Video
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The Routing Table: A Closer Look

Routing Protocols and Concepts – Chapter 8

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8.0.1 Chapter Introduction

OBJECTIVES

- Describe the various route types found in the routing table structure
- Describe the routing table lookup process.
- Describe routing behavior in routed networks.

Chapter Focus

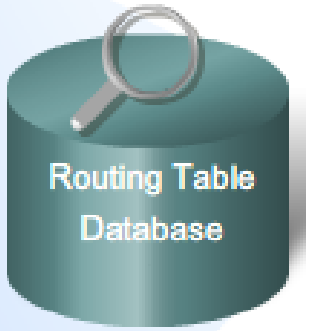
-Structure of the routing table

-Lookup process of the routing table

-Classless and classful routing behaviors

8.0.1 Chapter Introduction

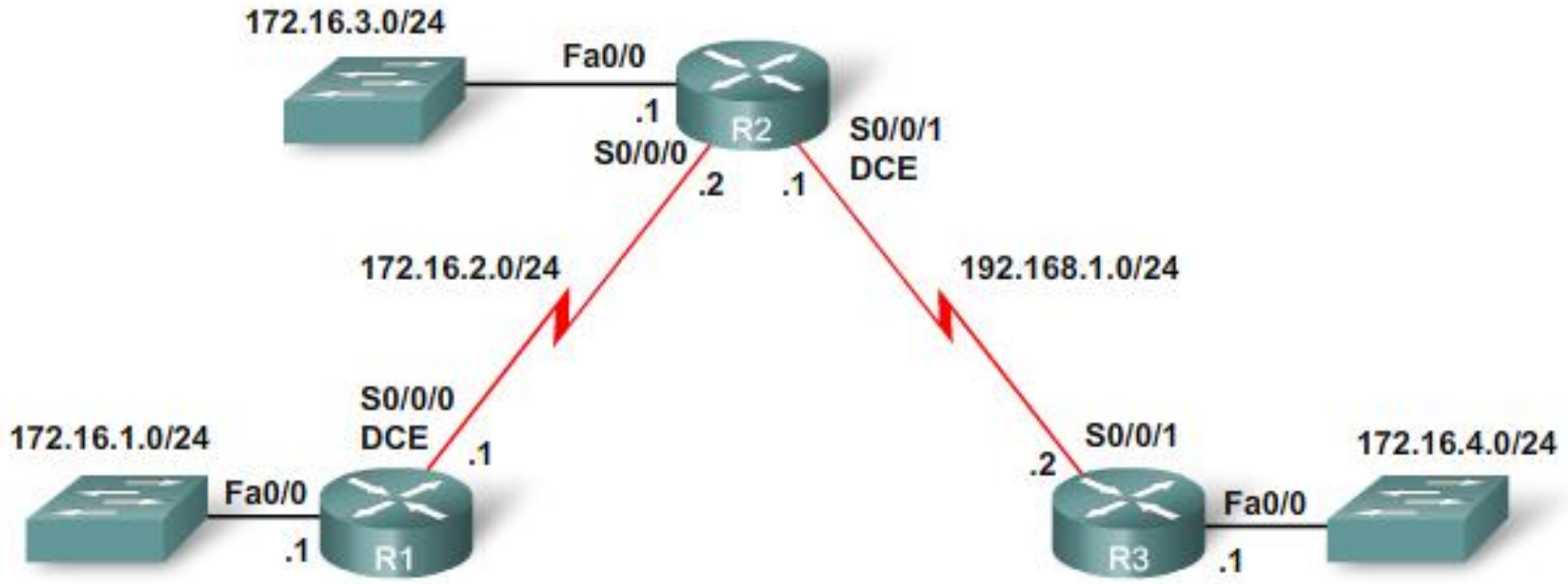
```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 3 subnets
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:12, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```



In this chapter, you will learn to:

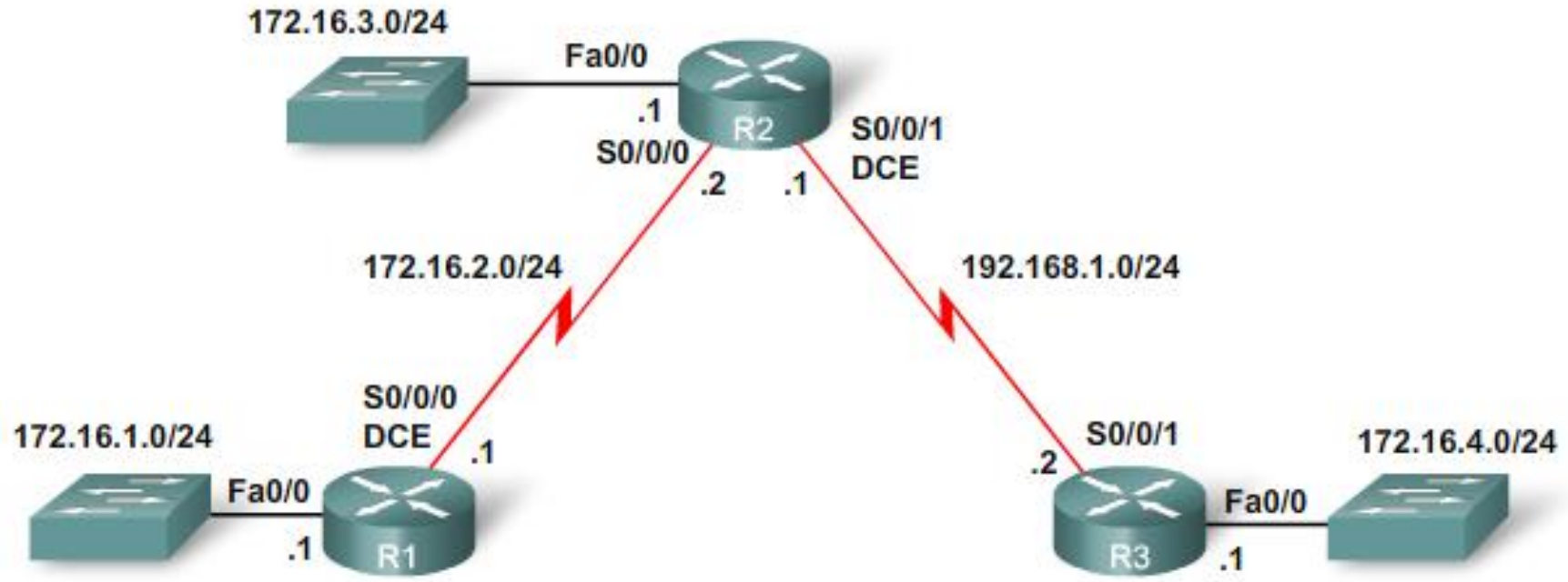
- Describe the various route types found in the routing table structure.
- Describe the route lookup process.
- Describe the routing behavior in routed networks.

8.1.1 Lab Topology




```
R1(config)#interface FastEthernet0/0
R1(config-if)#ip address 172.16.1.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#interface Serial0/0/0
R1(config-if)#ip address 172.16.2.1 255.255.255.0
R1(config-if)#clock rate 64000
R1(config-if)#no shutdown
R1(config-if)#end
R1#copy run start
```

8.1.1 Lab Topology




```
R3(config)#interface FastEthernet0/0
R3(config-if)#ip address 172.16.4.1 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#interface Serial0/0/1
R3(config-if)#ip address 192.168.1.2 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#end
R3#copy run start
```

8.1.2 Routing Table Entries

```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile,
(**output omitted**)

Gateway of last resort is not set
        10.0.0.0/16 is subnetted, 1 subnets
S       10.1.0.0 is directly connected, Serial0/0/1

     172.16.0.0/24 is subnetted, 4 subnets
S       172.16.4.0 is directly connected, Serial0/0/1
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:08, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S    192.168.100.0/24 is directly connected, Serial0/0/1
Router#
```

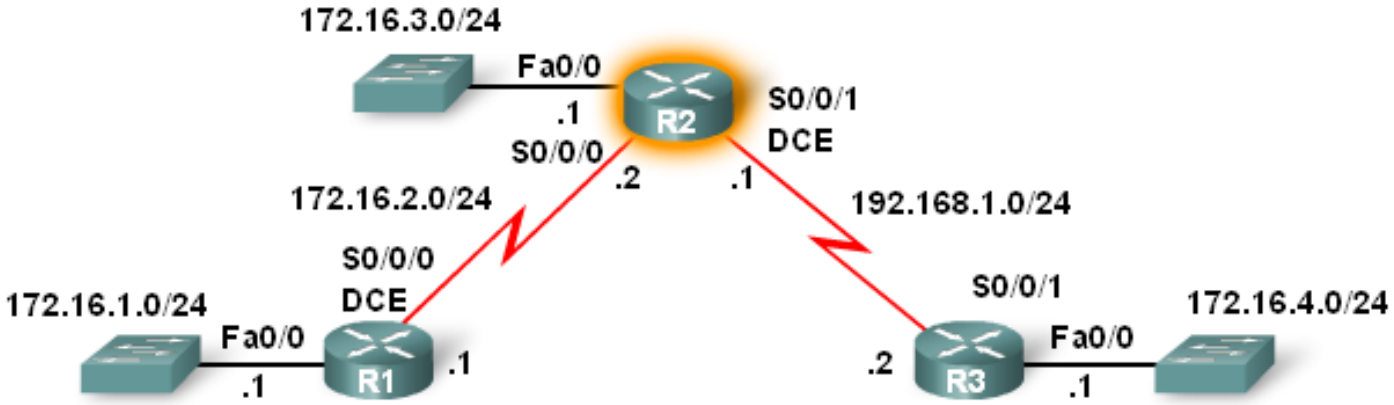
Routing table entries come from the following sources

- -Directly connected networks
- -Static routes
- -Dynamic routing protocols

8.1.3 Level 1 Routes

Level 1 Routes

- As soon as the no shutdown command is issued the route is added to routing table which can be observed with the debug command

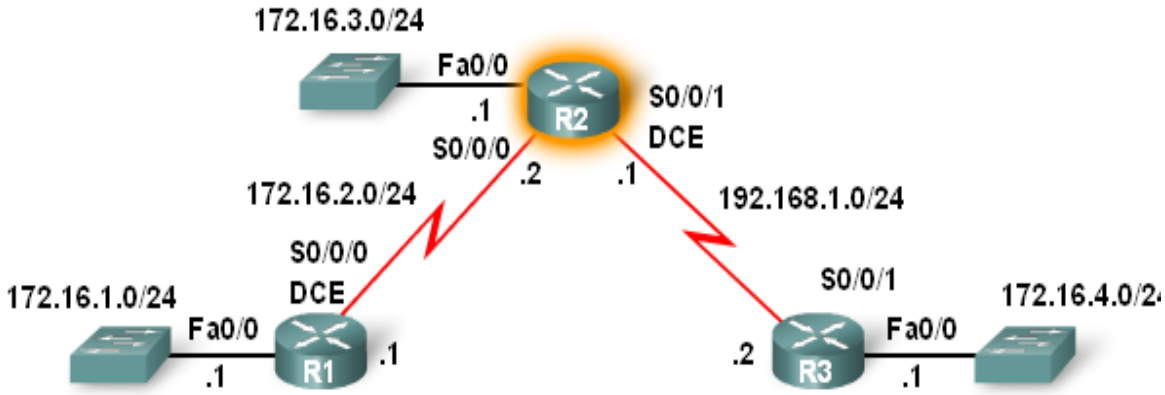



```
R2#debug ip routing
IP routing debugging is on
R2#conf t
R2(config)#interface serial 0/0/1
R2(config-if)#ip address 192.168.1.1 255.255.255.0
R2(config-if)#clock rate 64000
R2(config-if)#no shutdown
R2(config-if)#
00:11:06: %LINK-3-UPDOWN: Interface Serial0/0/1, changed state to up
R2(config-if)#
RT: add 192.168.1.0/24 via 0.0.0.0, connected metric [0/0]
RT: interface Serial 0/0/1 added to routing table
R2(config-if)#end
R2#undebug all
All possible debugging has been turned off
```

8.1.3 Level 1 Routes

Cisco IP routing table is a hierarchical structure

The reason for this is to speed up lookup process




```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    192.168.1.0/24 is directly connected, Serial0/0/1
```

8.1.3 Level 1 Routes

A level 1 route is a route with a subnet mask equal to or less than the classful mask of the network address. 192.168.1.0/24 is a level 1 network route, because the subnet mask is equal to the network's classful mask. ***/24 is the classful mask for class C networks, such as the 192.168.1.0 network.***

A level 1 route can function as a:

- Default route - A default route is a static route with the address 0.0.0.0/0.
- Supernet route - A supernet route is a network address with a mask less than the classful mask.
- Network route - A network route is a route that has a subnet mask equal to that of the classful mask. A network route can also be a parent route. Parent routes will be discussed in the next section.

The source of the level 1 route can be a directly connected network, static route, or a dynamic routing protocol.

8.1.3 Level 1 Routes

Routing Table: Level 1 Routes

```
C       192.168.1.0/24 is directly connected, Serial0/0/1
```

Level 1 Route Examples

- Default Route: 0.0.0.0/0
- Supernet Route: 192.168.0.0/22
- Network Route: 192.168.1.0/24

Level 1 Routes

-Have a subnet mask equal to or less than the classful mask of the network address.

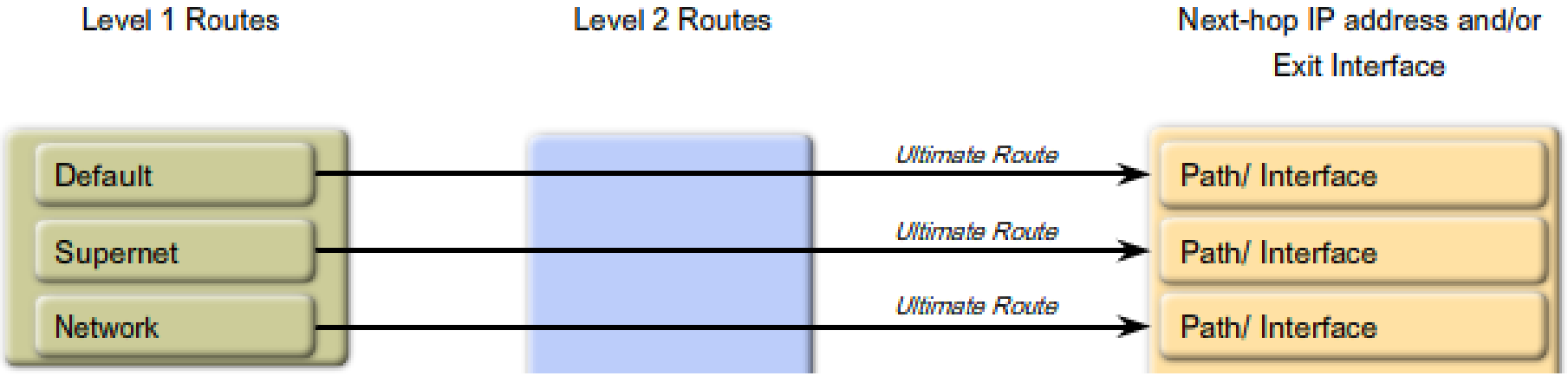
Level 1 route can function as

- -Default route
- -Supernet route
- -Network route

8.1.3 Level 1 Routes

Routing Table: Level 1 Routes

