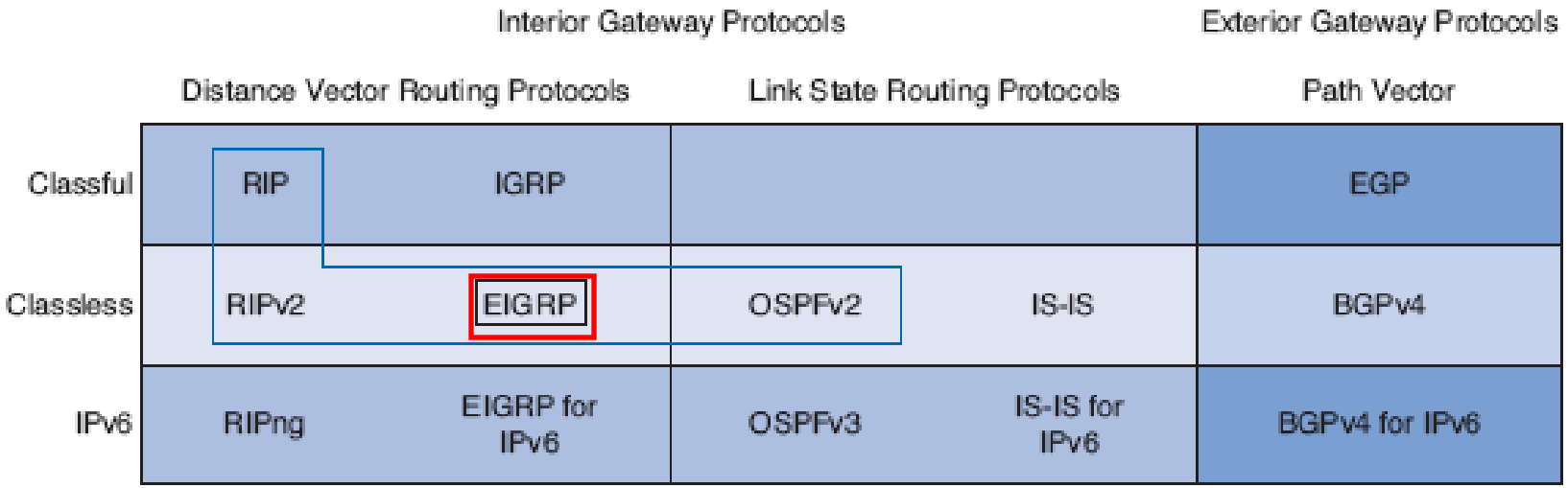
EIGRP

Module 1

Introduction to EIGRP



- Enhanced Interior Gateway Routing Protocol (EIGRP)
  - Distance vector
  - Classless routing protocol
- Released in 1992 with Cisco IOS Software Release 9.21.
- Enhancement of Cisco Interior Gateway Routing Protocol (IGRP).
- Both are Cisco proprietary
  - Operate only on Cisco routers.

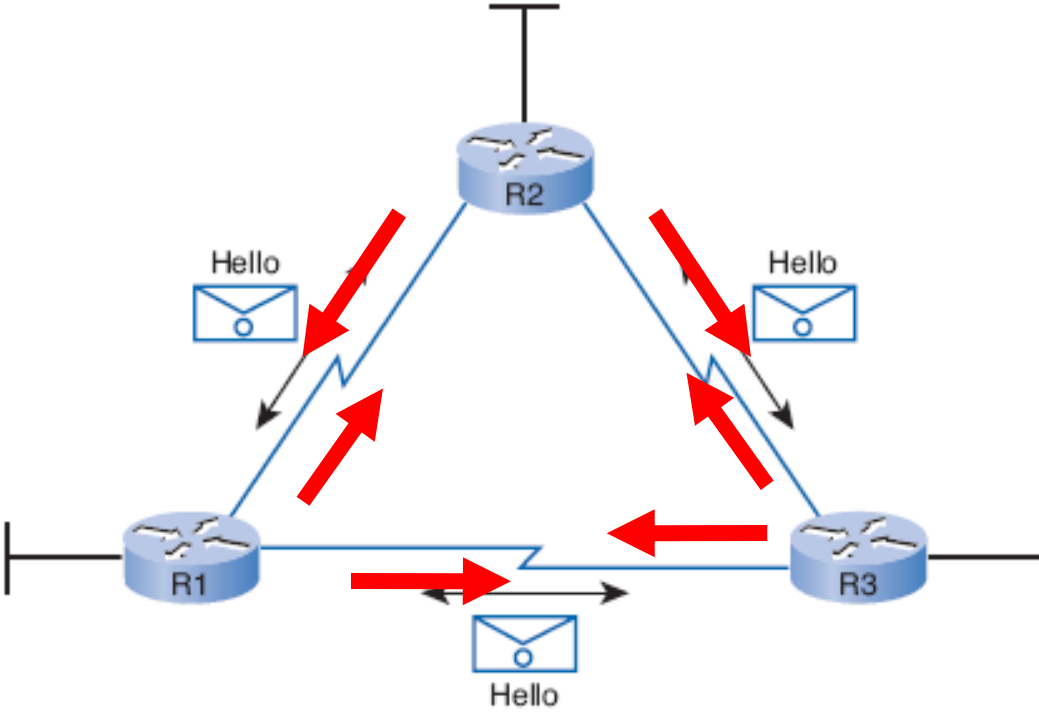
Principle Components of EIGRP

- **Protocol Dependent Modules (PDM)**
  - EIGRP supports several routed protocols independently.
  - Ex: IPv4 and IPv6
- **Reliable Transport Protocol (RTP)**
  - RTP sends uses both reliable and unreliable transport
  - Reliable
    - ACK is returned
    - EIGRP Queries, Updates and Replies
  - Unreliable
    - No ACK
    - EIGRP Hellos, and ACKs
- **Neighbor Discovery and Recovery**
  - Identify neighbors
  - Recognize when neighbor is down
- **Diffusing Update Algorithm (DUAL)**
  - Process for analyzing list of available paths, selecting best paths, and feasible fail-over routes,

RTP Packet Types

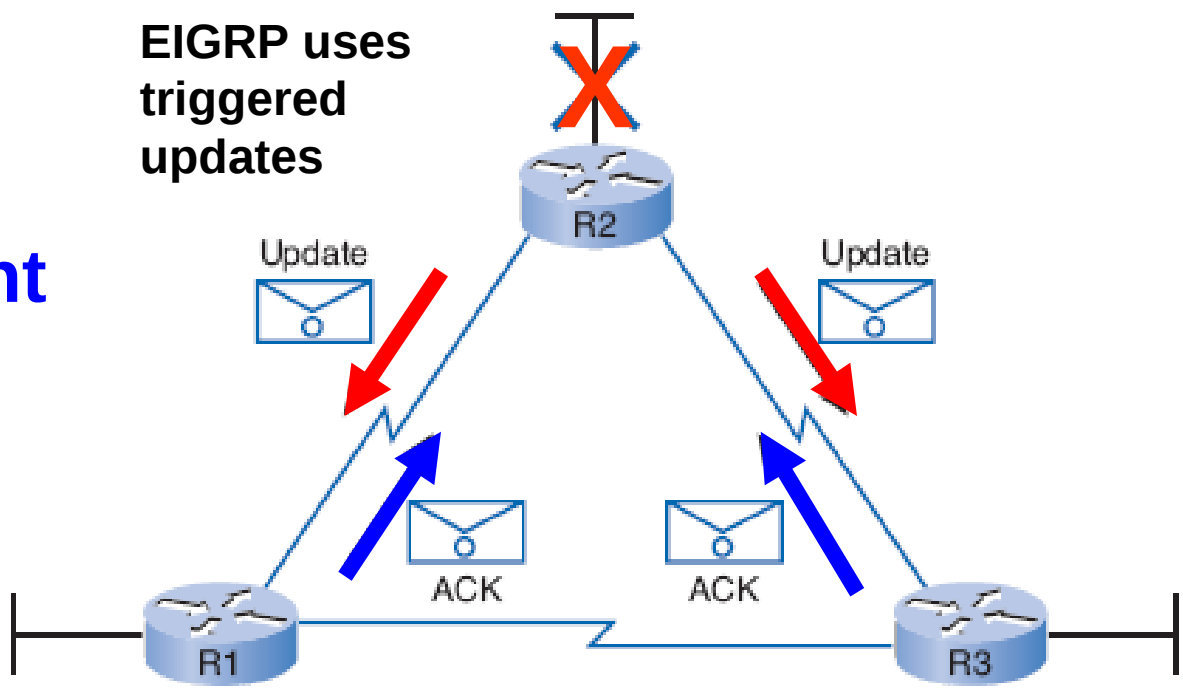
- **Hellos**
  - Identifies neighbors
- **Acknowledgements (ACK)**
  - Acknowledges receipt
- **Updates**
  - Advertises routes
- **Queries**
  - Ask about a route (DUAL)
- **Replies**
  - Answer a query (DUAL)

