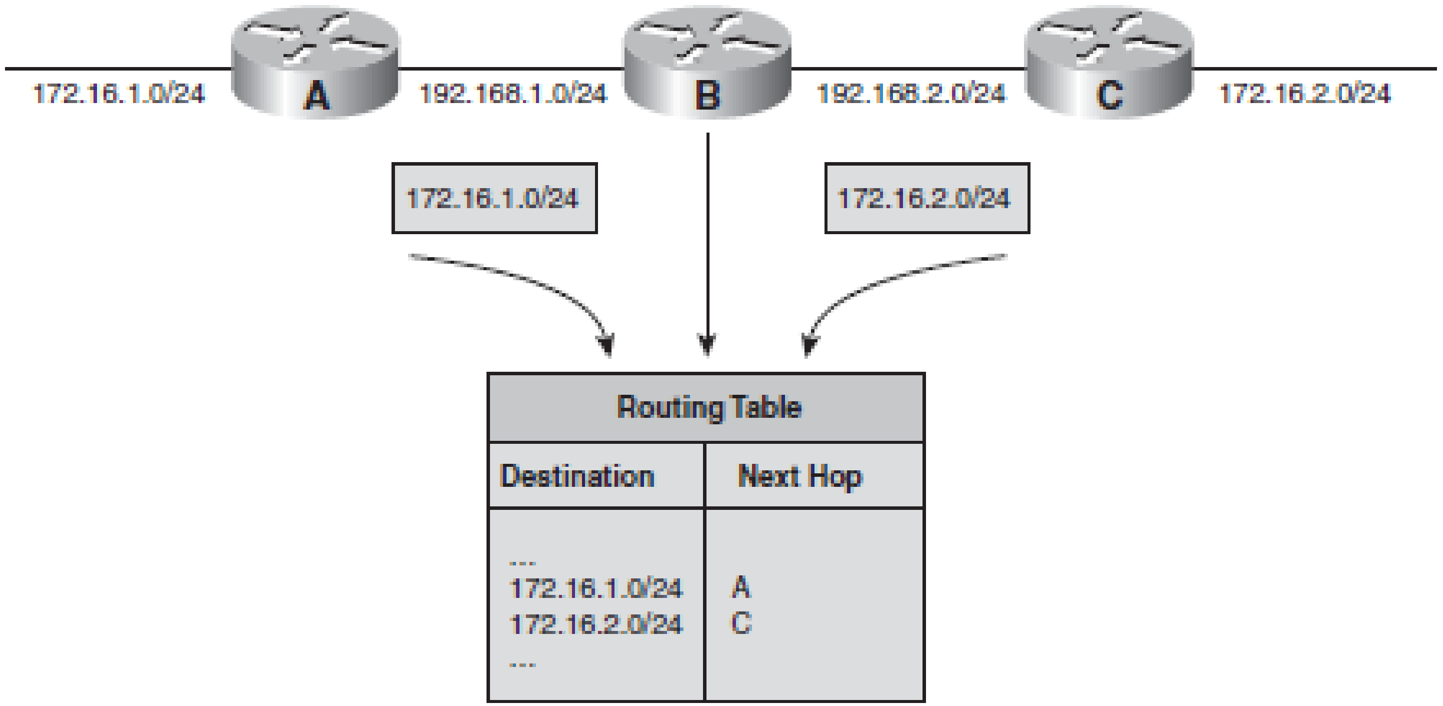
Classless Routing Protocols

The following figure illustrates how discontiguous networks are handled by a classless routing protocol.

Within this network, the classless routing protocol is running that does not automatically summarize at the network boundary. In this example, Router B learns about both subnetworks 172.16.1.0/24 and 172.16.2.0/24, one from each interface; routing is performed correctly.

Classless Routing Protocols

Classless Routing Protocols Send the Subnet Mask in the Routing Update



Assessment

1- With classful routing, routing updates _ _ _ _ carry the subnet mask.

2- With classless routing, routing updates _ _ _ _carry the subnet mask.

A- Do

B- Do not

Thank you