```
C       192.168.1.0/24 is directly connected, Serial0/0/1
```

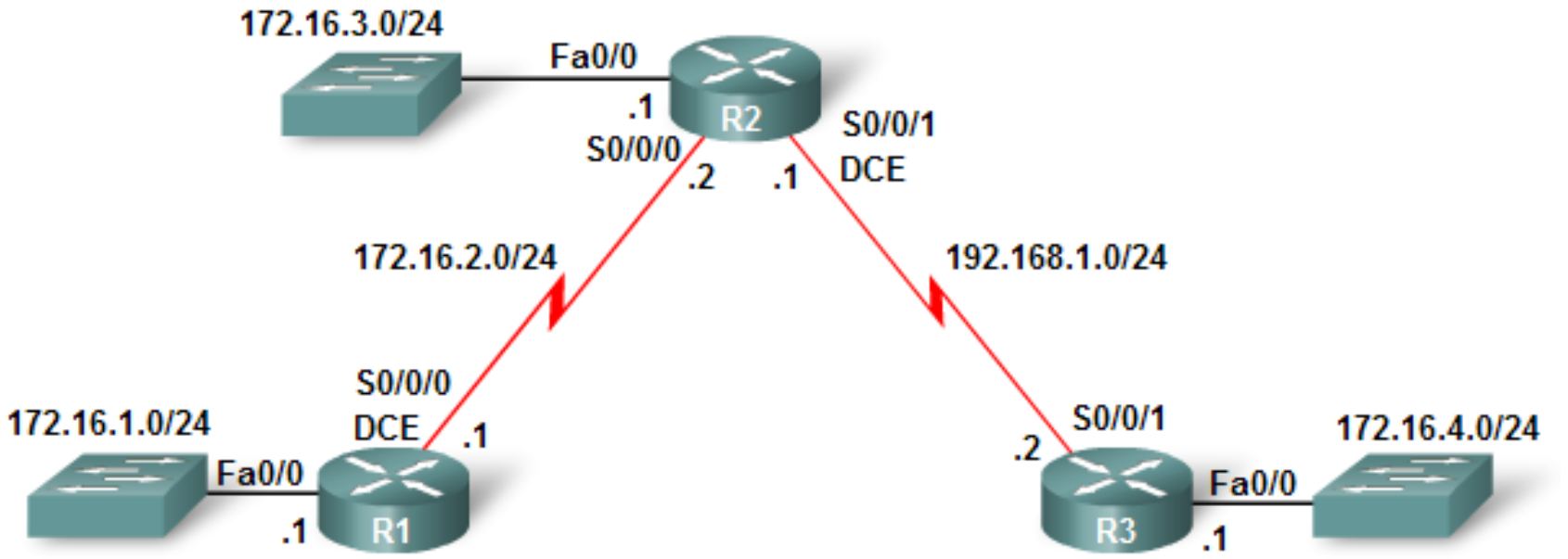


Level 1 Routes

- Ultimate Route
- Includes either:
  -A **next-hop** address
  or
  -An **exit interface**

The directly connected network 192.168.1.0/24 is a level 1 network route because it has a subnet mask that is the same as its classful mask. This same route is also an ultimate route because it contains the exit interface Serial 0/0/1.

8.1.4 Parent and Child Routes: Classful Networks



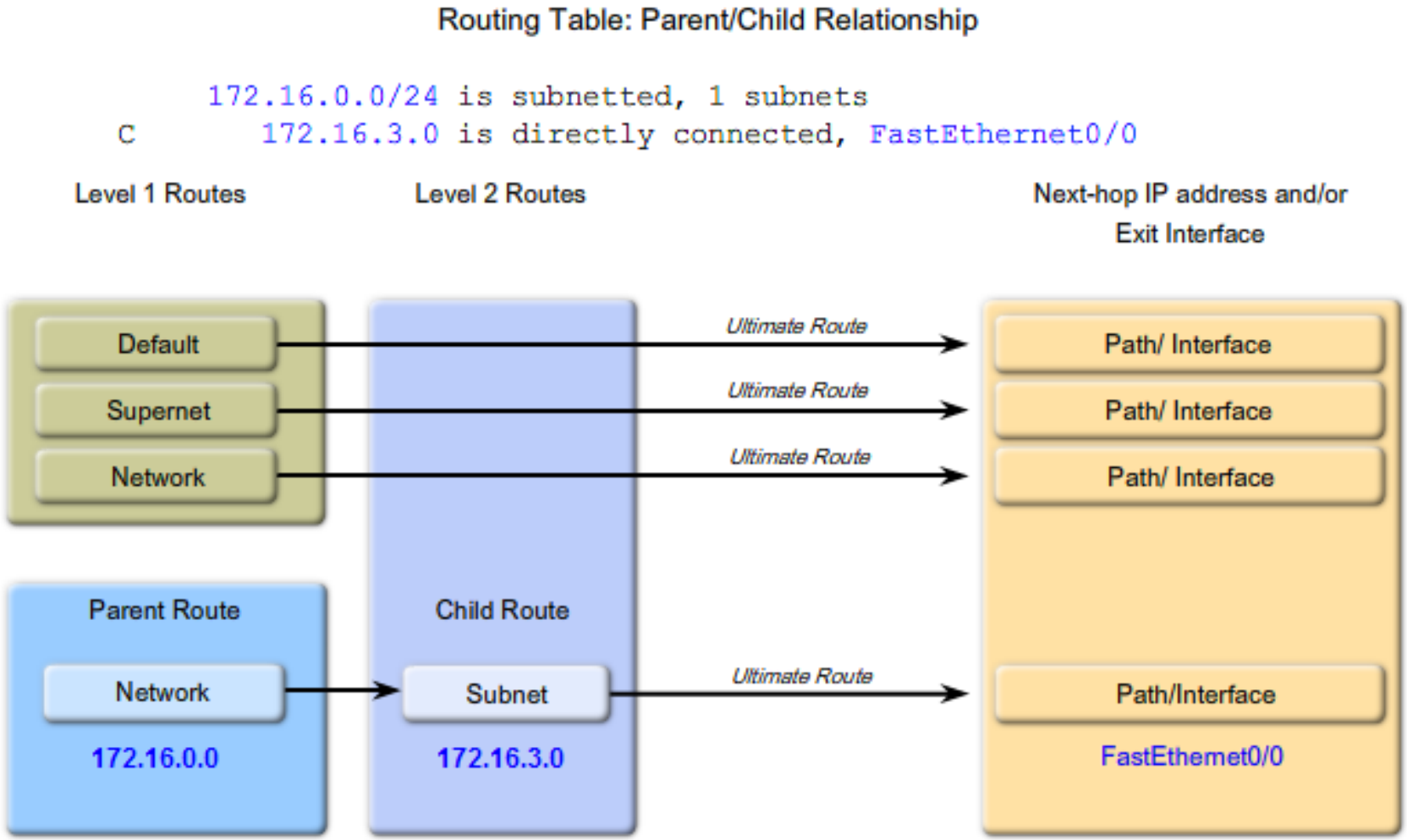

```
R2(config)#interface fastethernet 0/0
R2(config-if)#ip address 172.16.3.1 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#end
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - m
 ***output omitted***

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
R2#
```

- Parent and Child Routes

  -A **parent route** is a level 1 route

  -A **parent route does not contain** any next-hop IP address **or** exit interface information

8.1.4 Parent and Child Routes: Classful Networks

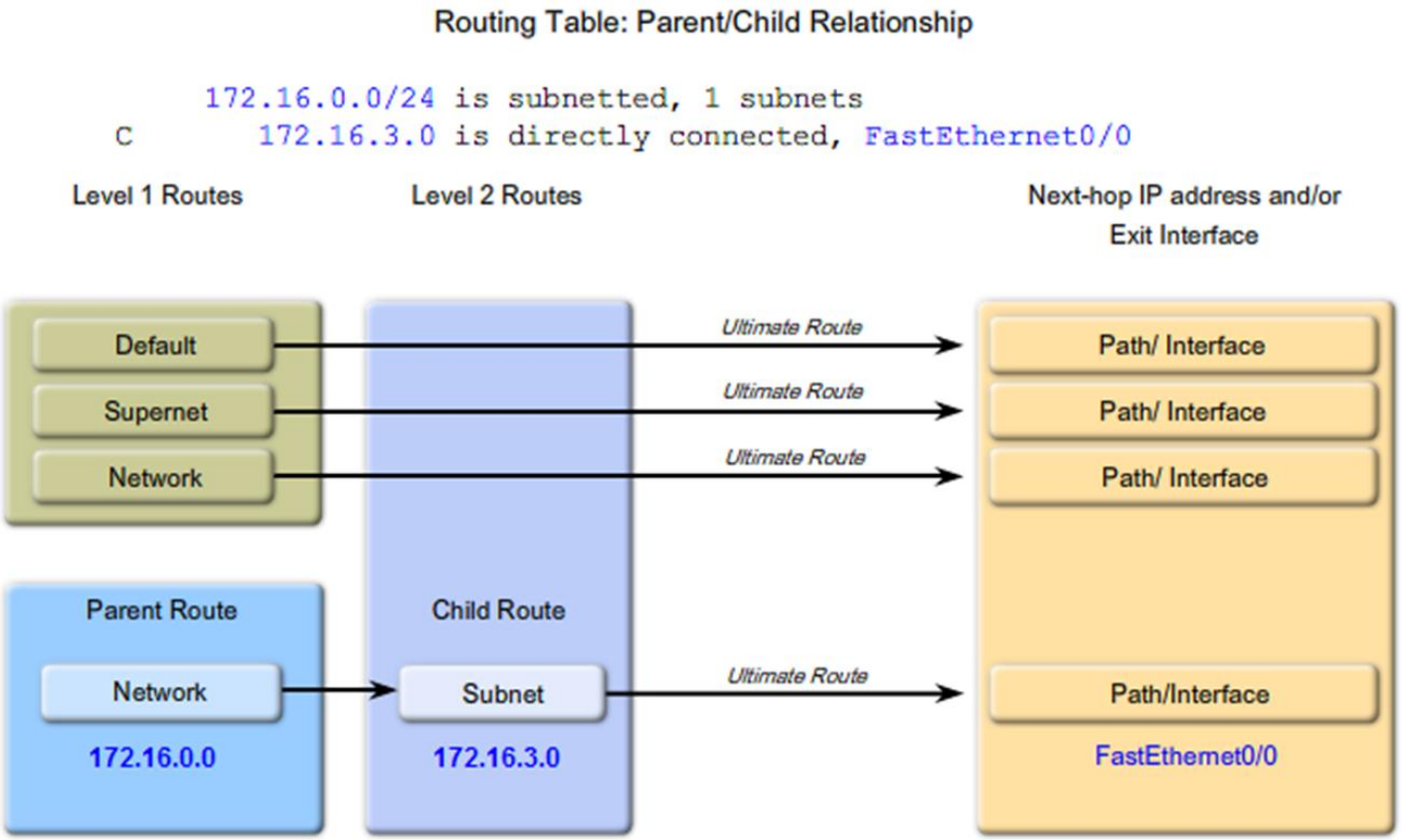


A level 1 parent route is a network route that does not contain a next-hop IP address or exit interface for any network. A parent route is actually a heading that indicates the presence of level 2 routes, also known as child routes.

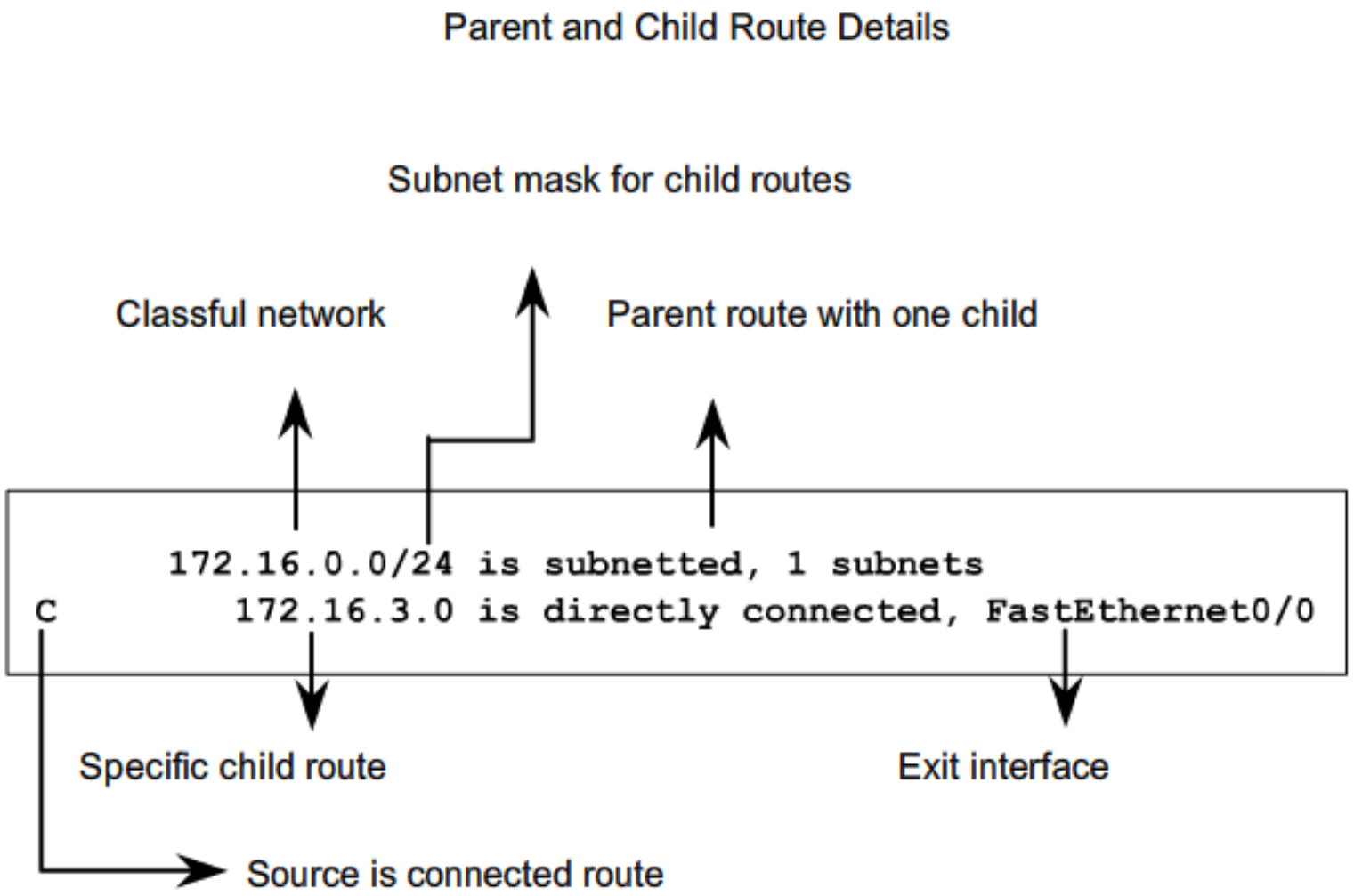
8.1.4 Parent and Child Routes: Classful Networks

Automatic creation of parent routes

- Occurs any time a subnet is added to the routing table
- Child routes
  - -Child routes are **level 2** routes
  - -Child routes are a **subnet** of a classful network address

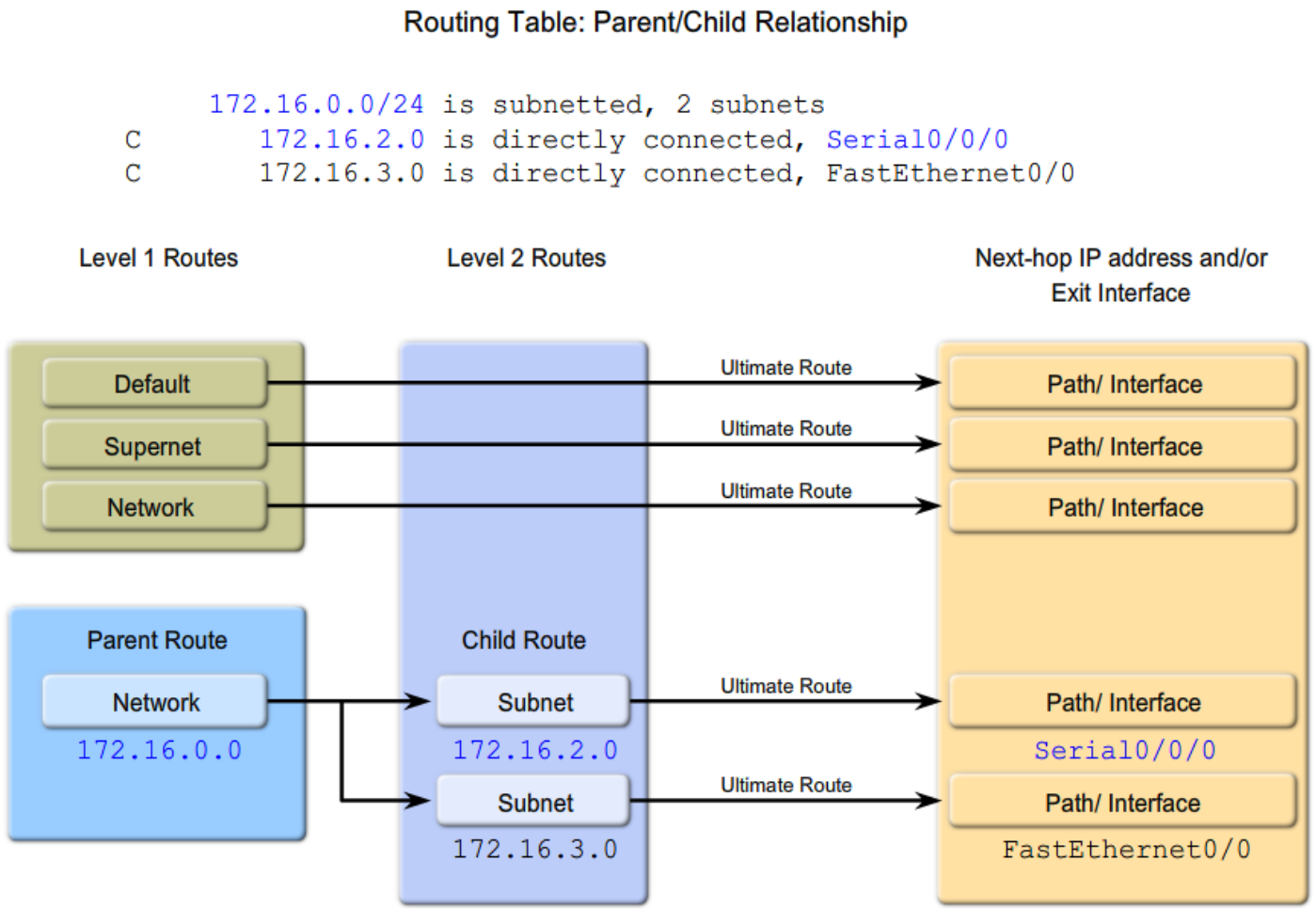


8.1.4 Parent and Child Routes: Classful Networks



Level 2 child routes contain route source & the network address of the route
Level 2 child routes are also considered ultimate routes
Reason: they contain the next hop address &/or exit interface

8.1.4 Parent and Child Routes: Classful Networks

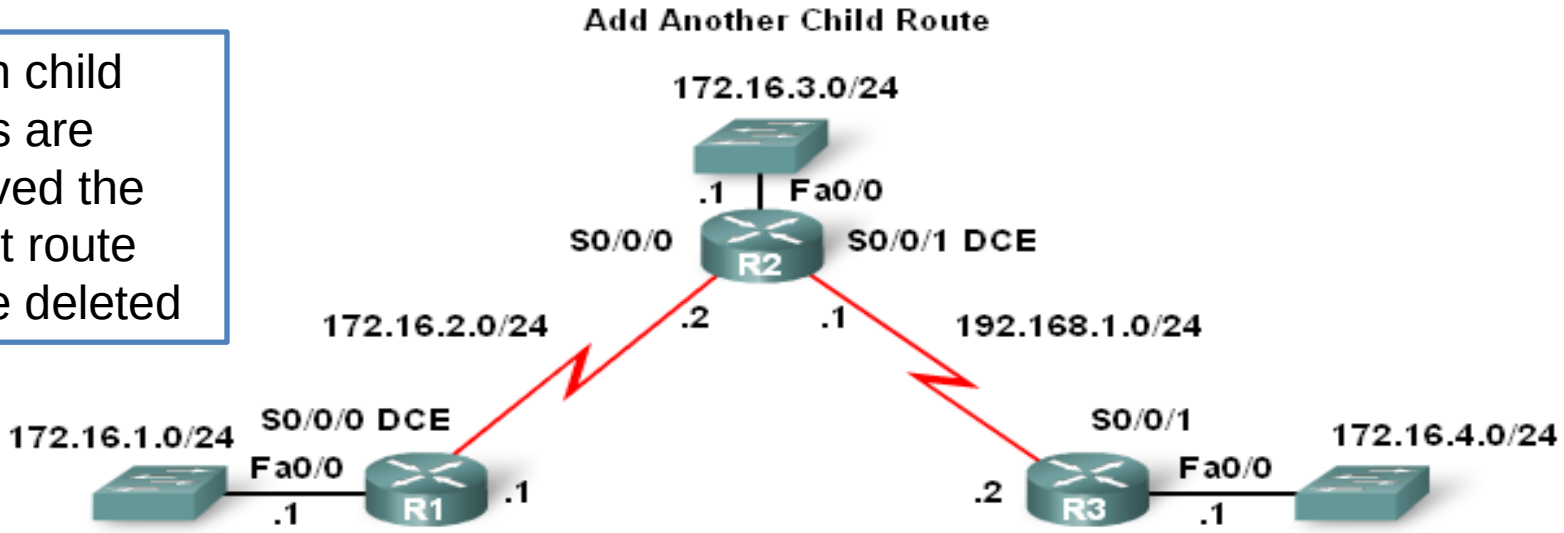


- Both child routes have the same subnet mask

  -This means the parent route maintains the /24 mask

8.1.4 Parent and Child Routes: Classful Networks

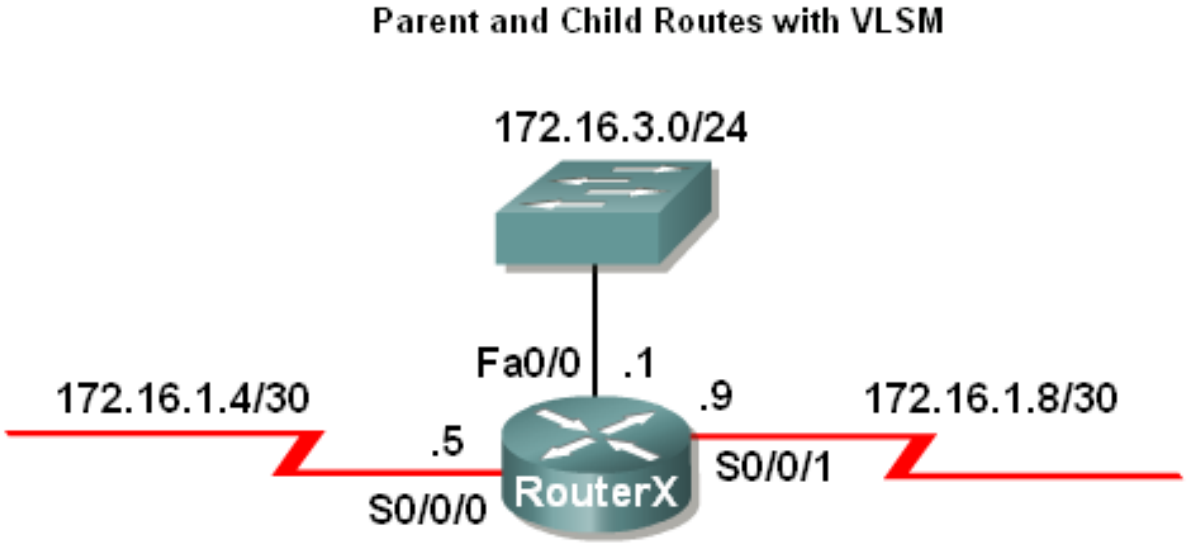
If both child routes are removed the parent route will be deleted