Hello Packet



- **Hello packets** are used by EIGRP to:
  - **Discover neighbors**
  - **Form adjacencies** with those neighbors
- EIGRP hello packets:
  - multicasts
  - unreliable delivery

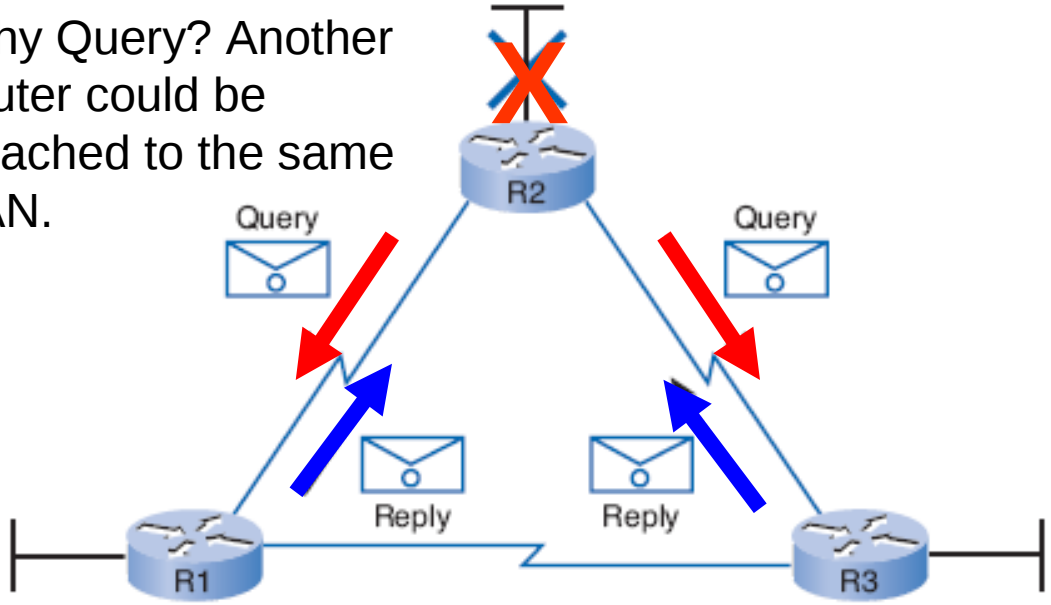
Update and Acknowledgement Packets



- **Update Packets**
  - Transmitted only when necessary
  - Unicast when sent to a specific router
  - Multicast when sent to multiple routers
  - Reliable delivery
- **Acknowledgment (ACK) Packets**
  - Hello packets with no data
  - Sent when reliable delivery is used (update, query, and reply packets).
  - Sent as an unreliable unicast.

Query and Reply Packets

Why Query? Another router could be attached to the same LAN.



Query Packet

- Used by DUAL when searching for networks or other tasks. Reply packet.
- Automatically sent in response to query packet acknowledgement (ACK) packet.
- Automatically sent back when reliable RTP is used.

- Used by **DUAL** when searching for networks and other tasks.
- **Queries** and **replies** use reliable delivery.
  - To keep this example simple, acknowledgments were omitted in the graphic.
  - All neighbors must send a reply regardless of whether they have a route to the downed network.
- **Queries**: multicast or unicast,
- **Replies** : unicast

Summary - RTP Packet Types

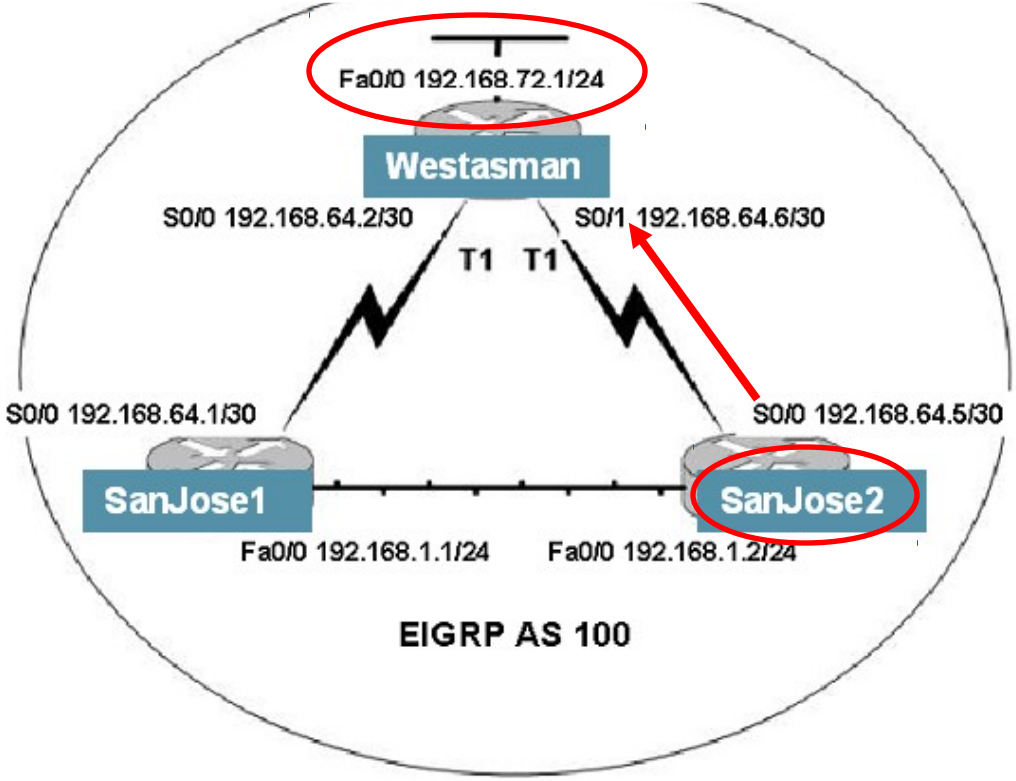
- **Hellos – Identifies neighbors**
  - Used by the neighbor discovery and recovery process.
  - Multicast
  - Unreliable delivery
- **Acknowledgements (ACK) – Acknowledges receipt**
  - Hello packets with no data
  - Unicast
  - Unreliable delivery
- **Updates – Advertises routes**
  - Transmitted only when necessary
  - Unicast when sent to a specific router
  - Multicast when sent to multiple routers
  - Reliable delivery
- **Queries – Ask about a route (DUAL)**
  - Reliable delivery
  - Multicast or Unicast
- **Queries and Replies – Ask about a route and answer a query (DUAL)**
  - Reliable delivery
  - Replies: Unicast