```
R2(config)#interface serial 0/0/0
R2(config-if)#ip address 172.16.2.2 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#end
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile,
<text omitted>

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets        Level 1 Parent Route
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
R2#
```

- Diagram illustrates 2 child networks belonging to the parent route 172.16.0.0 / 24

8.1.5 Parent and child Routes: Classless Networks



Parent and Child Routes with VLSM

```
RouterX#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
<output omitted>

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C       172.16.1.4/30 is directly connected, Serial0/0/0
C       172.16.1.8/30 is directly connected, Serial0/0/1
C       172.16.3.0/24 is directly connected, FastEthernet0/0
RouterX#
```

Level 1 Parent Route

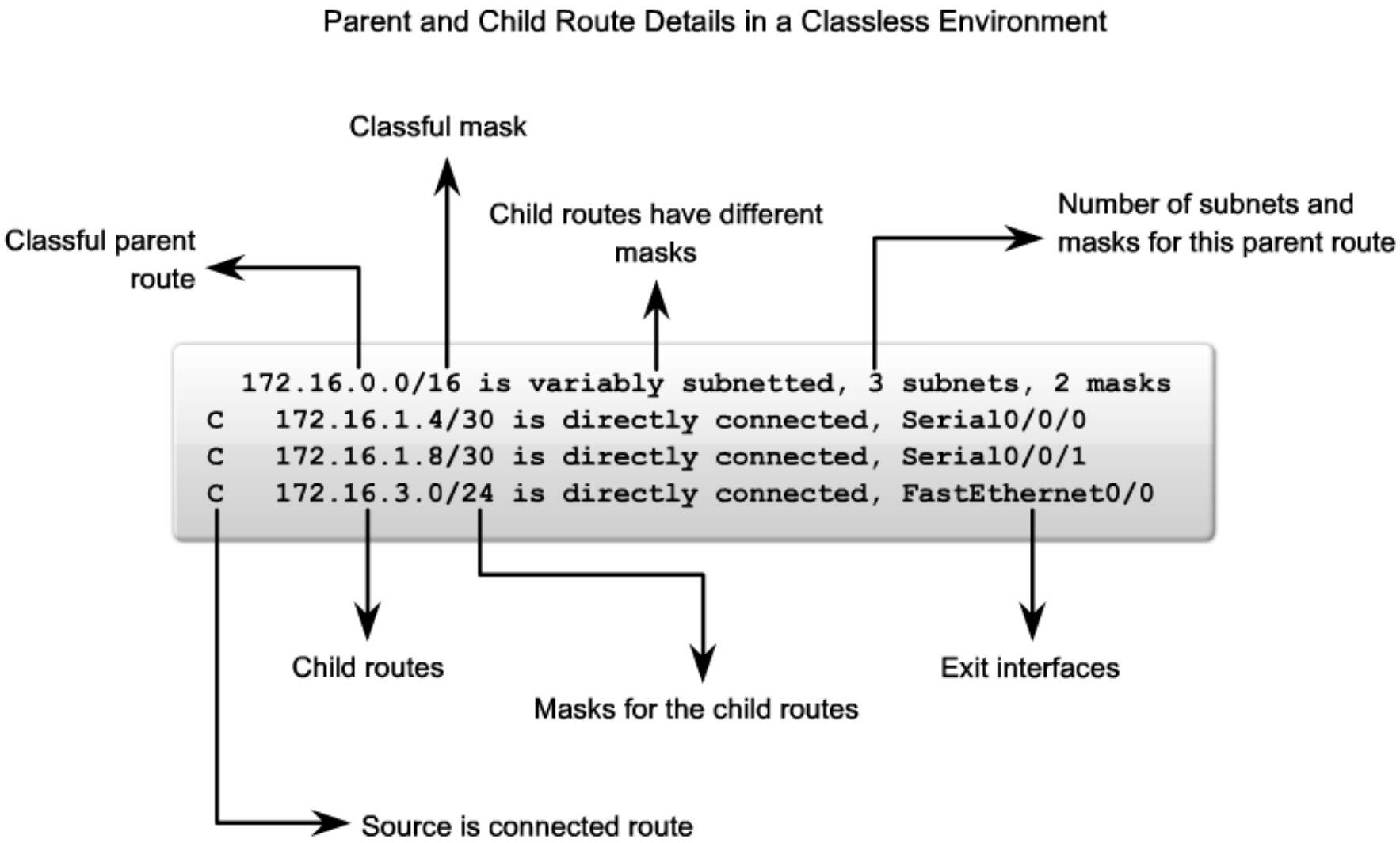
Level 2 Child Route

- In classless networks, child routes do not have to share the same subnet mask

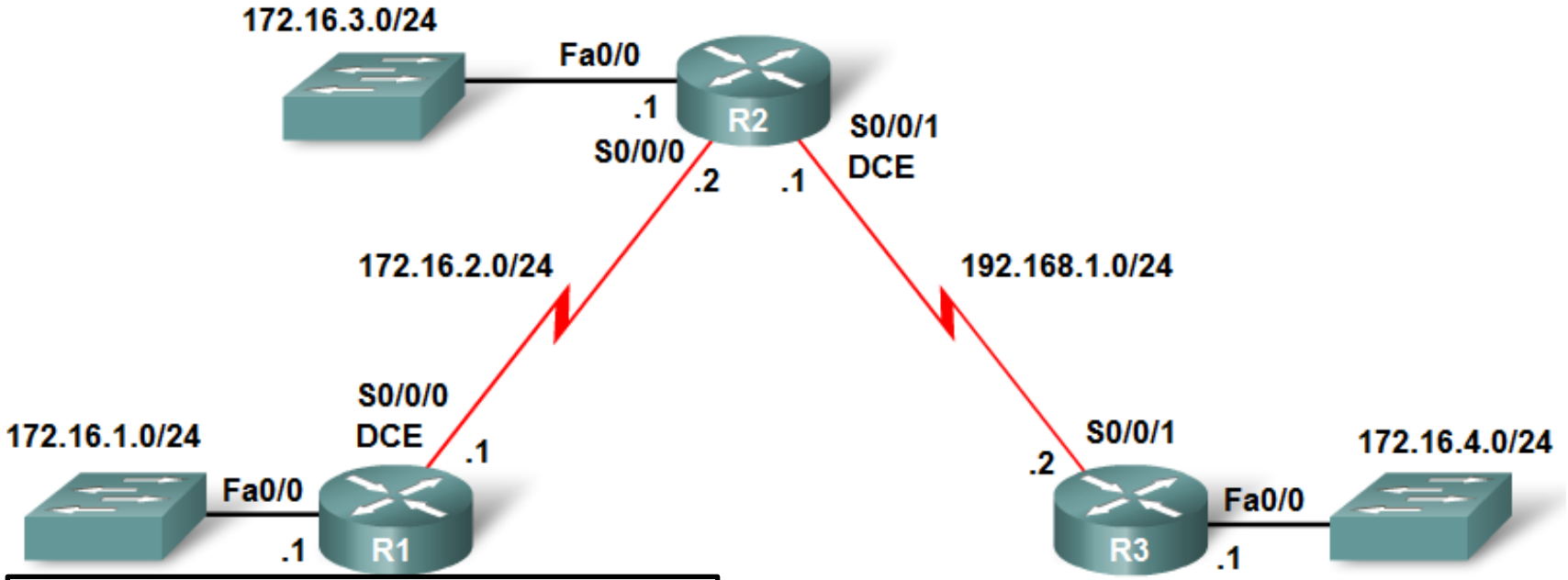
8.1.5 Parent and child Routes: Classless Networks

Network Type	Parent route's Classful mask is Displayed	Term variably subnetted is seen in parent route in routing table	Includes the # of different masks of child routes	Subnet mask included with each child route entry
Class-ful	No	No	No	No
Class-less	Yes	Yes	Yes	Yes

8.1.5 Parent and child Routes: Classless Networks



8.2.1 Steps in the Route Lookup Process



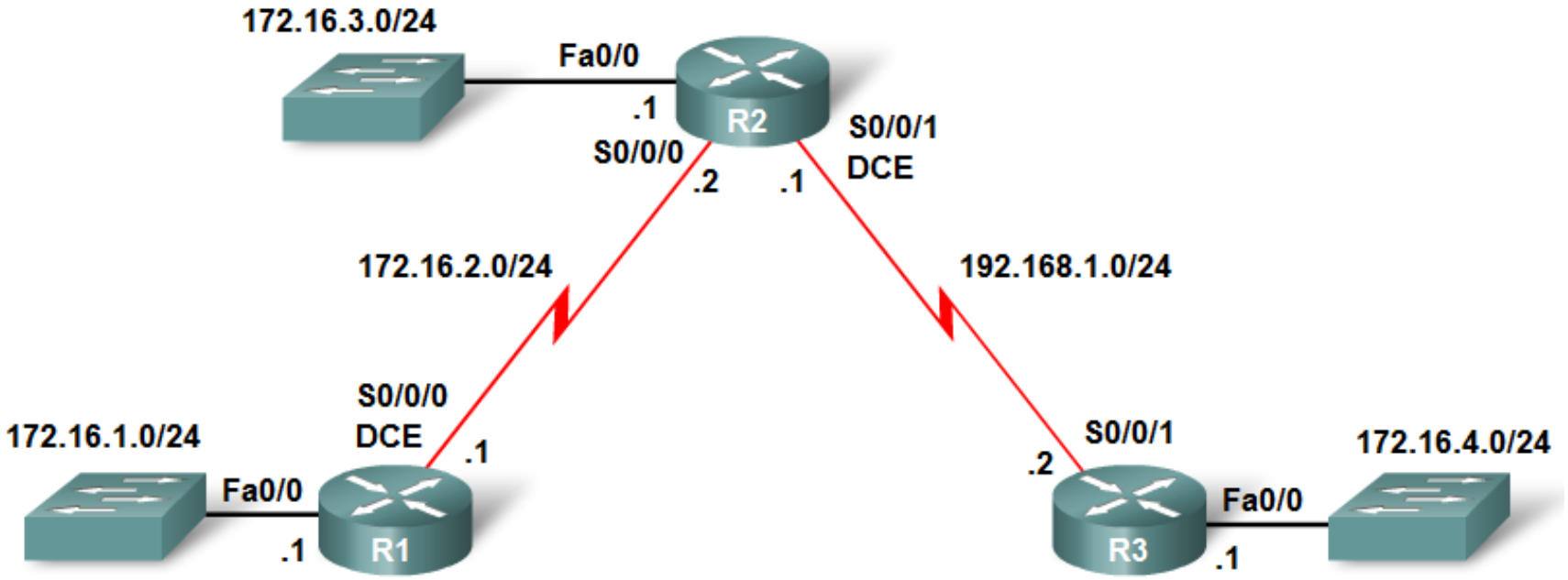

```
R1(config)#router rip
R1(config-router)#network 172.16.0.0
```

```
R2(config)#router rip
R2(config-router)#network 172.16.0.0
R2(config-router)#network 192.168.1.0
```

```
R3(config)#router rip
R3(config-router)#network 172.16.0.0
R3(config-router)#network 192.168.1.0
```

In this topology, RIPv1, a classful routing protocol, is now configured. Notice that we have specifically chosen a classful routing protocol with our discontiguous 172.16.0.0 subnets.

8.2.1 Steps in the Route Lookup Process




```
R3#show ip route
Codes: C - connected, S - static, I - IGRP, R - RI
       (**output omitted**)

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.4.0 is directly connected, FastEther
C    192.168.1.0/24 is directly connected, Serial0/
```

As you would expect with this addressing scheme and a classful routing protocol, there are reachability problems. Neither R1 nor R2 has a route to 172.16.4.0. Also, R3 does not have routes to subnets 172.16.1.0/24, 172.16.2.0/24, or 172.16.3.0/24.

8.2.1 Steps in the Route Lookup Process

- **The Route Lookup Process**
  - **Examine level 1 routes**

    -If best match is a level 1 ultimate route and is not a parent route this route is used to forward packet
  - **Router examines level 2 (child) routes**

    -If there is a match with level 2 child route then

    that subnet is used to forward packet

    -If no match then

    determine routing behavior type
  - **Router determines classful or classless routing behavior**

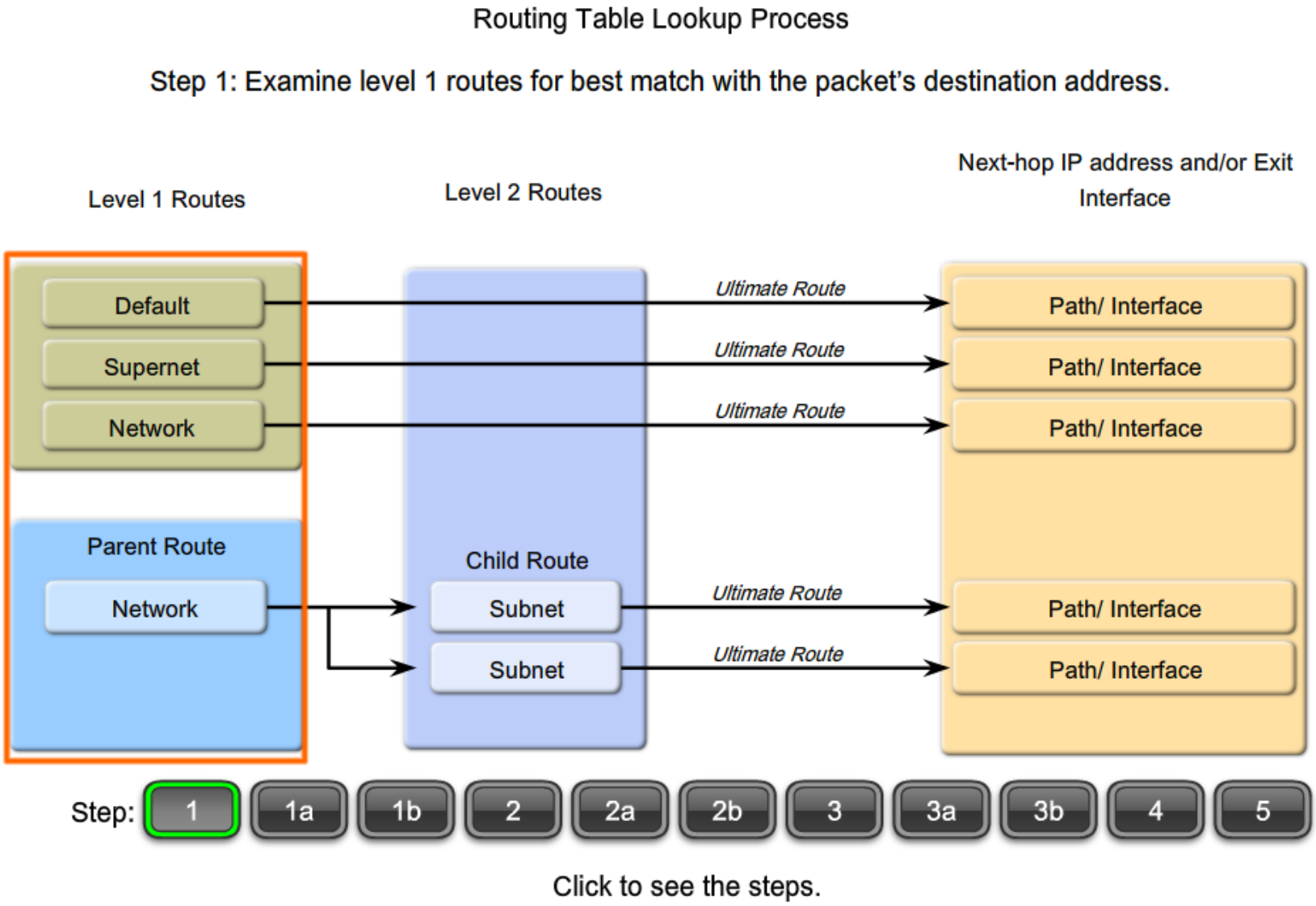
    -If classful then

    packet is dropped

    -If classless then router searches level one supernet and default routes

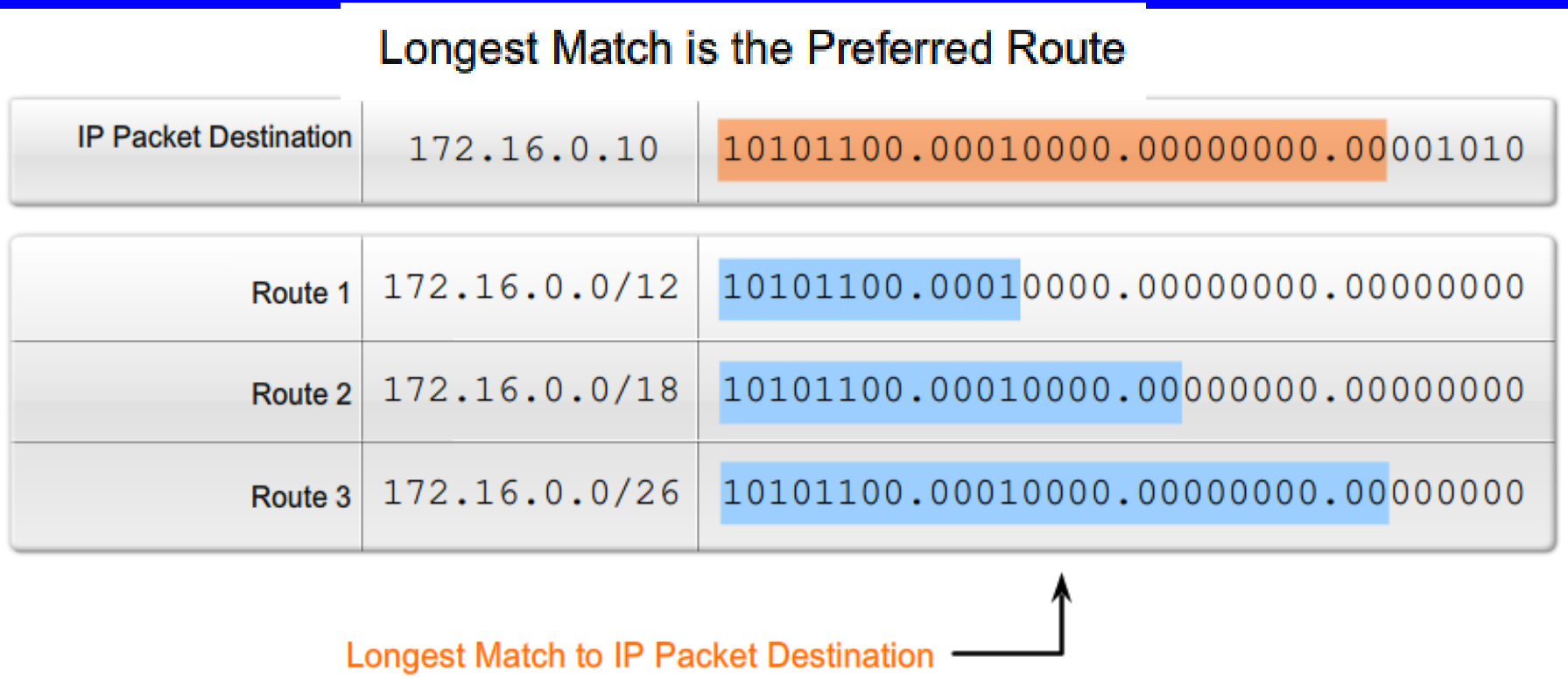
    -If there exists a level 1 supernet or default route match then Packet is forwarded. If not packet is dropped

8.2.1 Steps in the Route Lookup Process



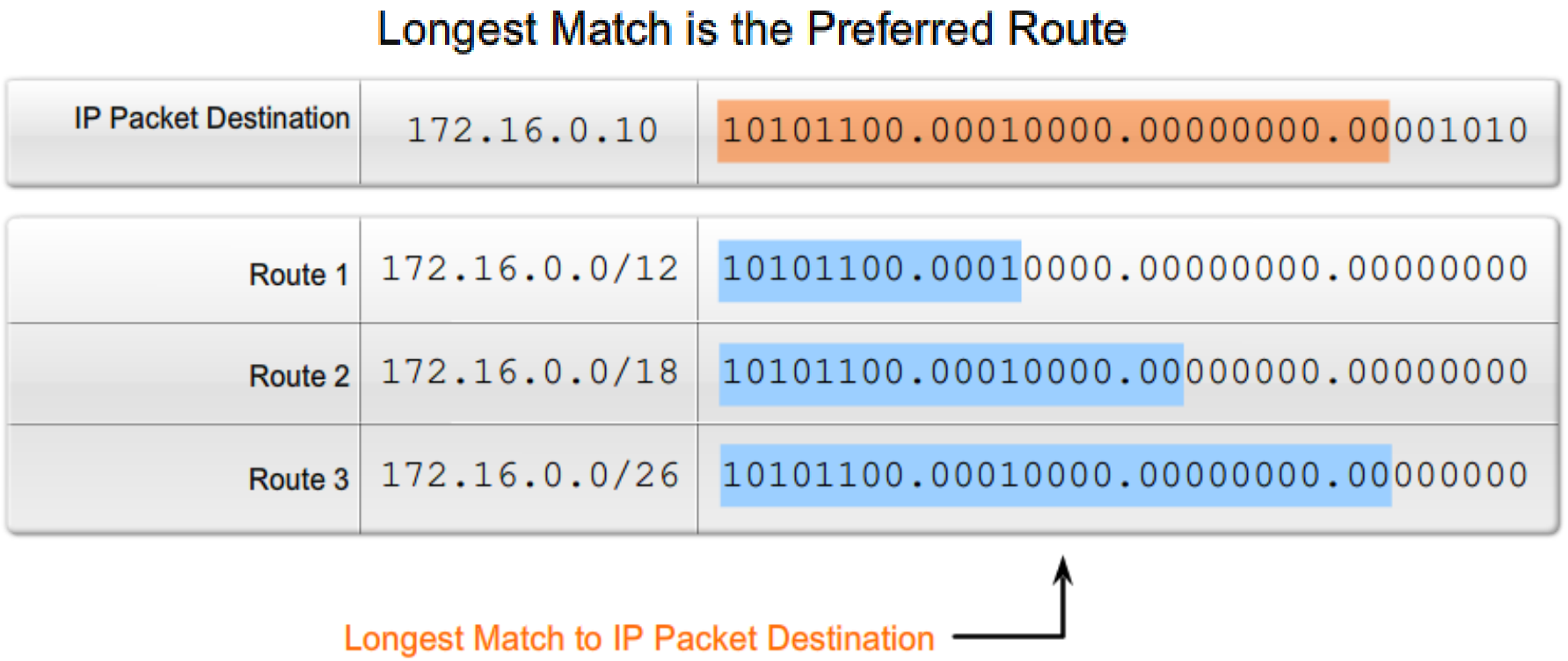
Your curriculum contains a nice graphic that will take you, step by step, through the Route Lookup Process. Check it out.

8.2.2 Longest Match – Level 1 Network Routes



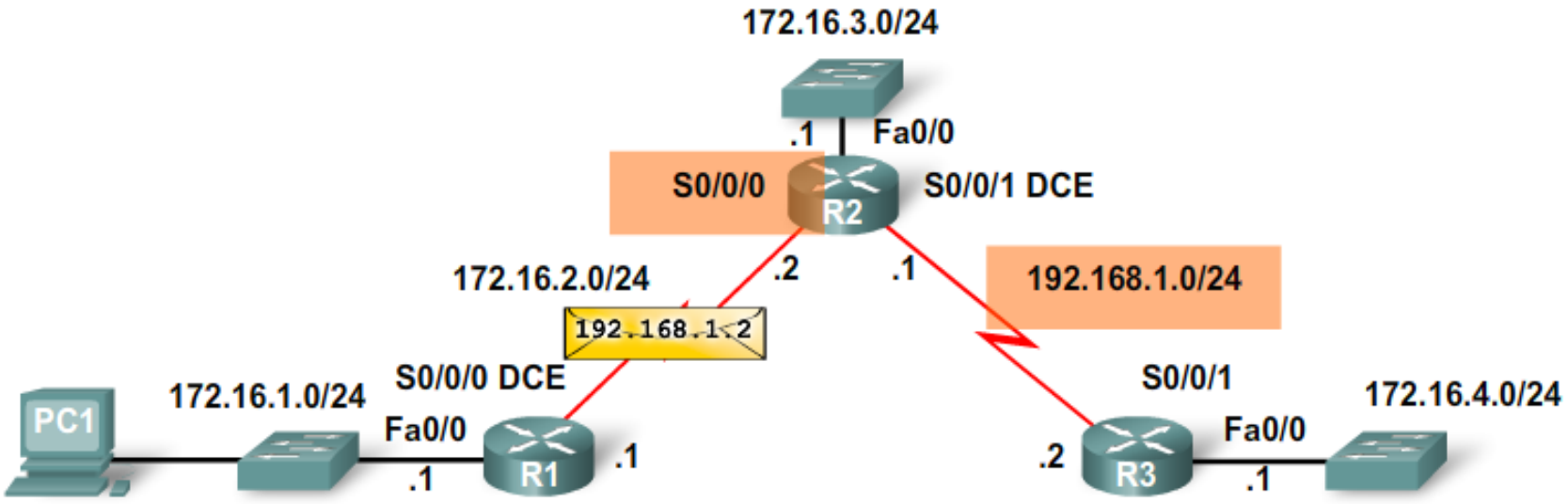
- Longest Match: Level 1 Network Routes
  - Best match is also known as the longest match
  - The **best match** is the one that has the most number of left most bits matching between the destination IP address and the route in the routing table.

8.2.2 Longest Match – Level 1 Network Routes



For example, in the figure we have a packet destined for 172.16.0.10. Many possible routes could match this packet. Three possible routes are shown that do match this packet: 172.16.0.0/12, 172.16.0.0/18, and 172.16.0.0/26. Of the three routes, 172.16.0.0/26 has the longest match. Remember, for any of these routes to be considered a match there must be at least the number of matching bits indicated by the subnet mask of the route.

8.2.2 Longest Match: Level 1 Network Routes



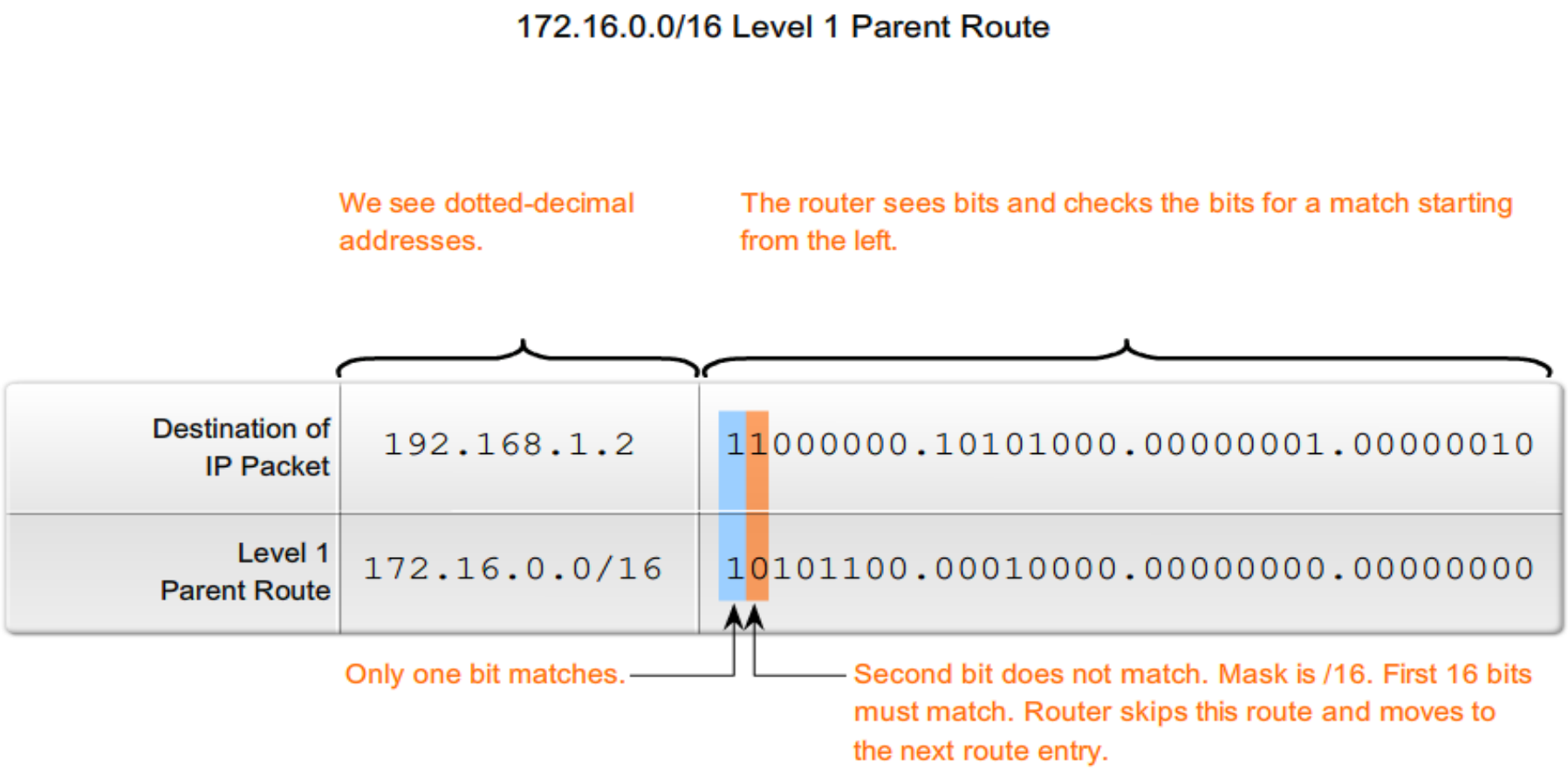
Step 1a: If best match is a level 1 ultimate route, use it to forward the packet.

- Finding the subnet mask used to determine the longest match

  Scenario:

  - PC1 pings 192.168.1.2
  - Router examines level 1 route for best match
  - There exist a match between192.168.1.2 & 192.168.1.0 / 24
  - Router forwards packets out s0/0/0

8.2.2 Longest Match: Level 1 Network Routes

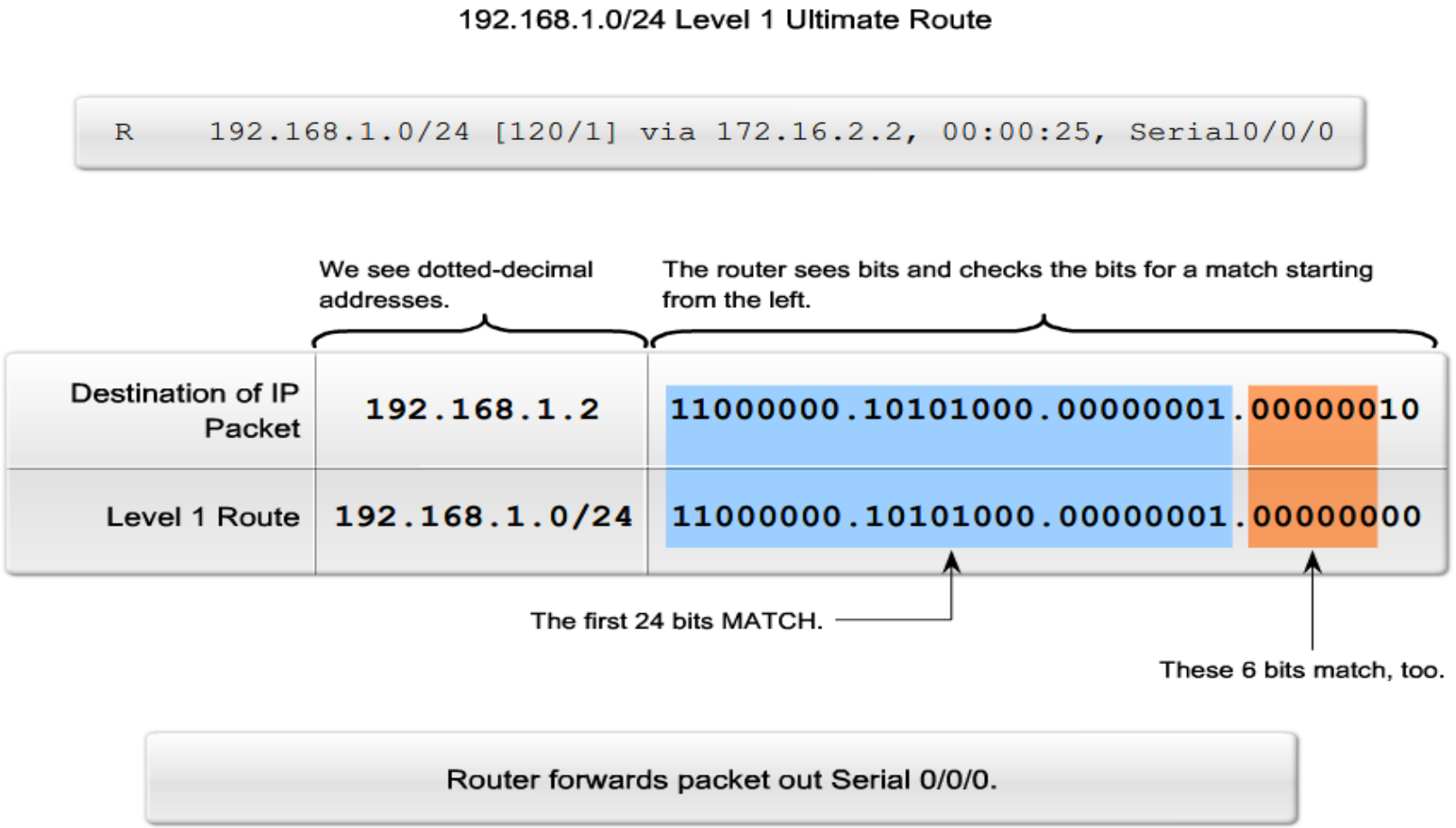


The process of matching

-1st there must be a match made between the parent route & destination IP

-If a match is made then an attempt at finding a match between the destination IP and the child route is made.

8.2.2 Longest Match: Level 1 Network Routes



- There may be multiple potential routes with different subnet masks in the routing table for the same destination IP address. The one with the most number of matching bits, the longest match, is preferred.

-The figure shows a match between the destination IP of 192.168.1.0 and the level one IP of 192.168.1.0 / 24 - the packet forwarded out s0/0/0

8.23 Longest Match: Level 1 Parent and Level 2 Child Routes

Example: Level 1 Parent Route and Level 2 Child Routes

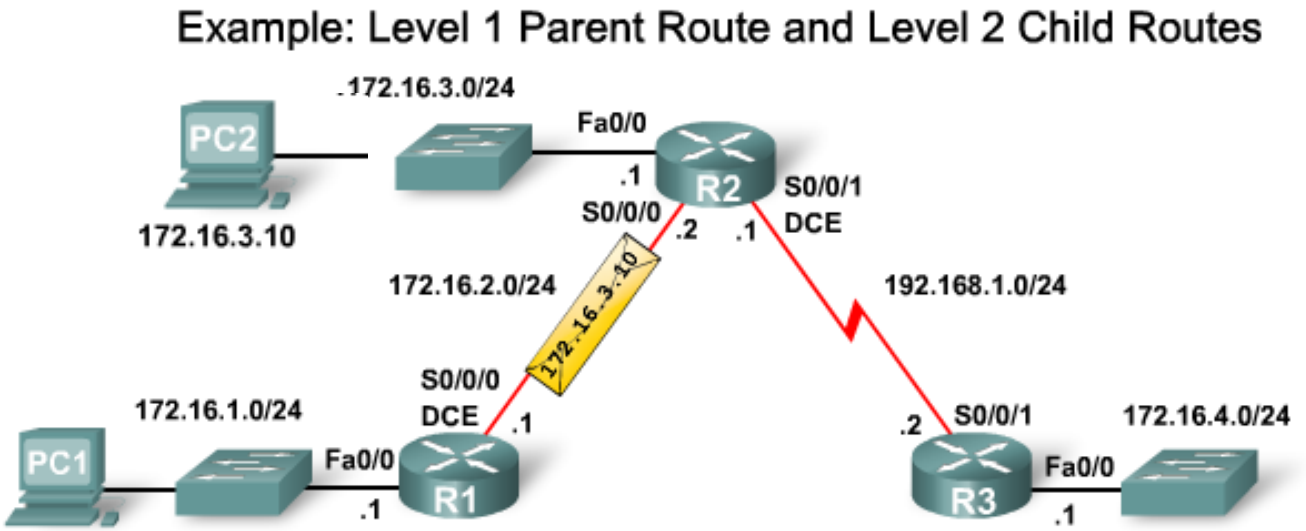
```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
BGP
***output omitted***