Forming Neighbor Adjacencies

- The following are the most common causes of problems with EIGRP neighbor relationships:
  - Unidirectional link
  - Uncommon subnet, primary, and secondary address mismatch
  - Mismatched masks
  - K value mismatches
  - Mismatched AS numbers
  - Stuck in active
  - Layer 2 problem
  - Access list denying multicast packets
  - Manual change (summary router, metric change, route filter)

Metric

How does SanJose2 calculate the cost for this route?




```
SanJose2#show ip route
D    192.168.72.0/24 [90/2172416]
           via 192.168.64.6, 00:28:26, Serial0
```

Administrative Distance / Metric

DUAL Concepts

- **Diffusing Update Algorithm** is the algorithm used by EIGRP.
- Determines:
  - best loop-free path
  - loop-free backup paths (which can be used immediately)
- DUAL also provides the following:
  - Fast convergence
  - Minimum bandwidth usage with bounded updates
- DUAL uses several terms that are discussed in more detail throughout this section:
  - **Successor**
  - **Feasible distance**
  - **Feasible successor**
  - **Reported distance** or advertised distance
  - **Feasible condition** or feasibility condition

Successors and Feasible Successors

Feasible distance (FD) is the minimum distance (metric) along a path to a destination network.

Reported distance (RD) is the distance (metric) towards a destination as advertised by an upstream neighbor. Reported distance is the distance reported in the queries, the replies and the updates.

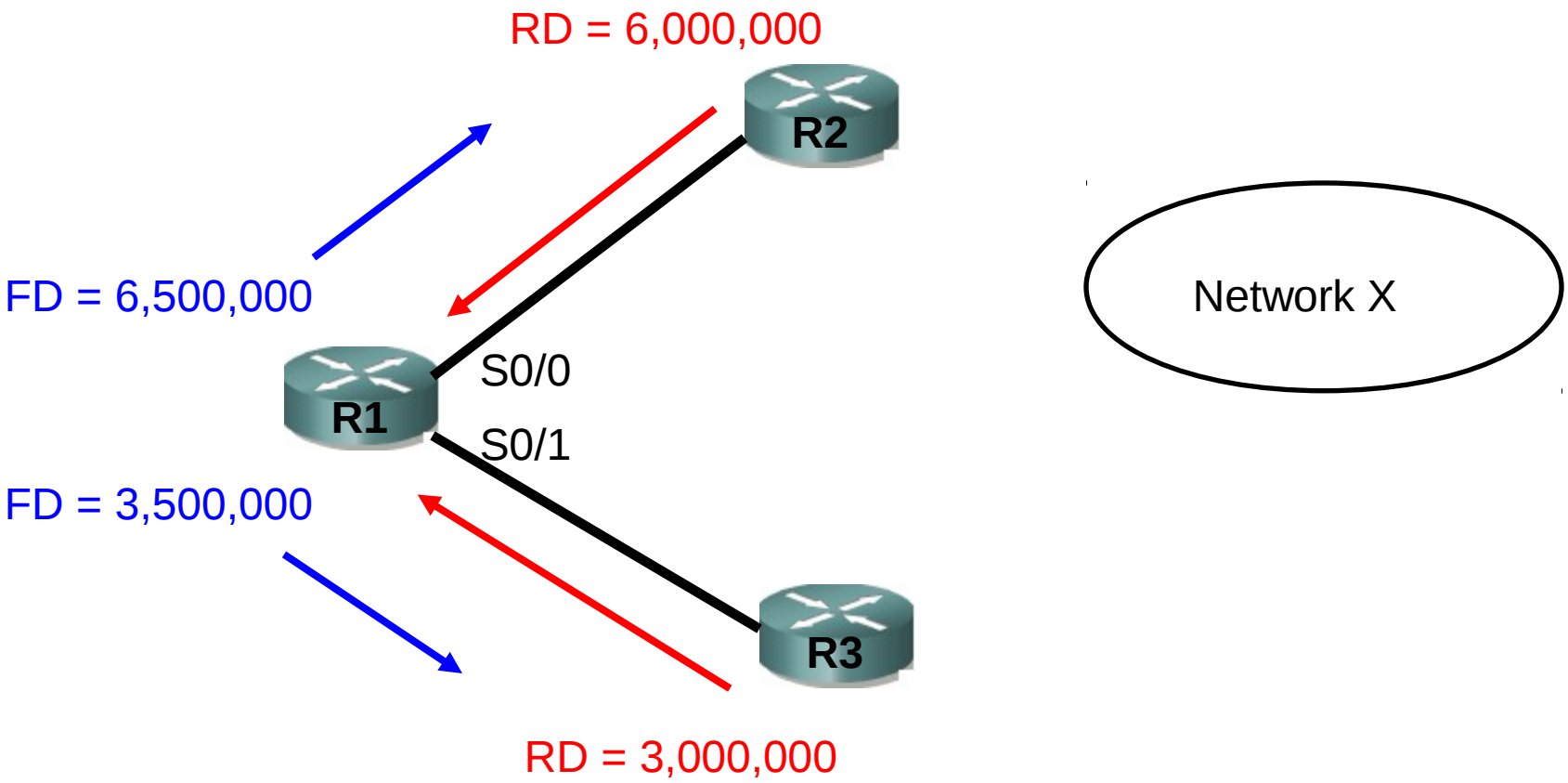
A neighbor meets the **feasible condition (FC)** if the reported distance by the neighbor is less than the current feasible distance (FD) of this router. "If a neighbors metric is less than mine, then I know the neighbor doesn't have a loop going through me."

A **feasible successor** is a neighbor whose reported distance (RD) is less than the current feasible distance (FD). Feasible successor is one who meets the feasible condition (FC).

Your route (metric) to the network (RD to me) must be LESS than my current route (my total metric) to that same network. If your route (metric) to the network (RD to me) is LESS than my current route (my total metric), I will include you as a **FEASIBLE SUCCESSOR**.

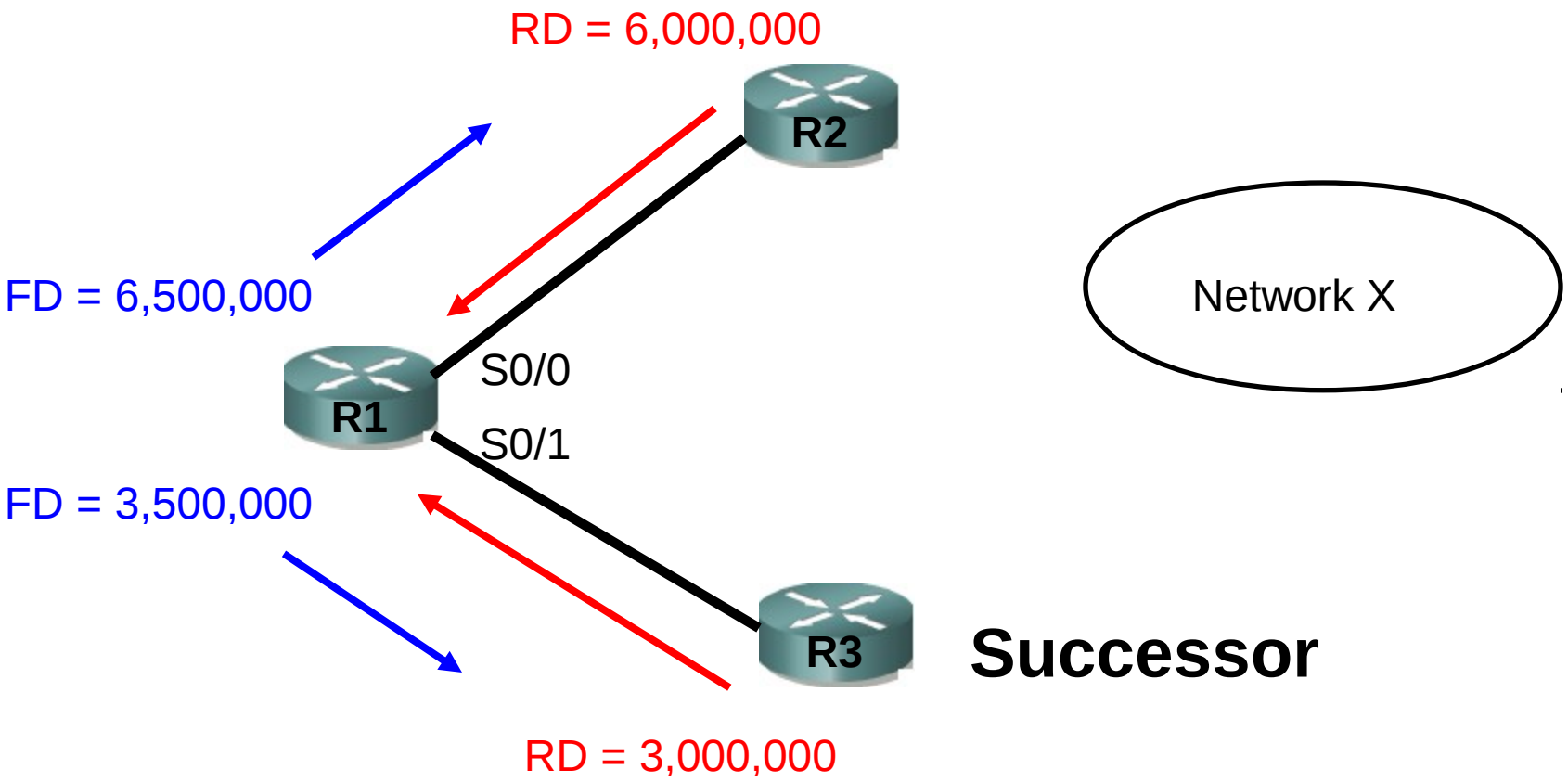
If your route (metric) to the network (RD to me) is MORE than my current route (my total metric), I will **NOT** include you as a **FEASIBLE SUCCESSOR**.

Example 1: Best Path (Successor)? Feasible Successor?



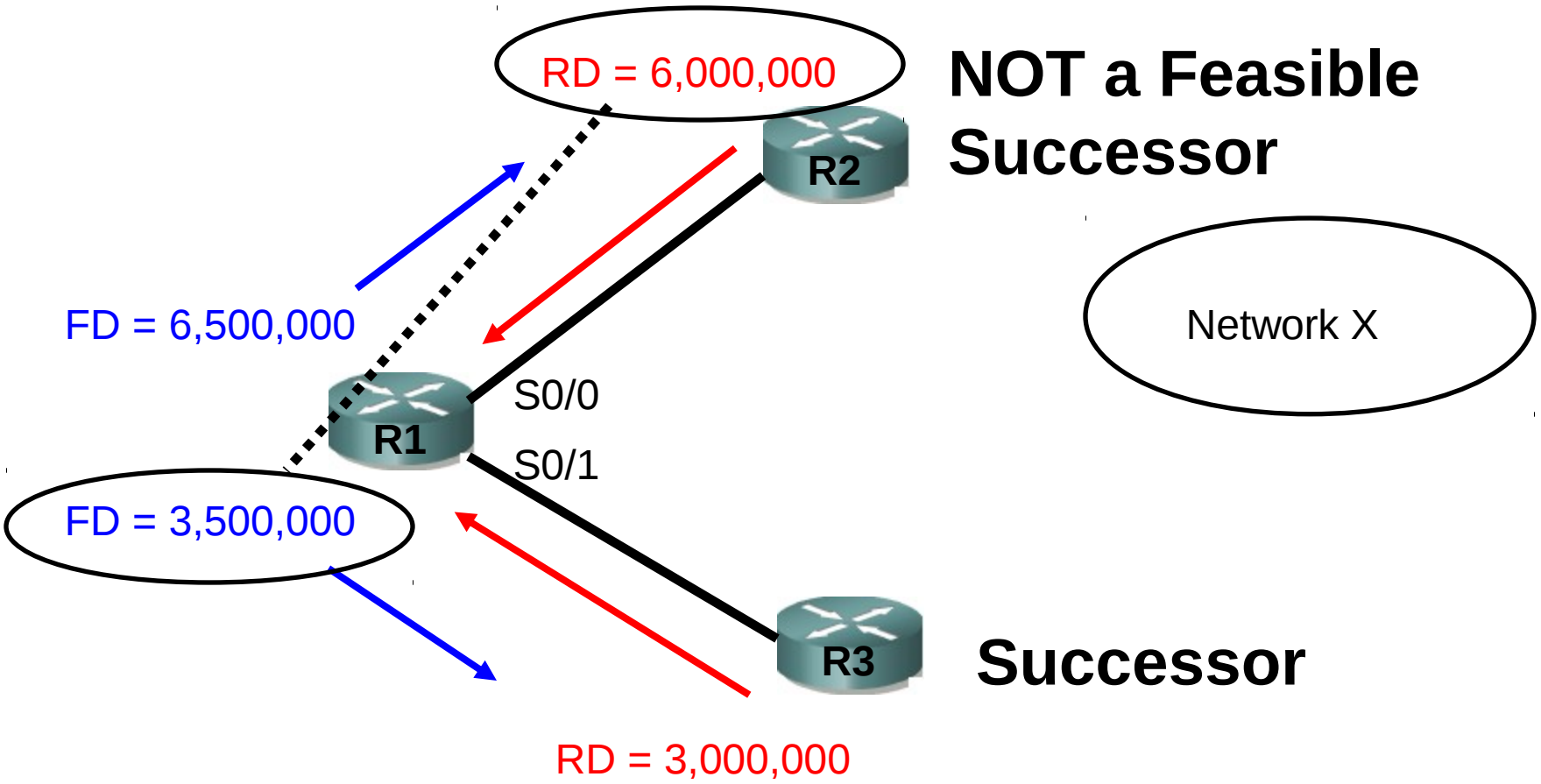
- FD = RD + additional Delay of serial link between R1 and neighbor. (This could also be due the slowest bandwidth.)