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
C       172.16.1.0 is directly connected, FastEthernet0/0
C       172.16.2.0 is directly connected, Serial0/0/0
R       172.16.3.0 [120/1] via 172.16.2.2, 00:00:25, Serial0/0/0
R    192.168.1.0/24 [120/1] via 172.16.2.2, 00:00:25, Serial0/0/0
```

Level 1 Parent Route "Header" for Child Routes

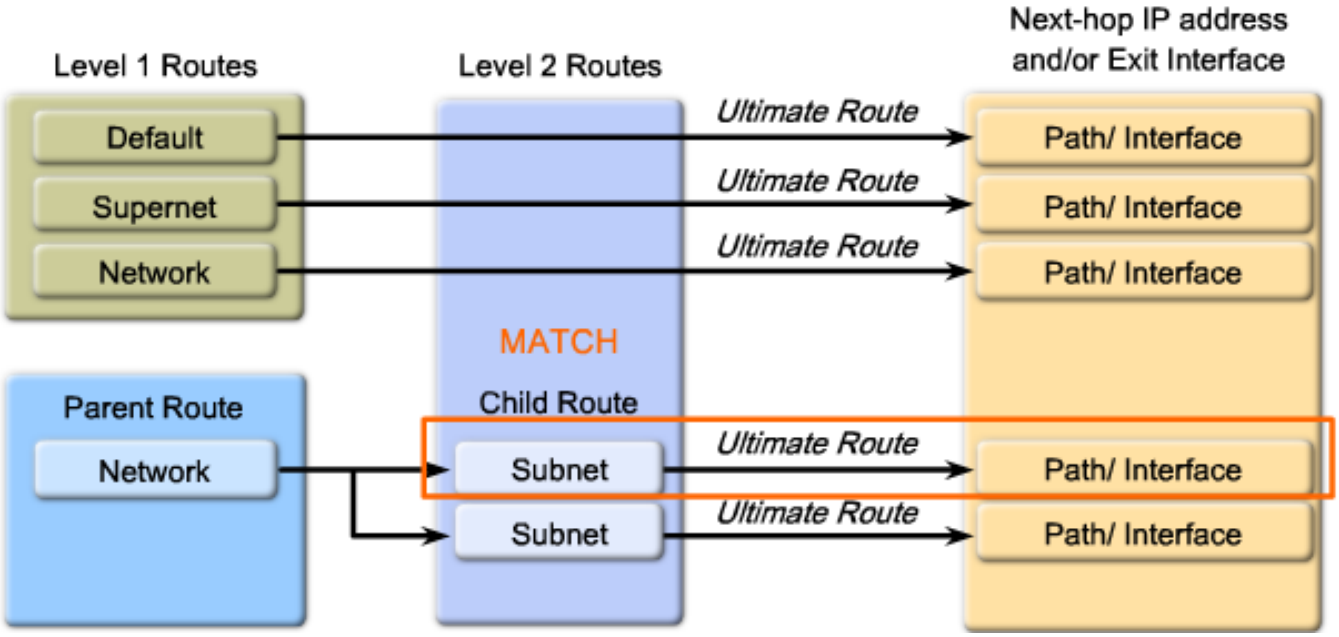
Level 1 Parent & Level 2 Child Routes

- A parent route does not include a next-hop address or an exit interface but is only a "header" for its level 2 child routes, the subnets
- Before level 2 child routes are examined There must be a match between classful level one parent route and destination IP address.

8.23 Longest Match: Level 1 Parent and Level 2 Child Routes



Step 2a: Match! Use this subnet to forward the packet.



After the match with parent route has been made Level 2 child routes will be examined for a match

Route lookup process searches for child routes with a match with destination IP of at least 24 bits

8.23 Longest Match: Level 1 Parent and Level 2 Child Routes

Example: Level 1 Parent Route and Level 2 Child Routes

Destination of IP Packet	**172.16.3.10**	**10101100 00010000 00000011** 00001010
Level 1 Parent Route	172.16.0.0/16	10101100 00010000 00000000 00000000
Level 2 Child Route	172.16.1.0/24	10101100 00010000 00000001 00000000
Level 2 Child Route	172.16.2.0/24	10101100 00010000 00000010 00000000
Level 2 Child Route	**172.16.3.0/24**	**10101100 00010000 00000011** 00000000

First 24 bits match.

How a router finds a match with one of the level 2 child routes

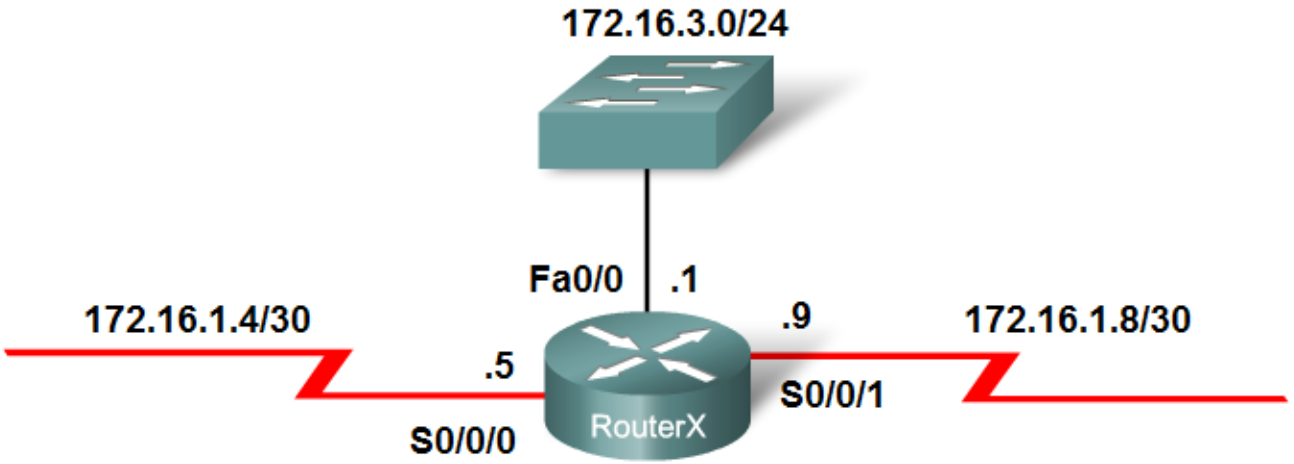
-First router examines parent routes for a match

-If a match exists then:

Child routes are examined

Child route chosen is the one with the longest match

8.23 Longest Match: Level 1 Parent and Level 2 Child Routes




```
RouterX#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile,
***output omitted***