Example 1



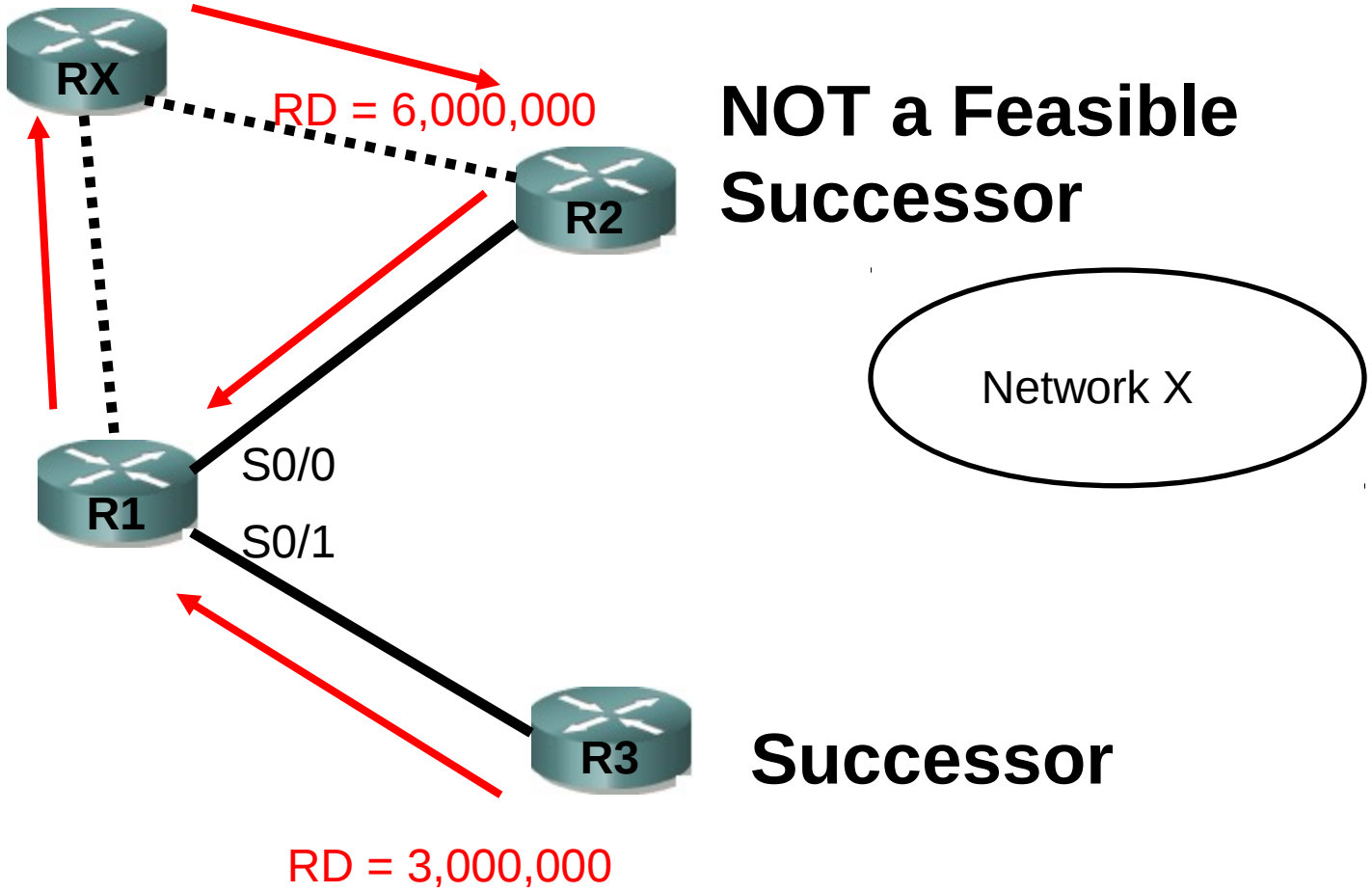
- FD of 3,500,000 is the metric for network X in the routing table for R1.

Example 1



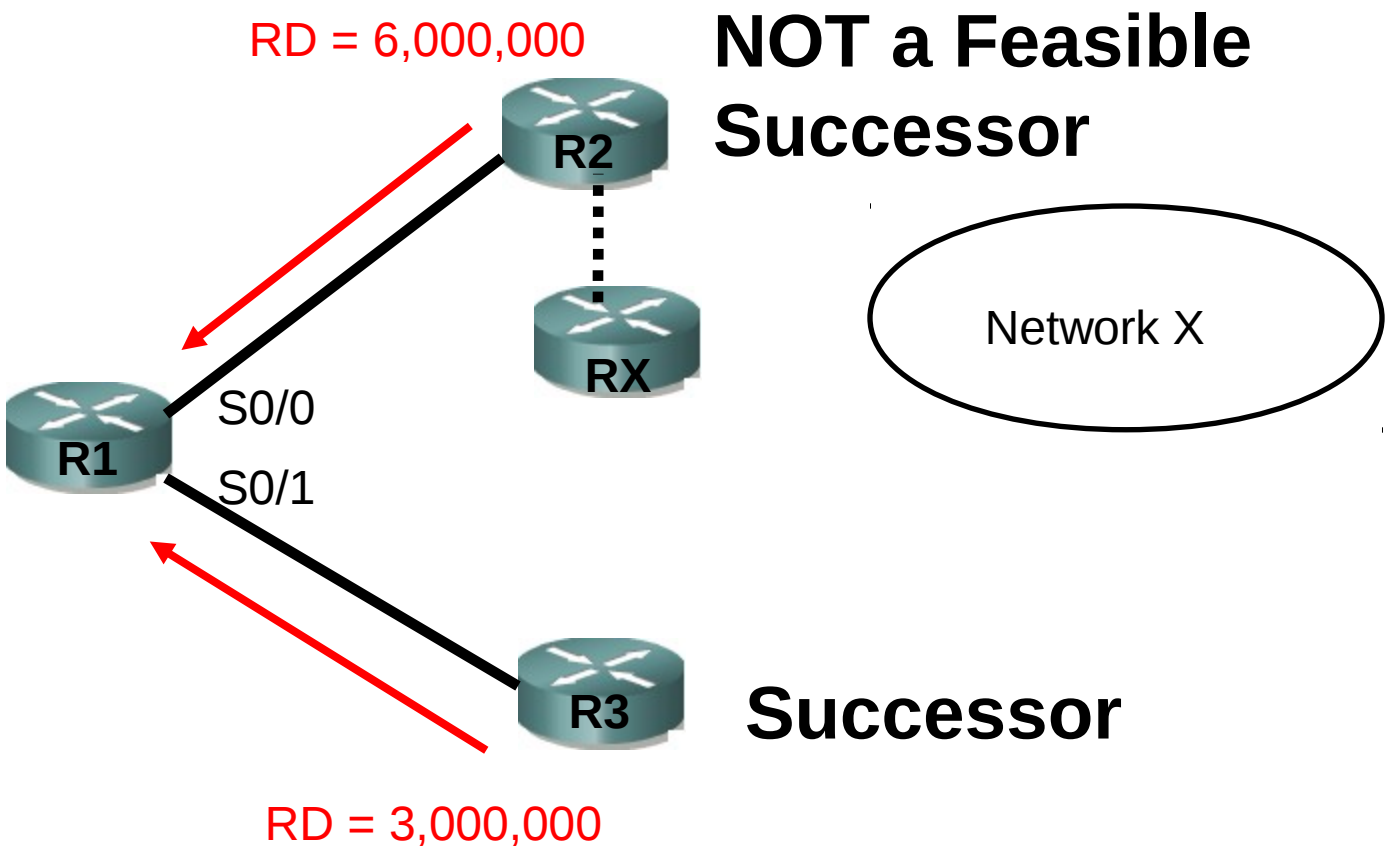
- RD of R2 is greater than FD through R3.
- Does not meet FC.
- No FS.