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C       172.16.1.4/30 is directly connected, Serial0/0/0
C       172.16.1.8/30 is directly connected, Serial0/0/1
C       172.16.3.0/24 is directly connected, FastEthernet0/0
RouterX#
```

Level 2 Child Route

Example: Route Lookup Process with VLSM

- The use of VLSM does not change the lookup process
- If there is a match between destination IP address and the level 1 parent route then
- Level 2 child routes will be searched

8.3.1 Classful and Classless Routing Behavior

Routing Protocols vs Routing Behaviors

Routing Sources

- Directly Connected Networks
- Static Routes
- Classful Routing Protocols
  - RIPv1
  - IGRP
- Classless Routing Protocols
  - RIPv2
  - EIGRP
  - OSPF
  - IS-IS

- Routing sources (including protocols) are used to build the routing table.
- Multiple sources and routing protocols can be used.

Routing Behaviors

- Classful
  - `no ip classless`
- IP Classless
  - `ip classless`

- Routing behaviors are used to locate information in the routing table.
- Only a single routing behavior can be used.

- Classful & classless **routing protocols**

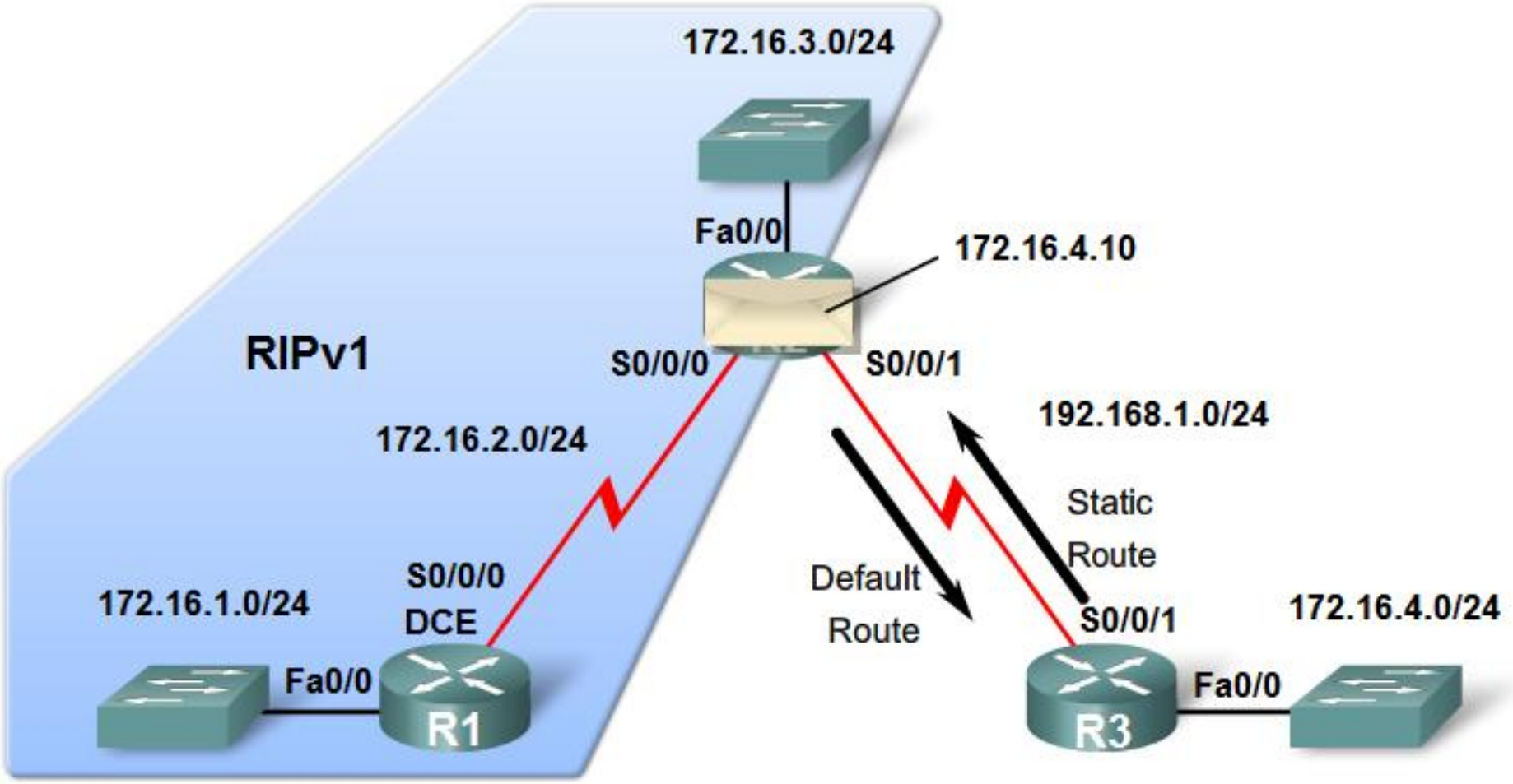
  Influence how routing table is **populated**

- Classful & classless **routing behaviors**

  Determines how routing table is **searched** after it is filled

8.3.1 Classful and Classless Routing Behavior

Topology Changes and Router Configurations

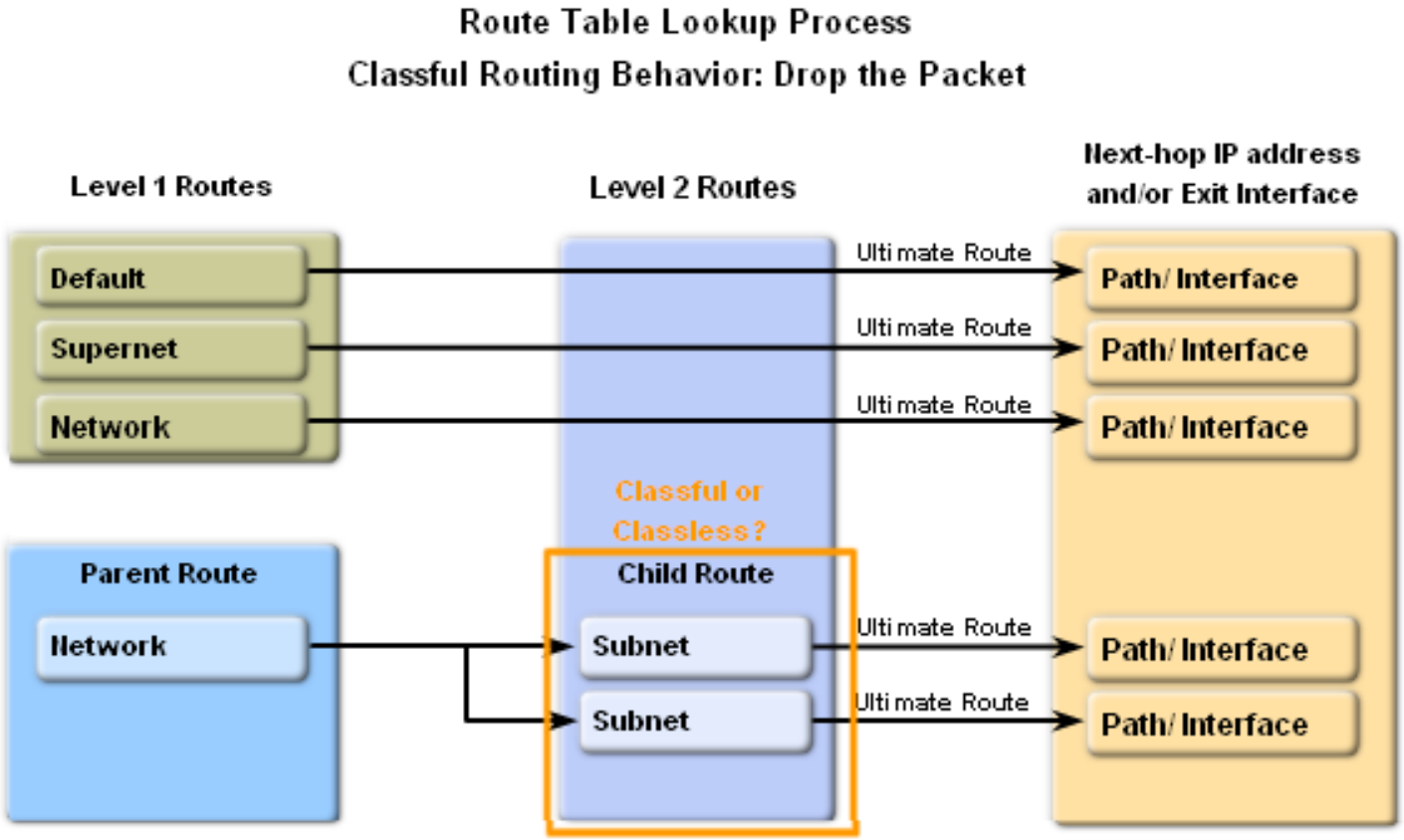


8.3.1 Classful and Classless Routing Behavior

```
R2(config)#ip route 0.0.0.0 0.0.0.0 s0/0/1
R2(config)#router rip
R2(config-router)#default-information originate
R2(config-router)#no network 192.168.1.0
R2(config-router)#end
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP


Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 3 subnets
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:00, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```

```
R3(config)#ip route 172.16.0.0 255.255.0.0 s0/0/1
R3(config)#no router rip
R3(config-router)#end
R3#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
***output omitted***

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.4.0/24 is directly connected, FastEthernet0/0
S       172.16.0.0/16 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
```

8.3.2 Classful Routing Behavior: no ip classless



- What happens if there is not a match with any level 2 child routes of the parent?

  -Router must determine if the routing behavior is classless or classful

  -If router is utilizing classful routing behavior then Lookup process is terminated and packet is dropped

8.3.2 Classful Routing Behavior: no ip classless

```
R2#show running-config
Building configuration...

Current configuration:
!
version 12.2
!

!
***output omitted***
no ip classless
```

The command no ip classless means that the route lookup process uses classful routing table lookups by default. This will be explained in the following sections.

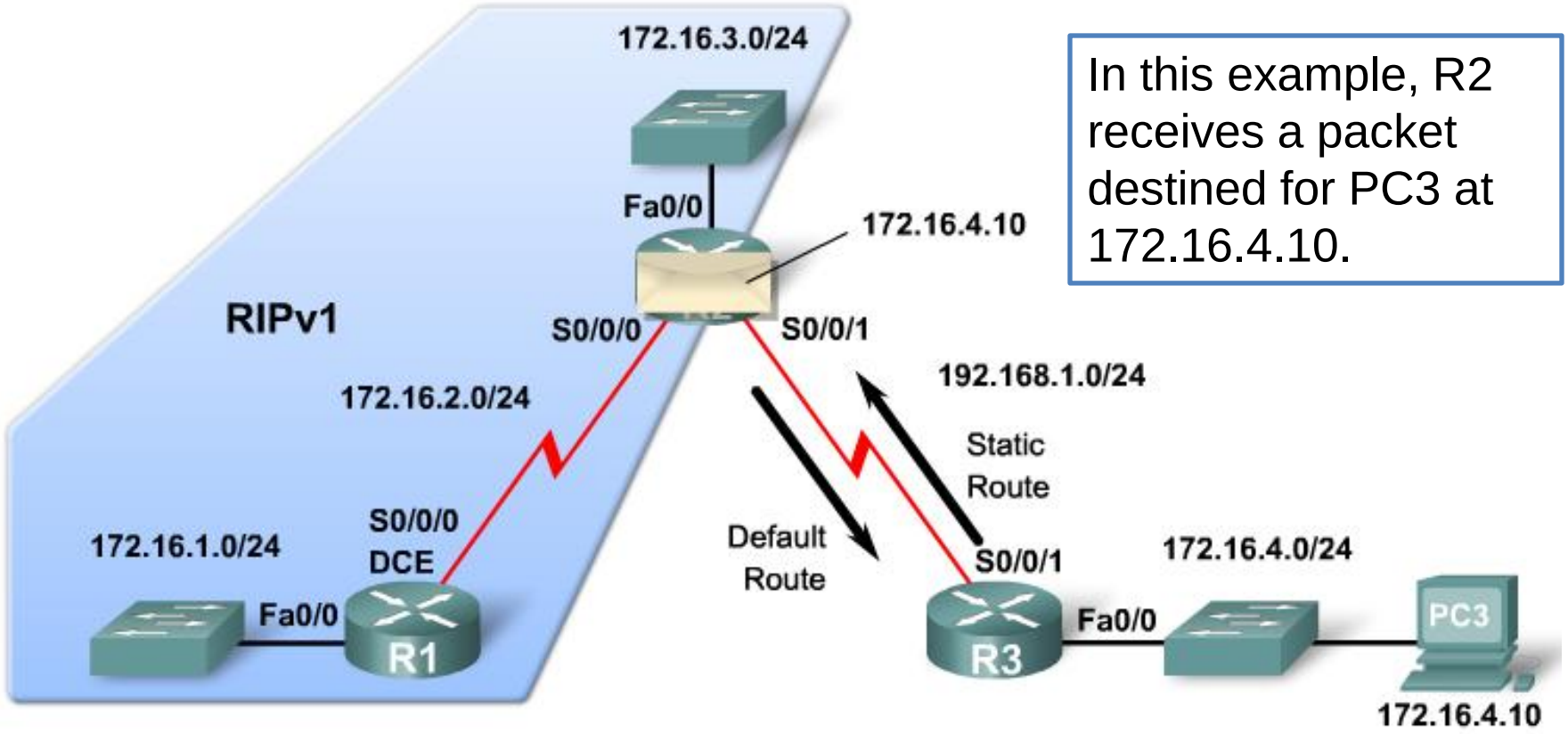
The commands no ip classless and ip classless are global configuration commands and can be viewed by typing show running-config. In IOS versions 11.3 and later, the command ip classless is the default, implementing a classless route lookup process.

What is the effect of classful routing behavior when all the routers are configured with the no ip classless command?

R1(config)#no ip classless R2(config)#no ip classless R3(config)#no ip classless

8.3.3 Classful Routing Behavior – Search Process

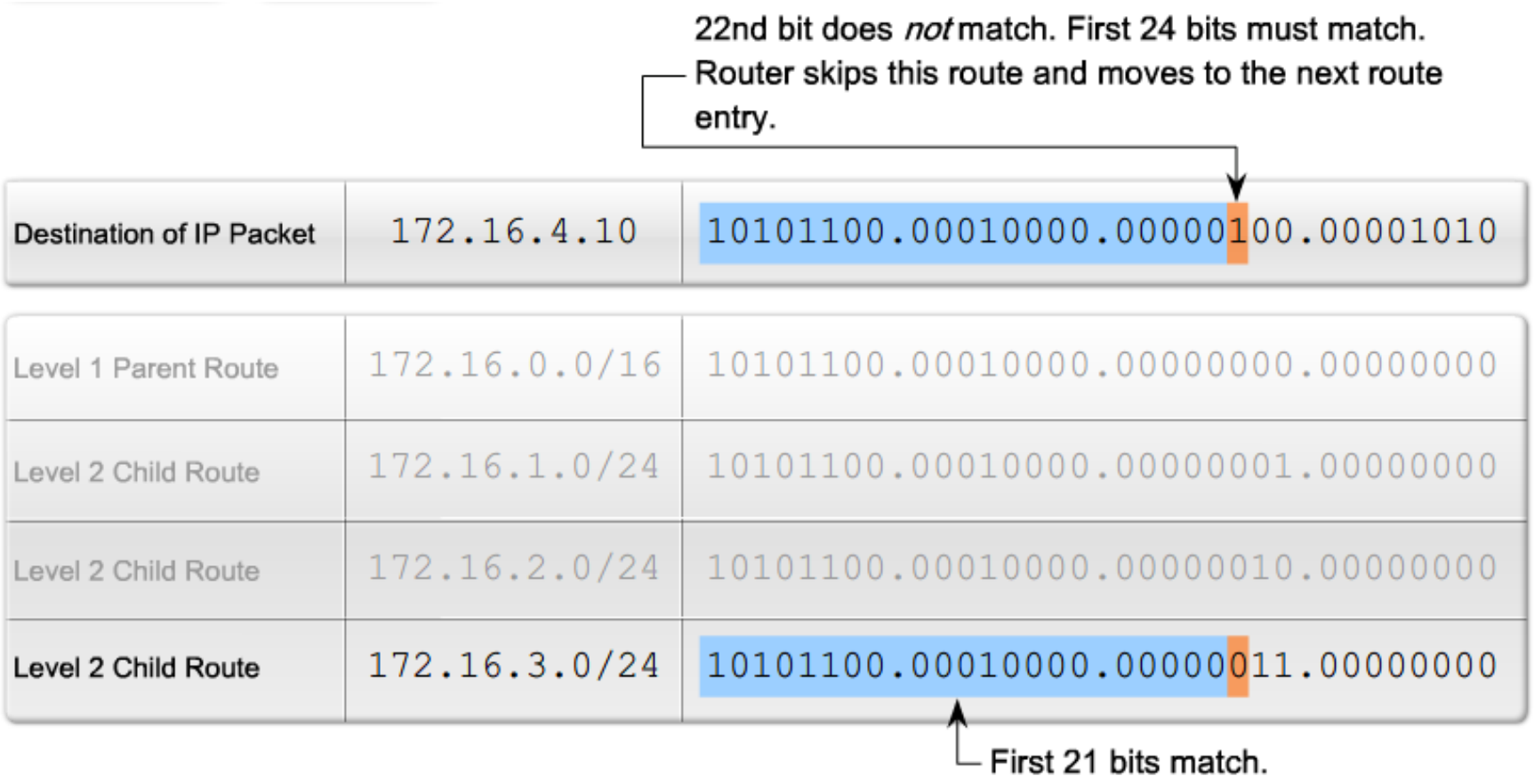
Example: R2 Operating with Classful Routing Behavior



In this example, R2 receives a packet destined for PC3 at 172.16.4.10.

When classful routing behavior is in effect (no ip classless) the process will not continue searching level 1 routes in the routing table. If a packet doesn't match a child route for the parent network route, then the router drops the packet.

8.3.3 Classful Routing Behavior – Search Process



None of the 24 left-most bits of the child routes matches the destination IP address of 172.16.4.10. At most, only 21 bits match. There is no match with the level 2 child routes.