Example 1



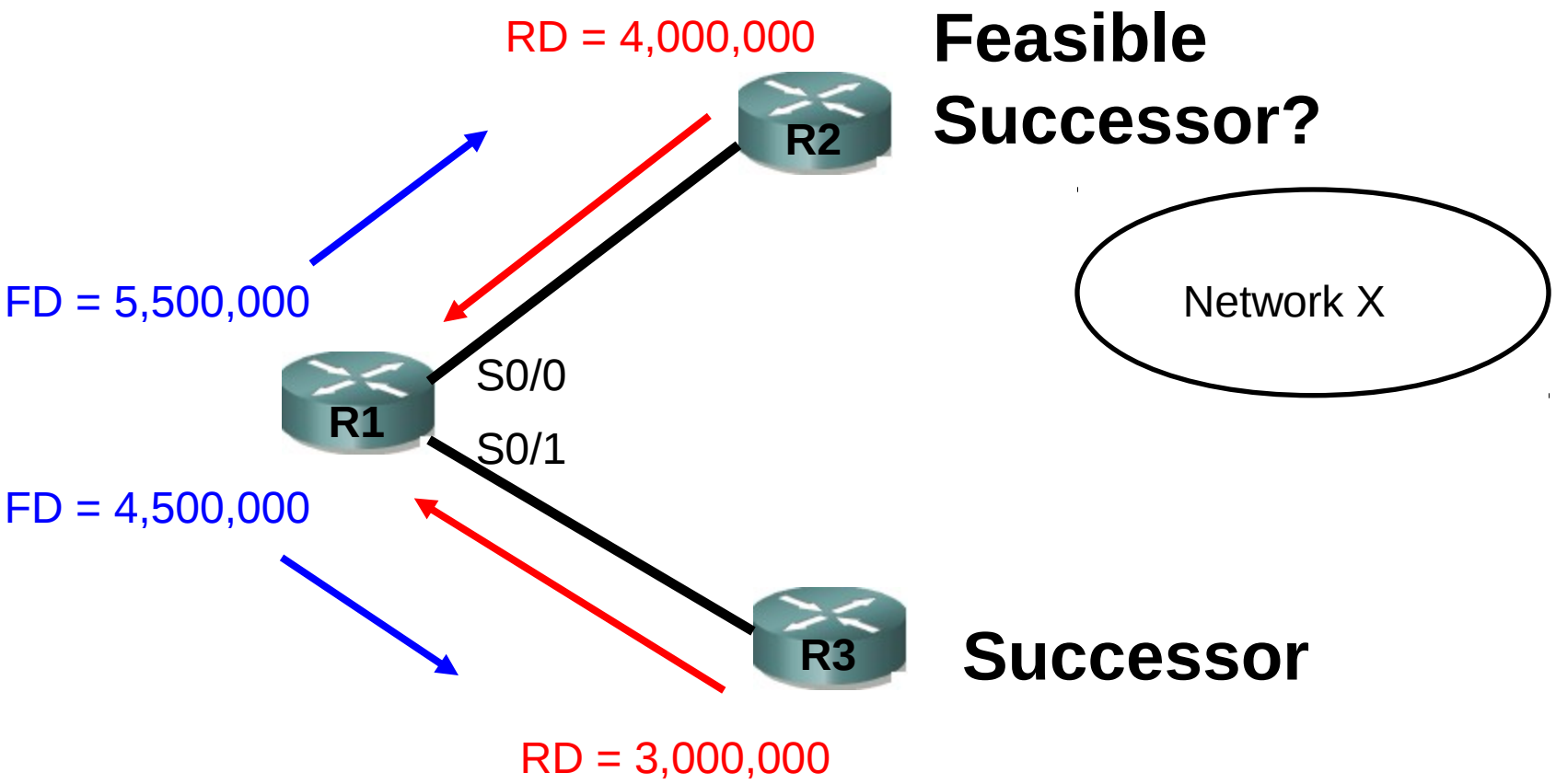
- Maybe R2's path to Network X includes R1 - Loop

Example 1



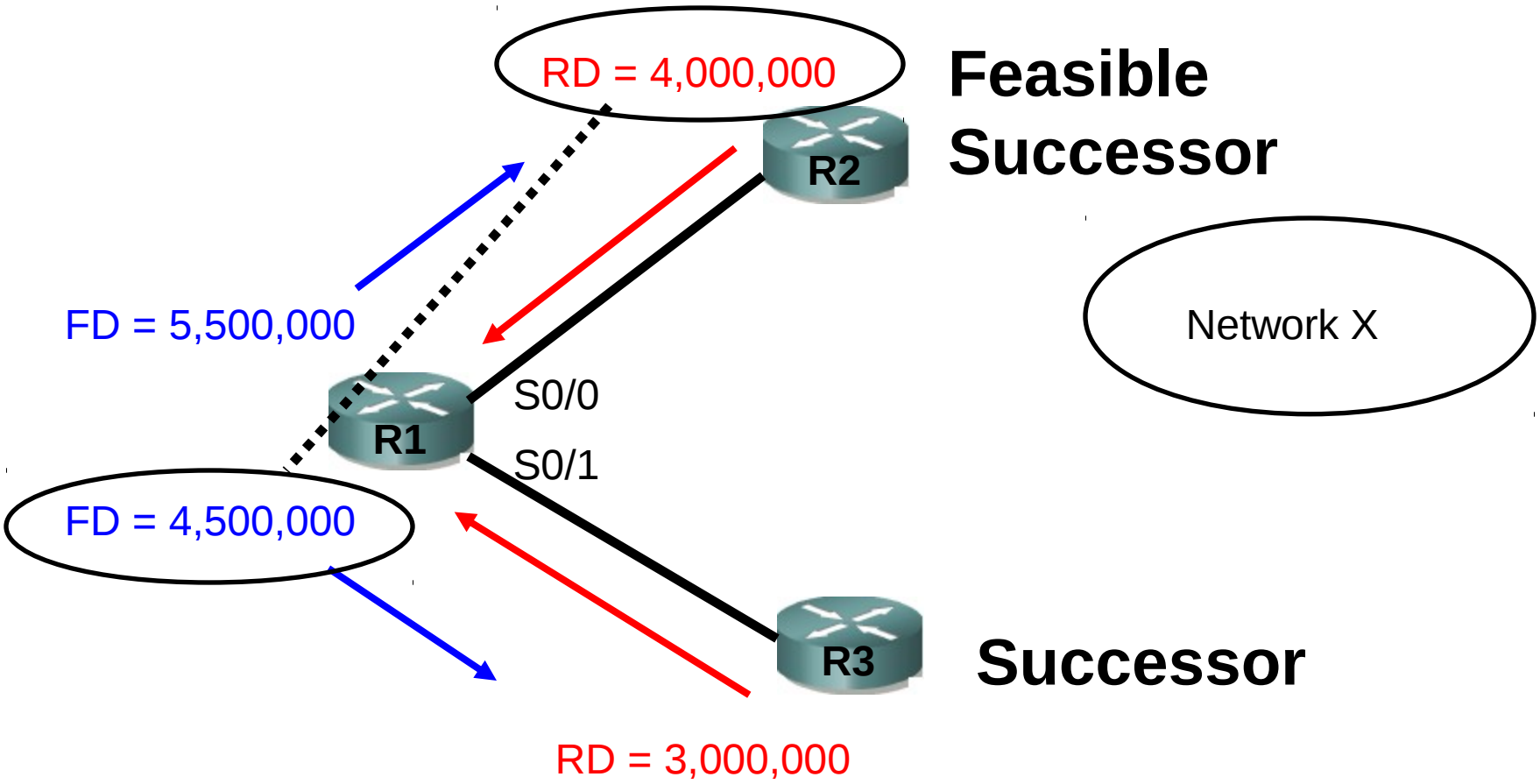
- Or maybe R2's does have a valid path to Network X.
- But R1 can't tell because the distance vector update only gives it distance and direction.

Example 2: Best Path (Successor)? Feasible Successor?