8.3.3 Classful Routing Behavior – Search Process

```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
***output omitted***

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 3 subnets
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:12, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```

Match!

No Match

No Match

No Match

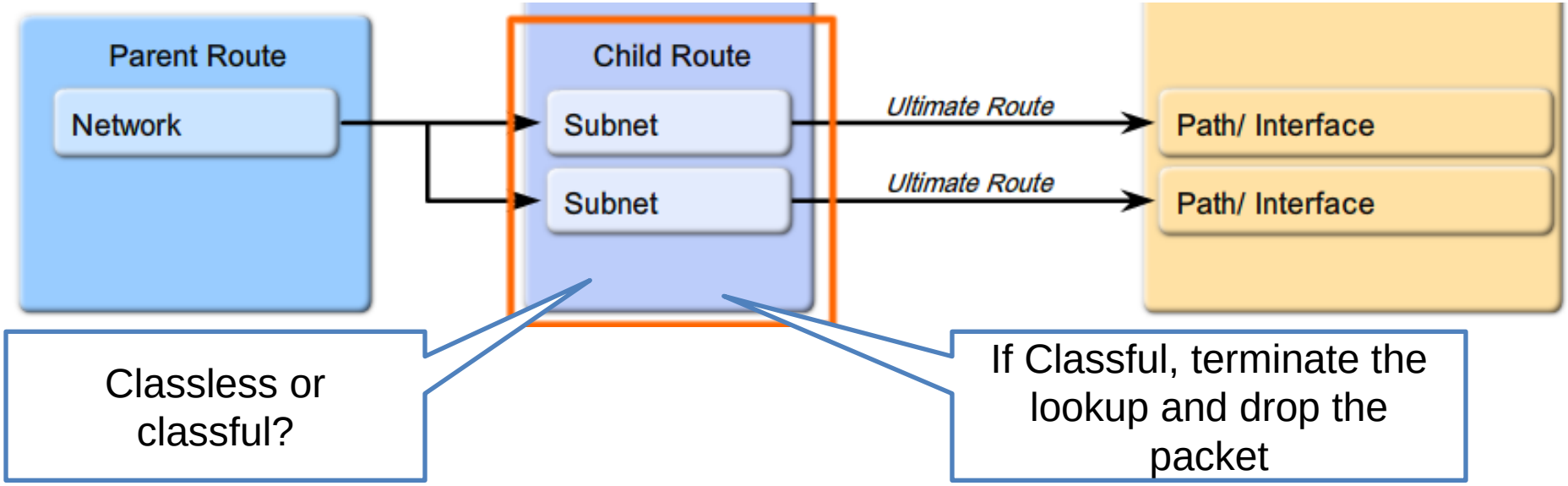
Drop Packet

The default route is *not* used.

Destination of IP Packet	172.16.4.10	10101100	00010000	00000100	00001010
Level 1 Parent Route	172.16.0.0/16	10101100	00010000	00000000	00000000
Level 2 Child Route	172.16.1.0/24	10101100	00010000	00000001	00000000
Level 2 Child Route	172.16.2.0/24	10101100	00010000	00000010	00000000
Level 2 Child Route	172.16.3.0/24	10101100	00010000	00000011	00000000

First 24 bits need to match.

8.3.4 Classless Routing Behavior: ip classless

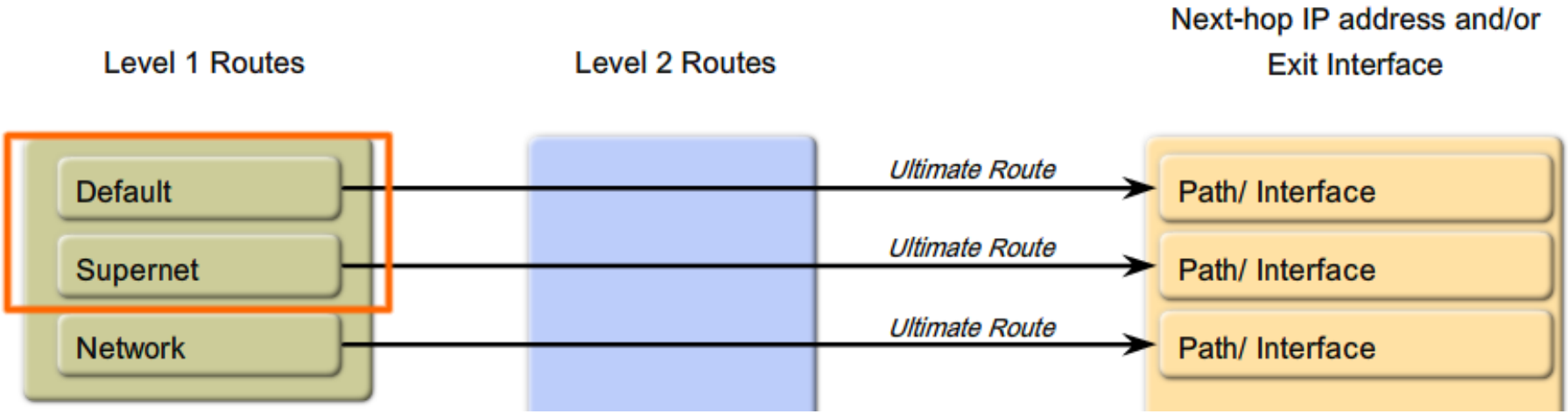


in Steps 1 and 2, the routing table process examines level 1 and level 2 child routes looking for the best match with the IP packet's destination address. Let's assume there is no match and resume the route lookup process

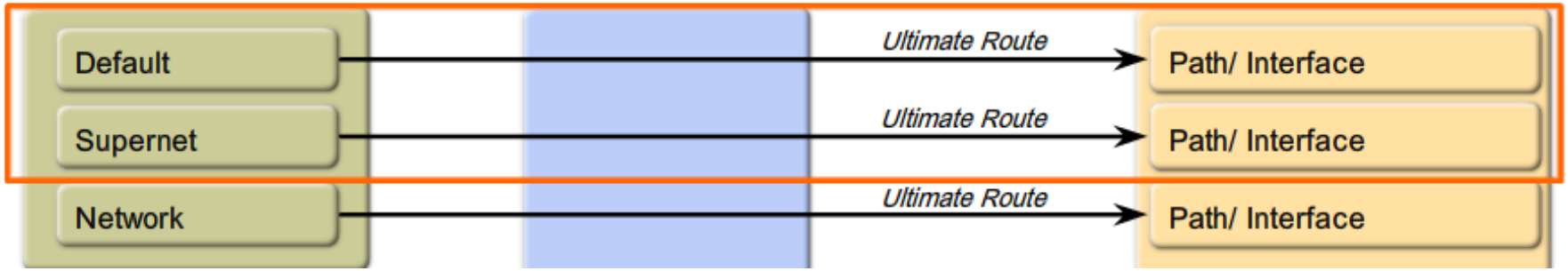
The Route Lookup Process:
Is the router implementing **classful** or **classless** routing behavior?

Classful routing behavior:
If classful routing behavior is in effect, terminate the lookup process and drop the packet.

8.3.4 Classless Routing Behavior: ip classless



Classless routing behavior: If classless routing behavior is in effect, continue searching level 1 supernet routes in the routing table for a match, including the default route, if there is one.

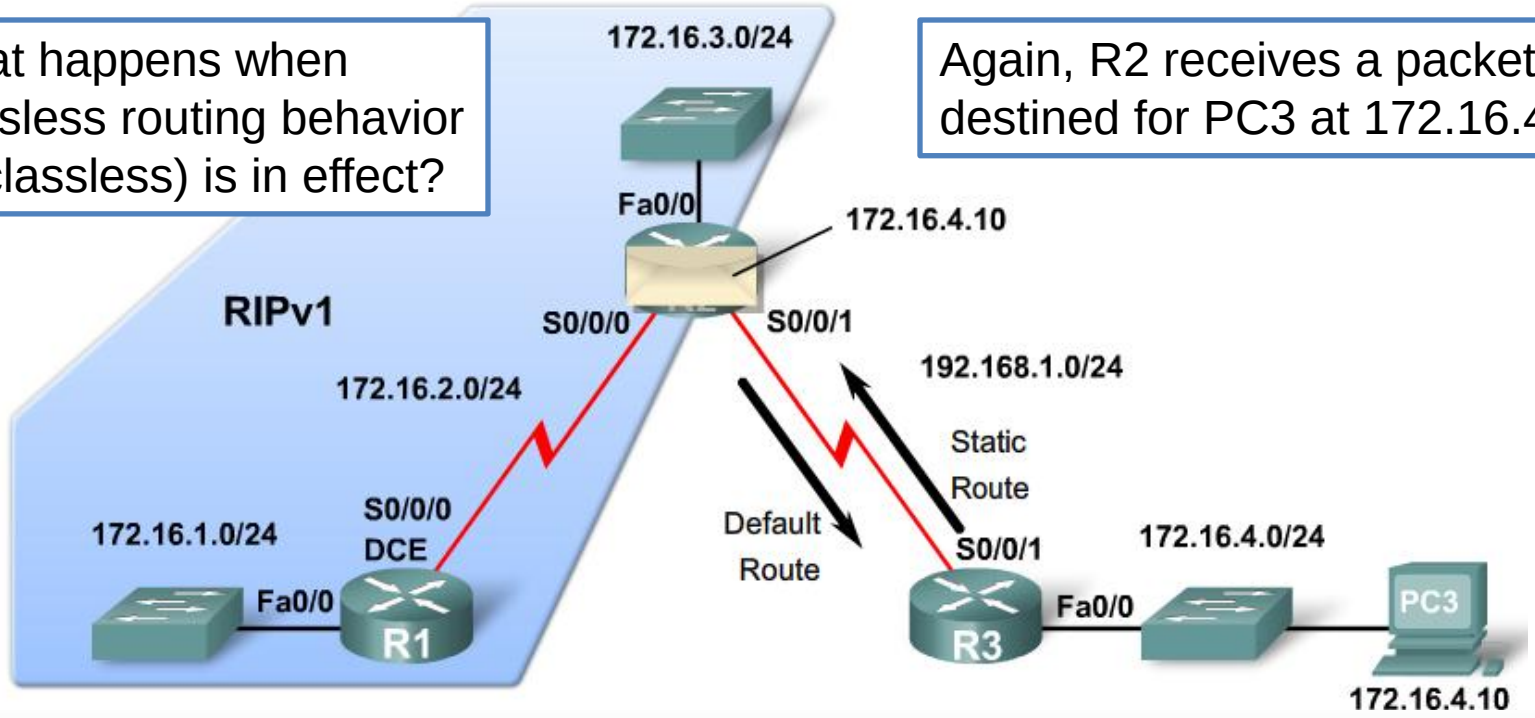


If there is now a lesser match with a level 1 supernet or default routes, the router uses that route to forward the packet.
If there is not a match with any route in the routing table, the router drops the packet.

8.3.5 Classless Routing Behavior – The Search Process

What happens when classless routing behavior (ip classless) is in effect?

Again, R2 receives a packet destined for PC3 at 172.16.4.10.




```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
***output omitted***

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 3 subnets
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:12, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```

Match

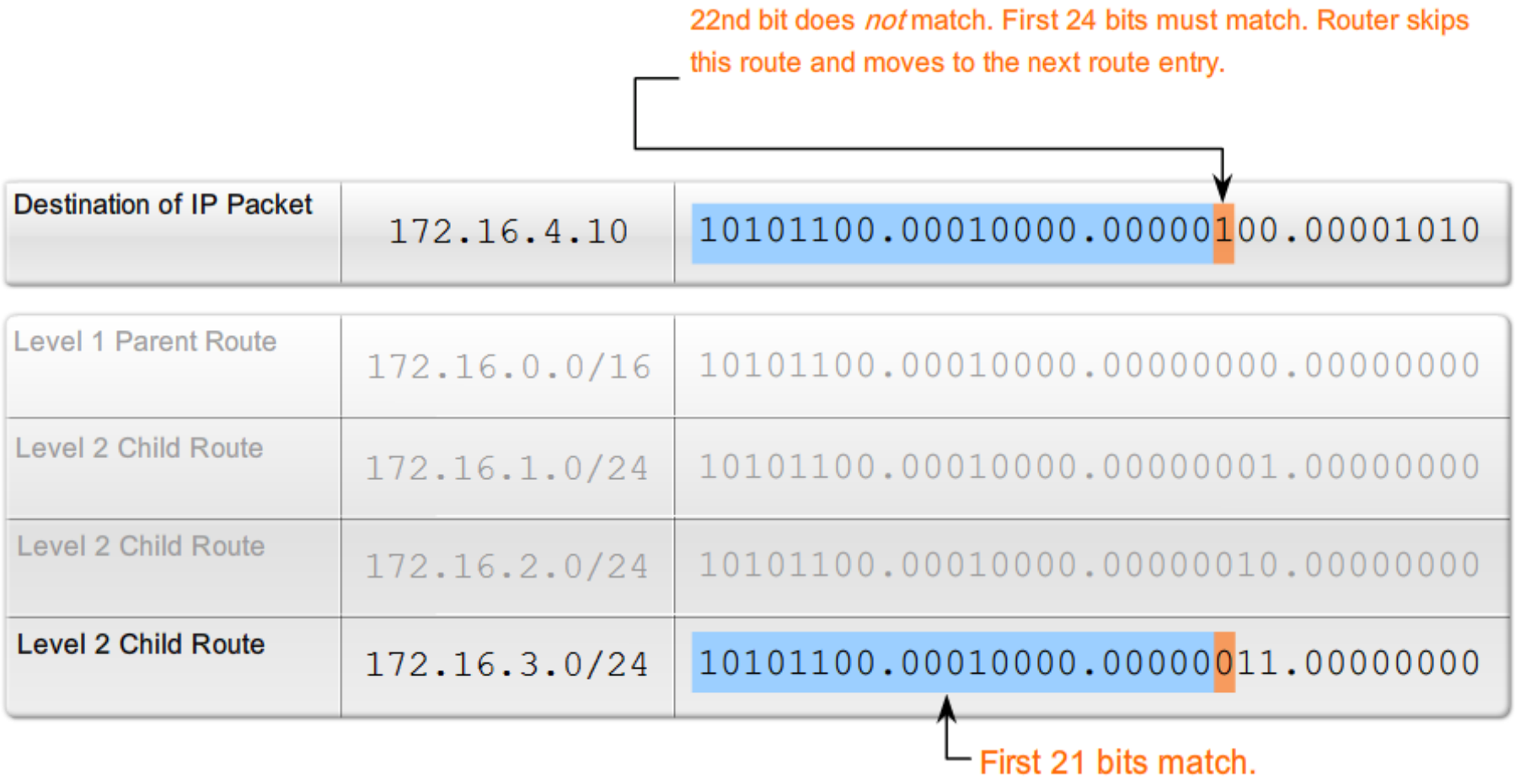
8.3.5 Classless Routing Behavior – The Search Process

Destination matches the parent route. R2 will now check the child routes.

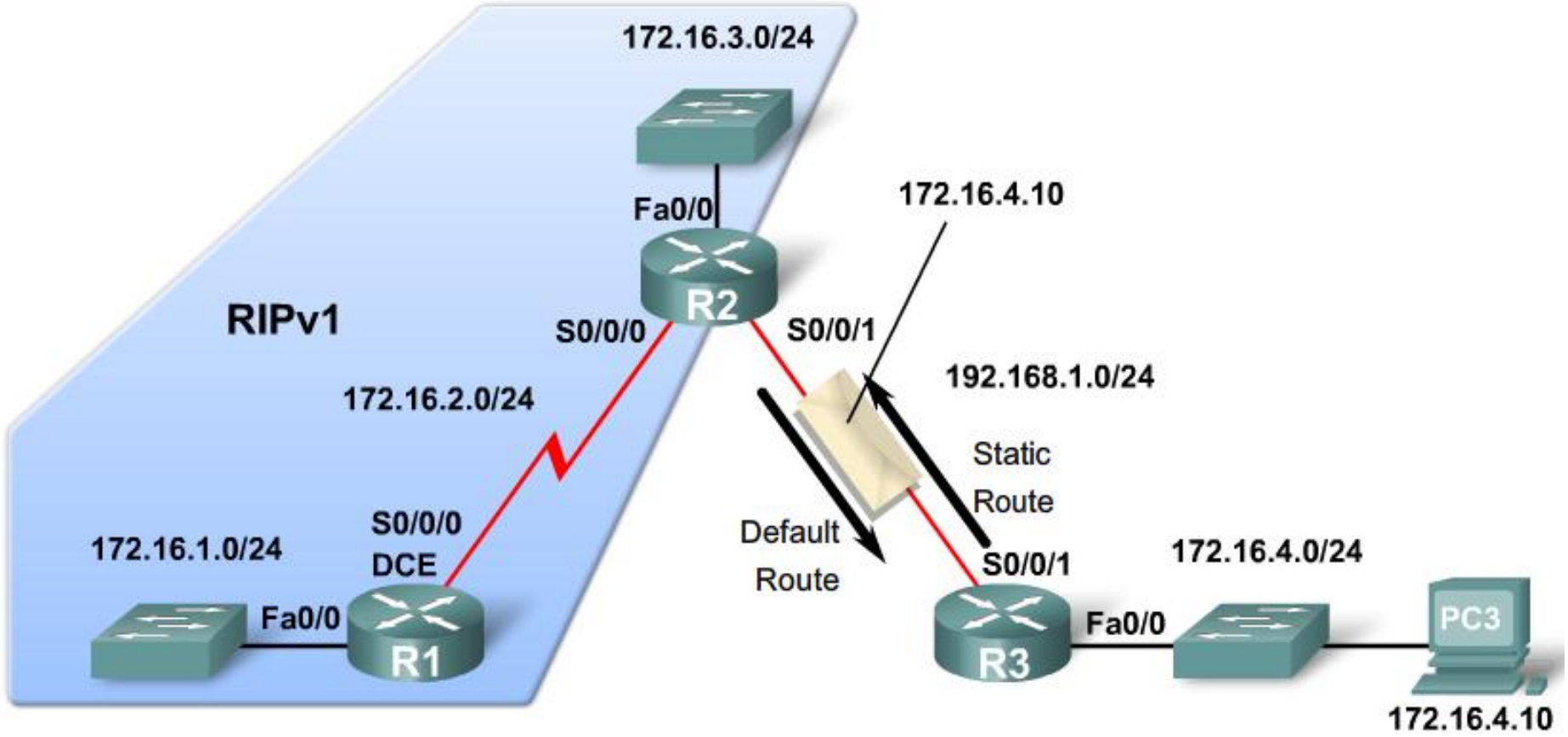
Destination of IP Packet	172.16.4.10	10101100.00010000.00000100.00001010
Level 1 Parent Route	172.16.0.0/16	10101100.00010000.00000000.00000000
Level 2 Child Route	172.16.1.0/24	10101100.00010000.00000001.00000000
Level 2 Child Route	172.16.2.0/24	10101100.00010000.00000010.00000000
Level 2 Child Route	172.16.3.0/24	10101100.00010000.00000011.00000000

Just as it did with the classful routing behavior, the router searches the routing table and finds a 16-bit match with the parent route 172.16.0.0, as shown in the figure. According to Step1b of the routing process, if there is a match with a parent route, then the child routes are checked.