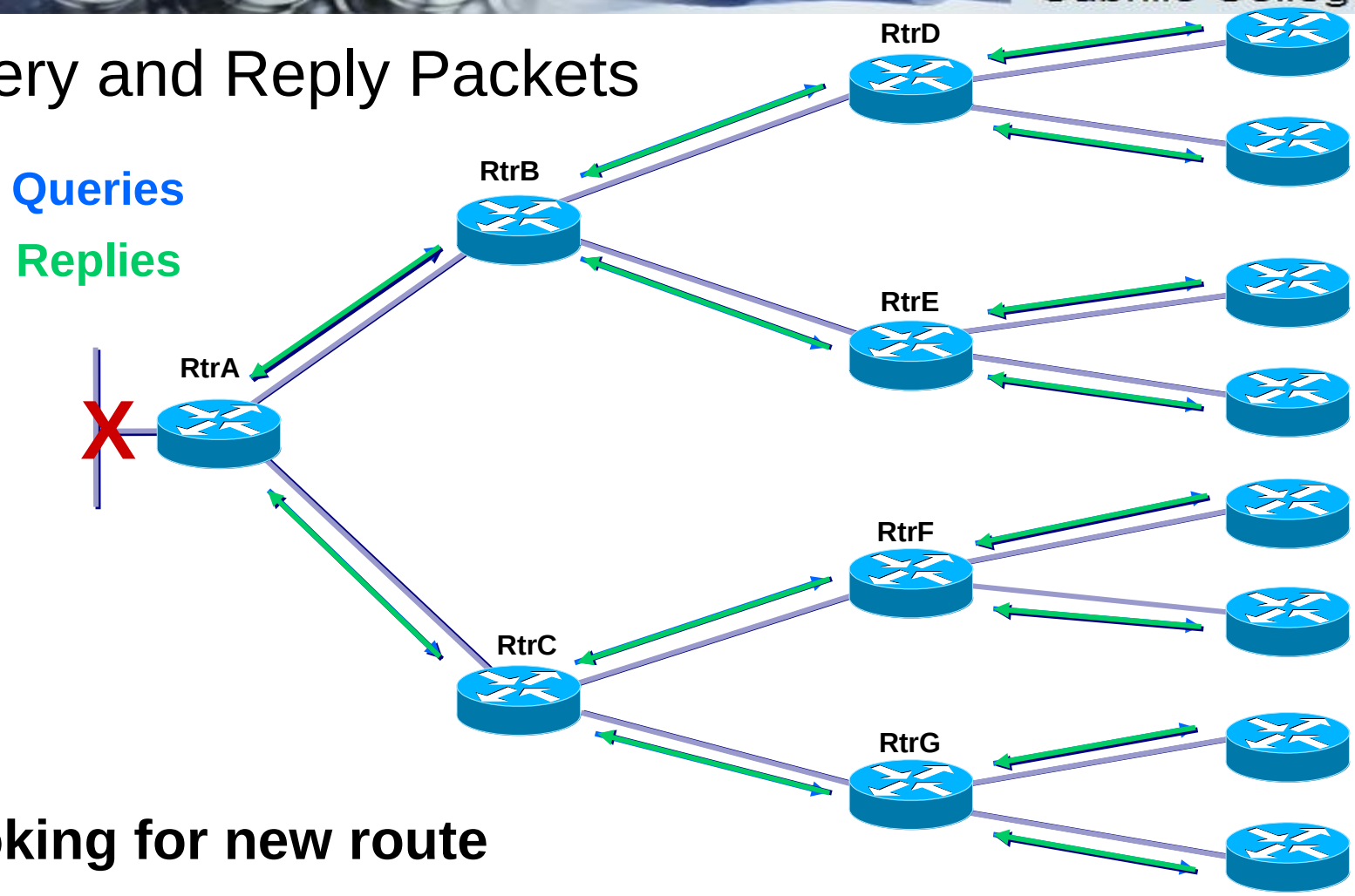
- FD = RD + additional Delay of serial link between R1 and neighbor. (This could also be due the slowest bandwidth.)

Example 2



- RD of R2 is less than (or equal to) the FD through R3.
- Meets FC, there is no loop back through R1.
- Is a FS.