8.3.5 Classless Routing Behavior – The Search Process

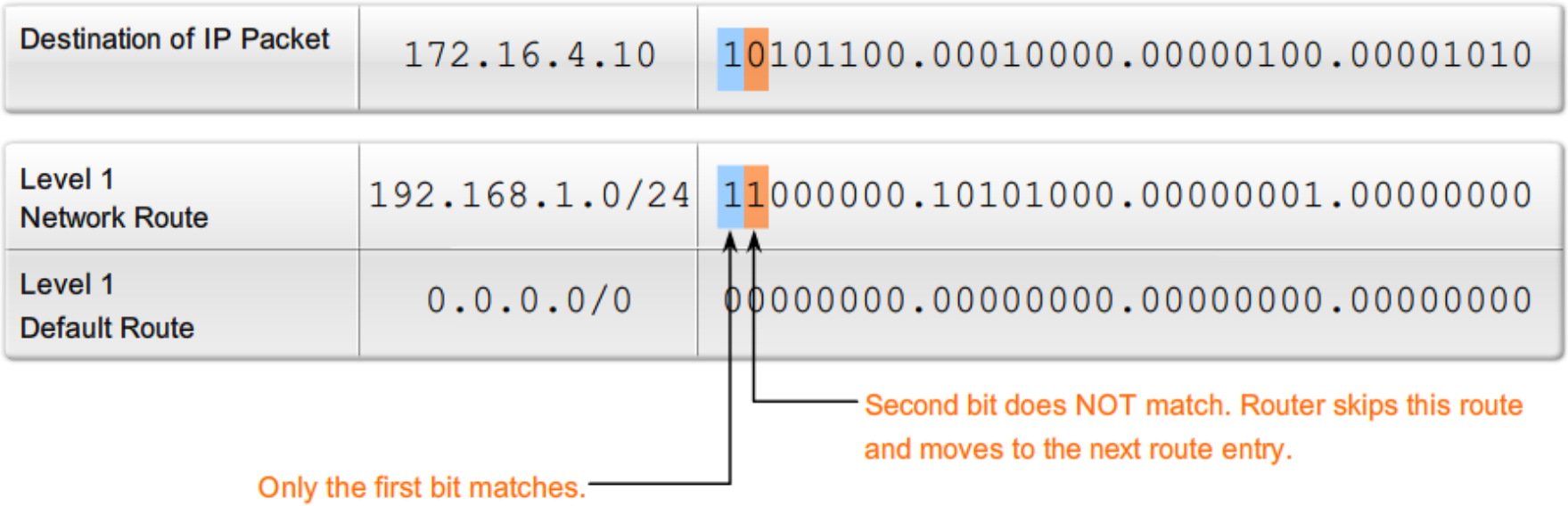


As before, none of the 24 left-most bits of the child routes matches the destination IP address of 172.16.4.10. At most, only 21 bits match. There is no match with the level 2 child routes.



Because we are using classless routing behavior (ip classless), the router continues searching the routing table, beyond this parent route and its child routes. The routing process will continue to search the routing table for a route with a subnet mask fewer than the 16 bits of the previous parent route. In other words, the router will now continue to search the other routes in the routing table where there may be fewer bits that match, but still a match.

8.3.5 Classless Routing Behavior – The Search Process



The 192.168.1.0/24 route does not have 24 left-most bits that match the destination IP address.

C 192.168.1.0/24 is directly connected, Serial0/0/1

8.3.5 Classless Routing Behavior – The Search Process

A /0 mask means that no bits have to match to use the default route. R2 uses the default route and forwards the packet.

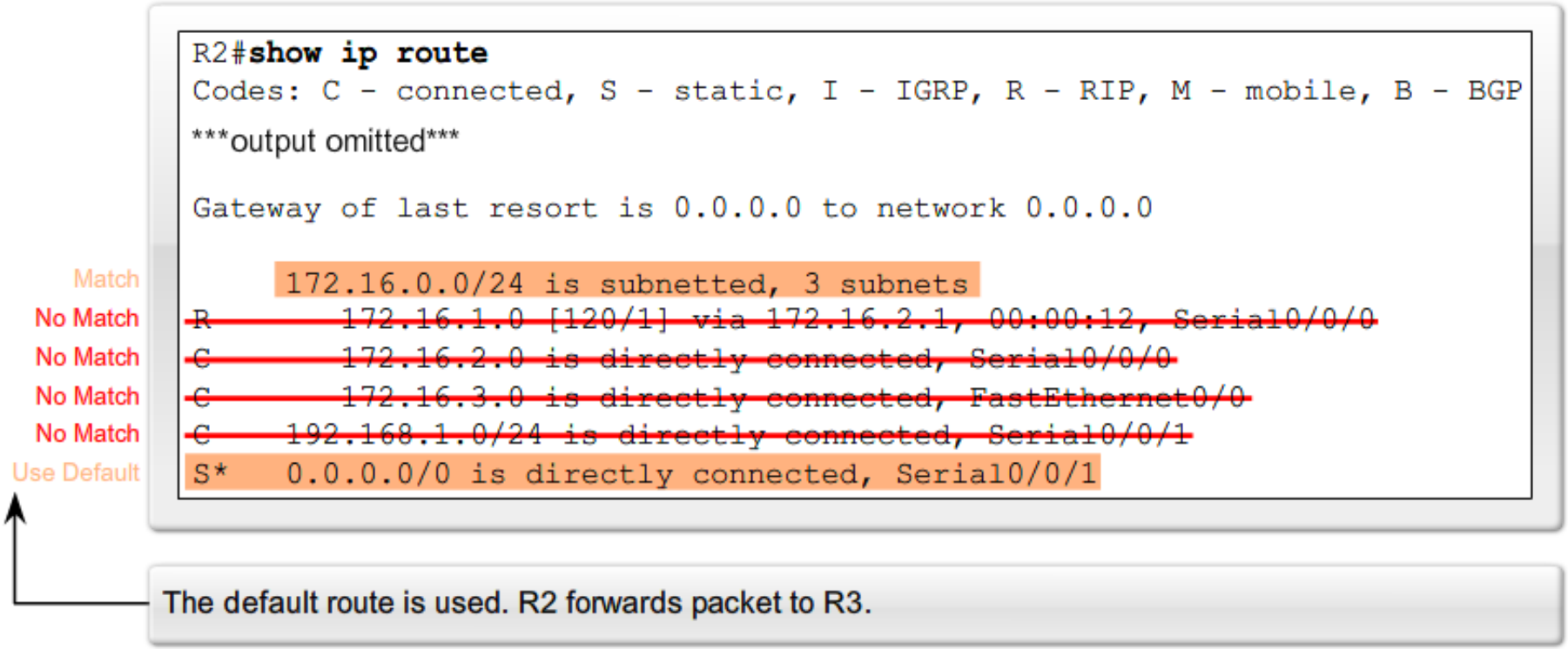
Destination of IP Packet	172.16.4.10	10101100.00010000.00000100.00001010
Level 1 Network Route	192.168.1.0/24	11000000.10101000.00000001.00000000
Level 1 Default Route	0.0.0.0/0	00000000.00000000.00000000.00000000

How about the default route? How many bits need to match?

S* 0.0.0.0/0 is directly connected, Serial0/0/1

The mask is /0, which means that zero or no bits need to match. A default route will be the lowest-bit match. In classless routing behavior, if no other route matches, the default route will match.

8.3.5 Classless Routing Behavior – The Search Process



In this case the router will use the default route, because it is the best match. The packet will be forwarded out the Serial 0/0/1 interface.

Classful Route on R3

8.3.5 Classless Routing Behavior – The Search Process

```
R3#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.4.0/24 is directly connected, FastEthernet0/0
S       172.16.0.0/16 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
```

Match!

No Match

Child Match!

R3 uses the 172.16.0.0/16 child route and forwards the packet to R2.

8.3.5 Classless Routing Behavior – The Search Process

Classful vs. Classless Routing Behavior in the Real World

Routing Protocols vs Routing Behaviors

Routing Sources

- Directly Connected Networks
- Static Routes
- Classful Routing Protocols
  - RIPv1
  - IGRP
- Classless Routing Protocols
  - RIPv2
  - EIGRP
  - OSPF
  - IS-IS

- Routing sources (including protocols) are used to build the routing table.
- Multiple sources and routing protocols can be used.

Routing Behaviors

- Classful
  - `no ip classless`
- IP Classless
  - `ip classless`

- Routing behaviors are used to locate information in the routing table.
- Only a single routing behavior can be used.

8.4.1 Investigating the Routing Table Lookup Process

Hands-on Lab:
Investigating the Routing Table Lookup Process

In this lab, you will be able to investigate classless and classful routing behavior.

Packet Tracer Exploration:
Investigating the Routing Table Lookup Process

In this Packet Tracer activity, you will be able to investigate classless and classful routing behavior.

8.4.2 Show IP Route Challenge Lab

Hands-on Lab:
Show IP Route Challenge Lab

In this lab activity, you will determine the topology of a network using the outputs from the show ip route command. You must draw a topology diagram and determine the interface addressing on each router. Then you must build and configure the network based on the outputs. The DTE and DCE assignment is at your discretion. When complete, the outputs from your network must match those given below.

Packet Tracer Exploration:
The Show IP Route Challenge Lab

In this lab activity, you will determine the topology of a network using the outputs from the show ip route command.

8.5.1 Summary and Review

Route Lookup Process

```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 3 subnets
R       172.16.1.0 [120/1] via 172.16.2.1, 00:00:12, Serial0/0/0
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial0/0/1
S*   0.0.0.0/0 is directly connected, Serial0/0/1
```

In this chapter, you have learned to:

- Describe the various route types found in the routing table structure.
- Describe the route lookup process.
- Describe the routing behavior in routed networks.

8.5.1 Summary and Review

Understanding the structure and lookup process of the routing table can be an important tool in verifying and troubleshooting networks. Knowing which routes should be included and which routes should not be included in the routing table is a critical skill when troubleshooting routing issues.

The Cisco IP routing table is structured in a classful manner, which means that it uses to the default, classful addresses, to organize the route entries. The source of a routing entry can be a directly connected network, static route, or a route learned dynamically from a routing protocol.

In this chapter, you learned that there are level 1 and level 2 routes. A level 1 route can be either an ultimate route or a parent route. A level 1 ultimate route is a route with a subnet mask equal to, or less than the default classful mask of the network; and either a next hop address or an exit interface. For example, a route learned through RIP with the network address of 192.168.1.0 and a /24 network mask is a level 1 ultimate route. These routes are displayed in the routing table as a single route entry, such as:
R 192.168.1.0/24 [120/1] via 172.16.2.2, 00:00:25, Serial0/0/0

8.5.1 Summary and Review

Another type of level 1 route is a parent route. A level 1 parent route is automatically created when a subnet route is added to the routing table. The subnet route is known as a level 2 child route. The parent route is a header for level 2 child routes. Here is an example of a level 1 parent route and a level 2 child route:

172.16.0.0/24 is subnetted, 1 subnets
R 172.16.1.0 [120/1] via 172.16.2.1, 00:00:07, Serial0/0/0

The subnet mask of the child routes are displayed in the parent route unless VLSM is used. With VLSM, the parent route displays the default classful mask and the subnet mask is included with the individual VLSM route entries.

You were also introduced to the routing table lookup process in this chapter. When a packet is received by the router, it looks for the longest match with one of the routes in the routing table. The longest match is the route with the largest number of left-most bits that match between the destination IP address of the packet and the network address of the route in the routing table. The subnet mask associated with the network address in the routing table defines the minimum number of bits that must match for that route to be a match.

8.5.1 Summary and Review

Before examining any level 2 child routes (subnets) for a match there must first be a match with the level 1 parent route. The classful mask of the parent determines how many bits must match the parent route. If there is a match with the parent route, then the child routes will be searched for a match.

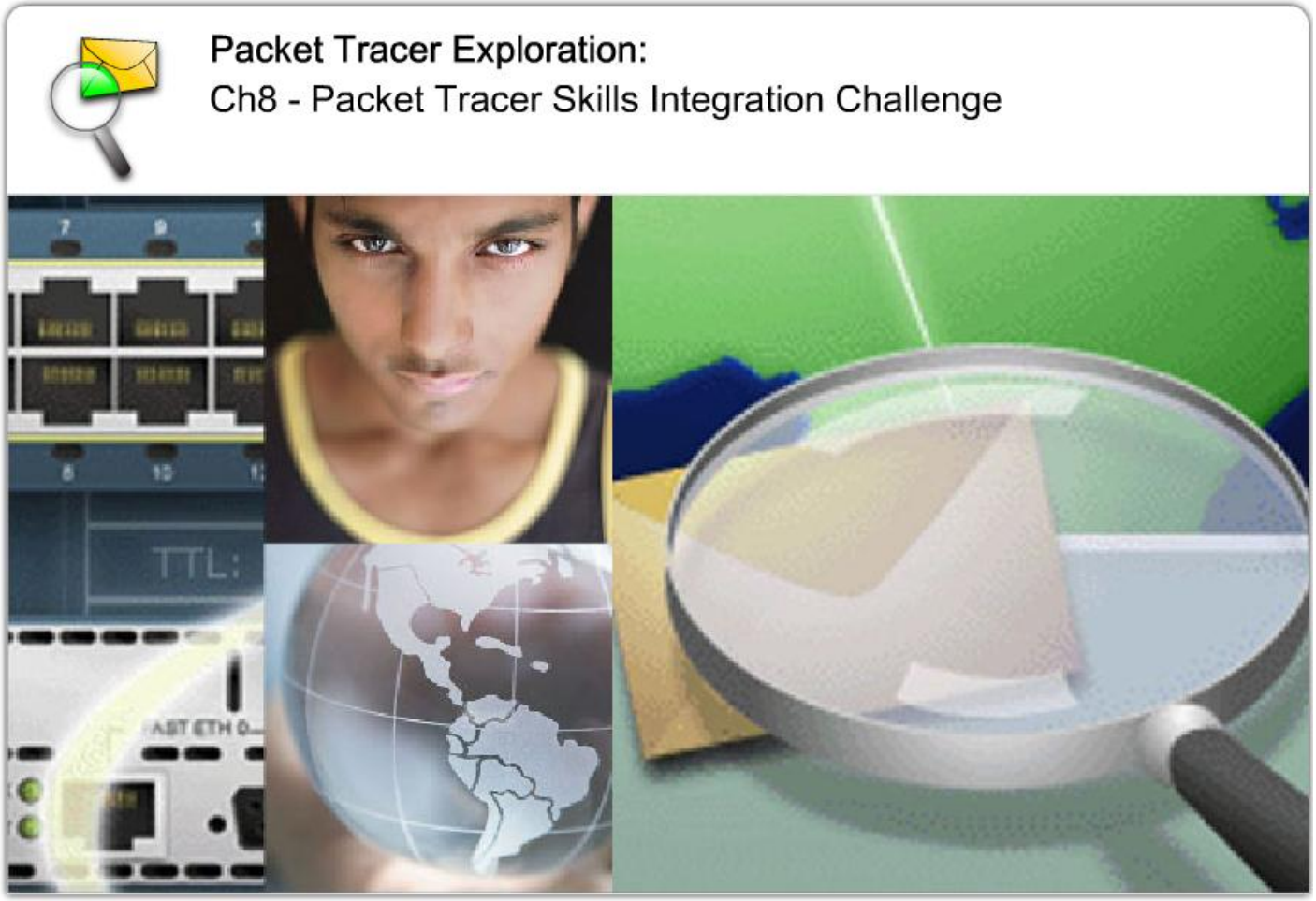
What happens when there is a match with the parent route but none of the child routes? If the router is using classful routing behavior, no other routes will be searched and the packet will be discarded. Classful routing behavior was the default routing behavior on Cisco routers prior to IOS 11.3. Classful routing behavior can be implemented using the no ip classless command.

8.5.1 Summary and Review

Starting with IOS 11.3 classless routing behavior became the default. If there is a match with a parent route but none of the child routes, the routing table process will continue to search other routes in the routing table including a default route should one exist. Classless routing behavior is implemented by using the ip classless command.

Routes to networks get added to the routing table from various sources including directly connected networks, static routes, classful routing protocols and classless routing protocols. The lookup process, classful or classless routing behavior, is independent of the source of the route. A routing table may have routes learned from a classful routing protocol such as RIPv1, but uses classless routing behavior, no ip classless, for the lookup process

8.5.1 Summary and Review

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