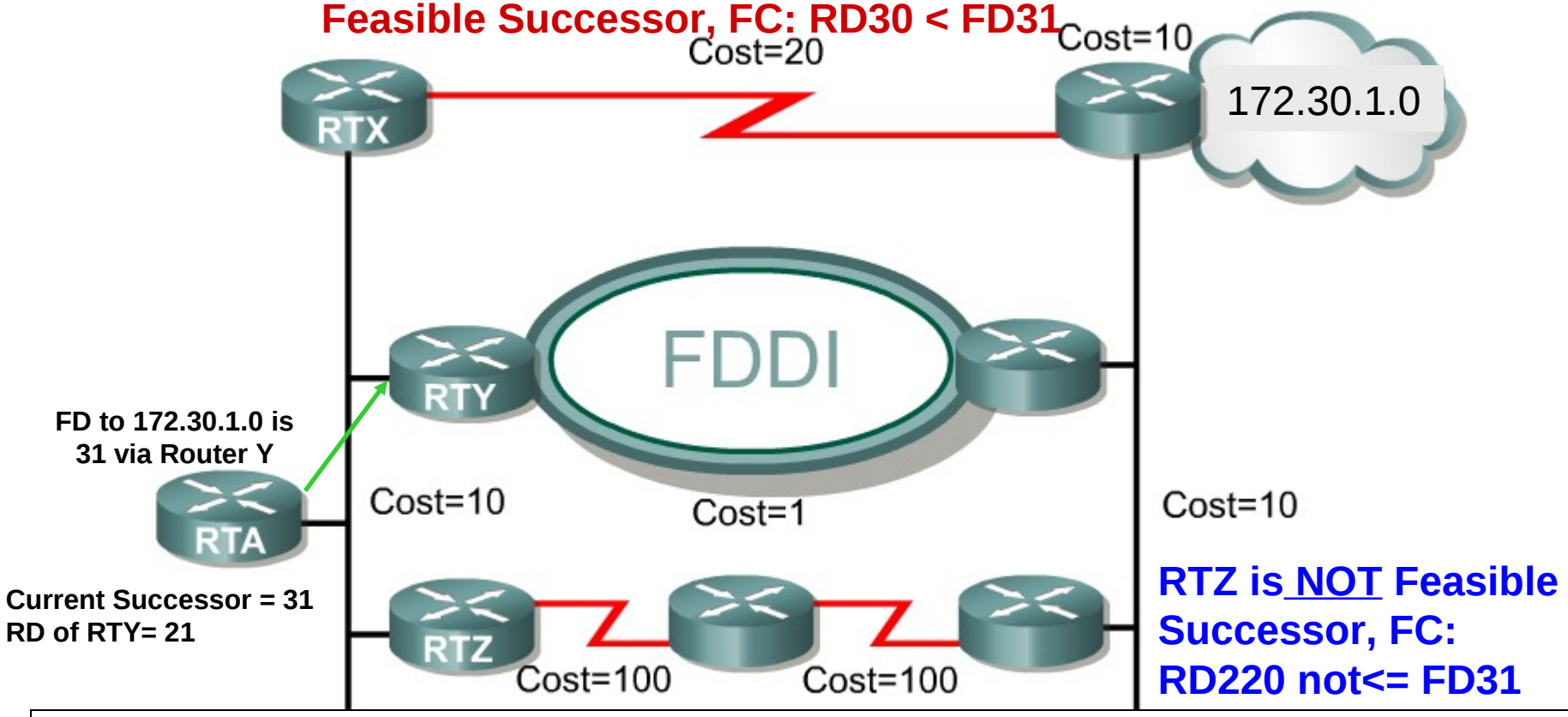
Query and Reply Packets



Looking for new route

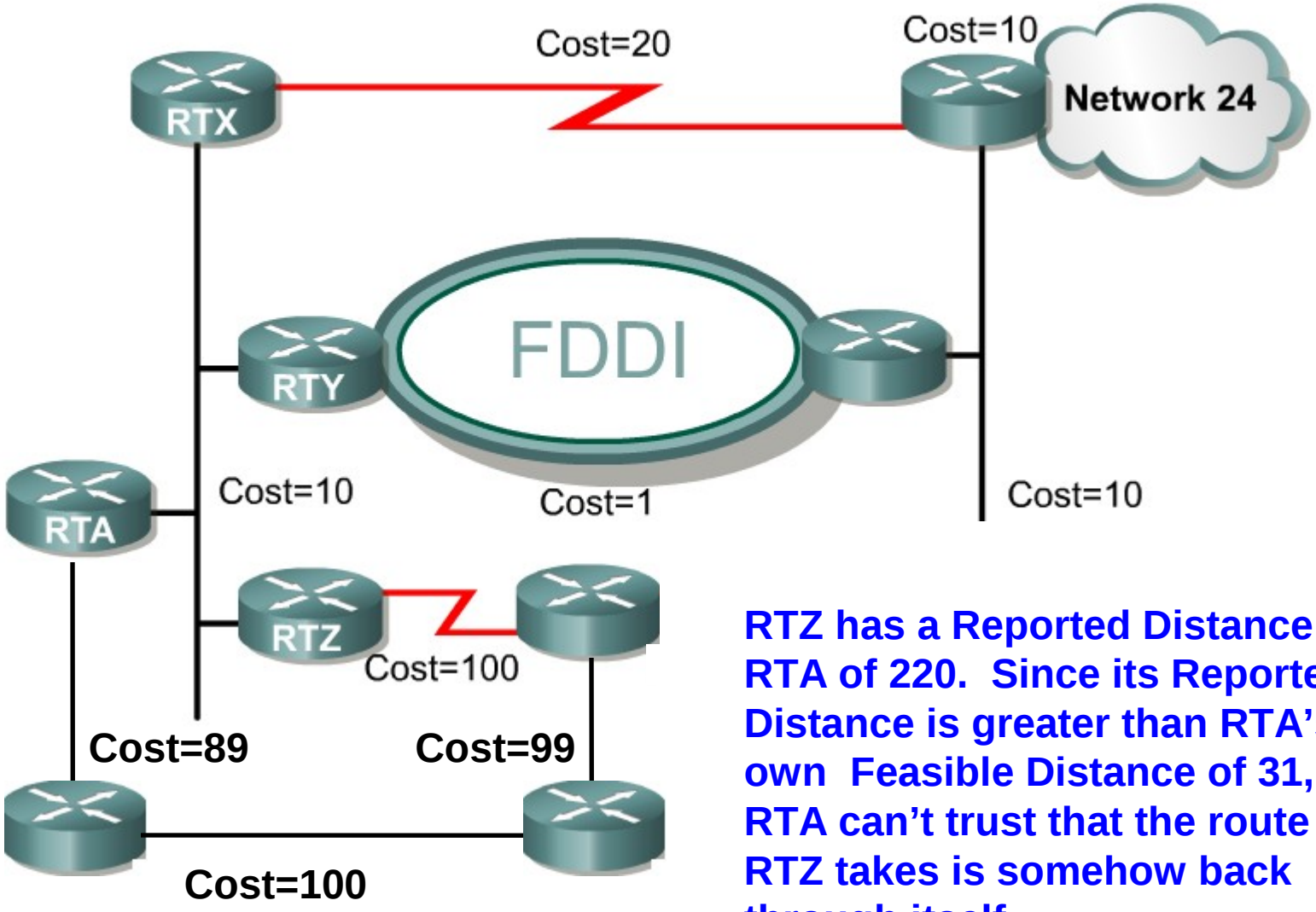
- If there are no Feasible Successors, the router must ask neighbors for help in hope of finding a new, loop-free path to the destination.
- Neighbor routers are compelled to reply to this query.
  - If a neighbor has a route, it will reply with information about the successor(s).
  - If not, the neighbor notifies the sender that it doesn't have a route to the destination either.

Successors and Feasible Successors



Destination	Feasible Dist.	Advertised or Reported. Dist.	Neighbor	
172.30.1.0	40	30	X	In Topology Table
172.30.1.0	**31**	21	Y	In Routing Table
172.30.1.0	230	220	Z	Not in Topology Table

Example of a Loop



RTZ has a Reported Distance to RTA of 220. Since its Reported Distance is greater than RTA's own Feasible Distance of 31, RTA can't trust that the route RTZ takes is somehow back through itself.

What if the successor fails?

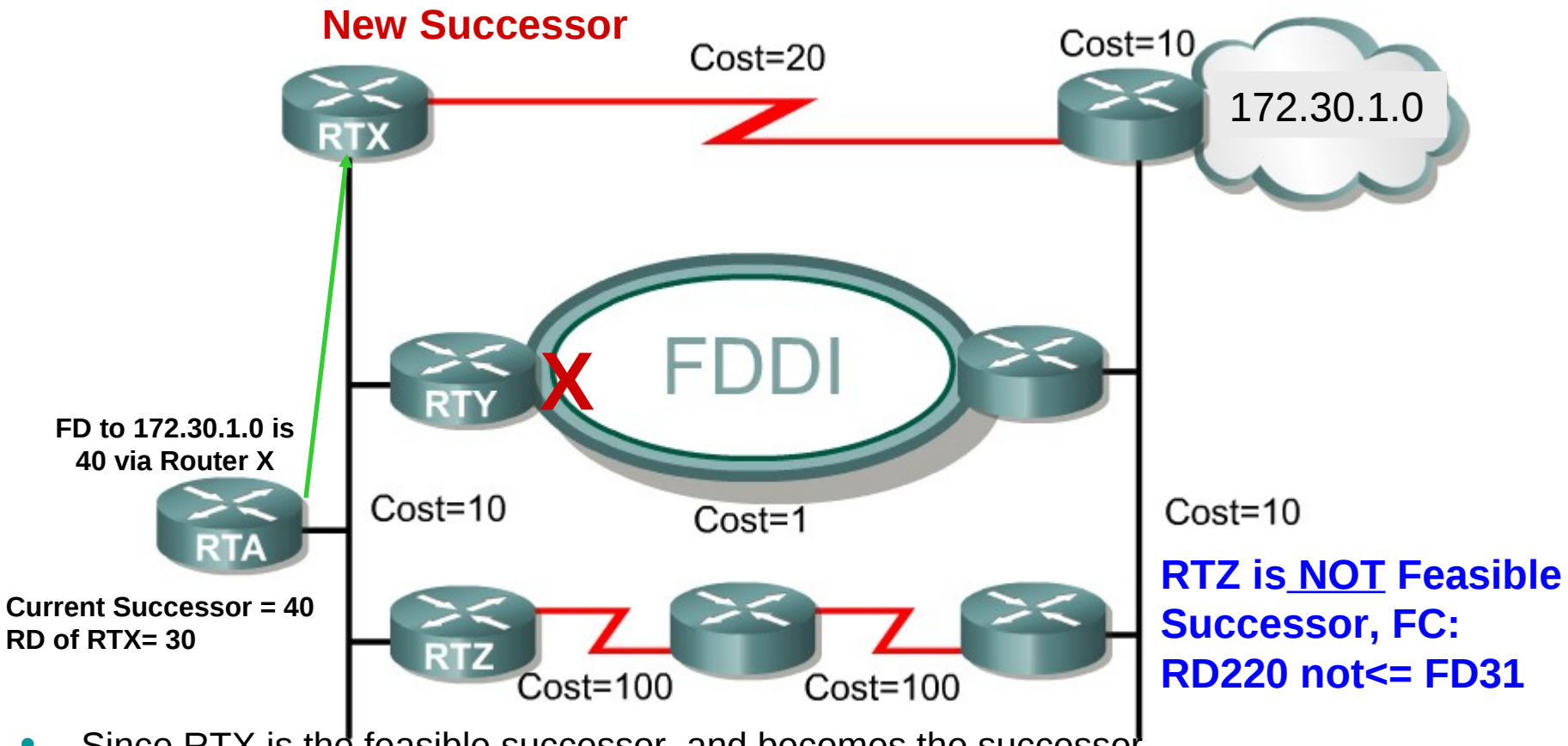
Feasible Successor exists:

- If current successor route fails, feasible successor becomes the current successor, i.e. the current route.
- Routing of packets continue with little delay.

No Feasible Successor exists:

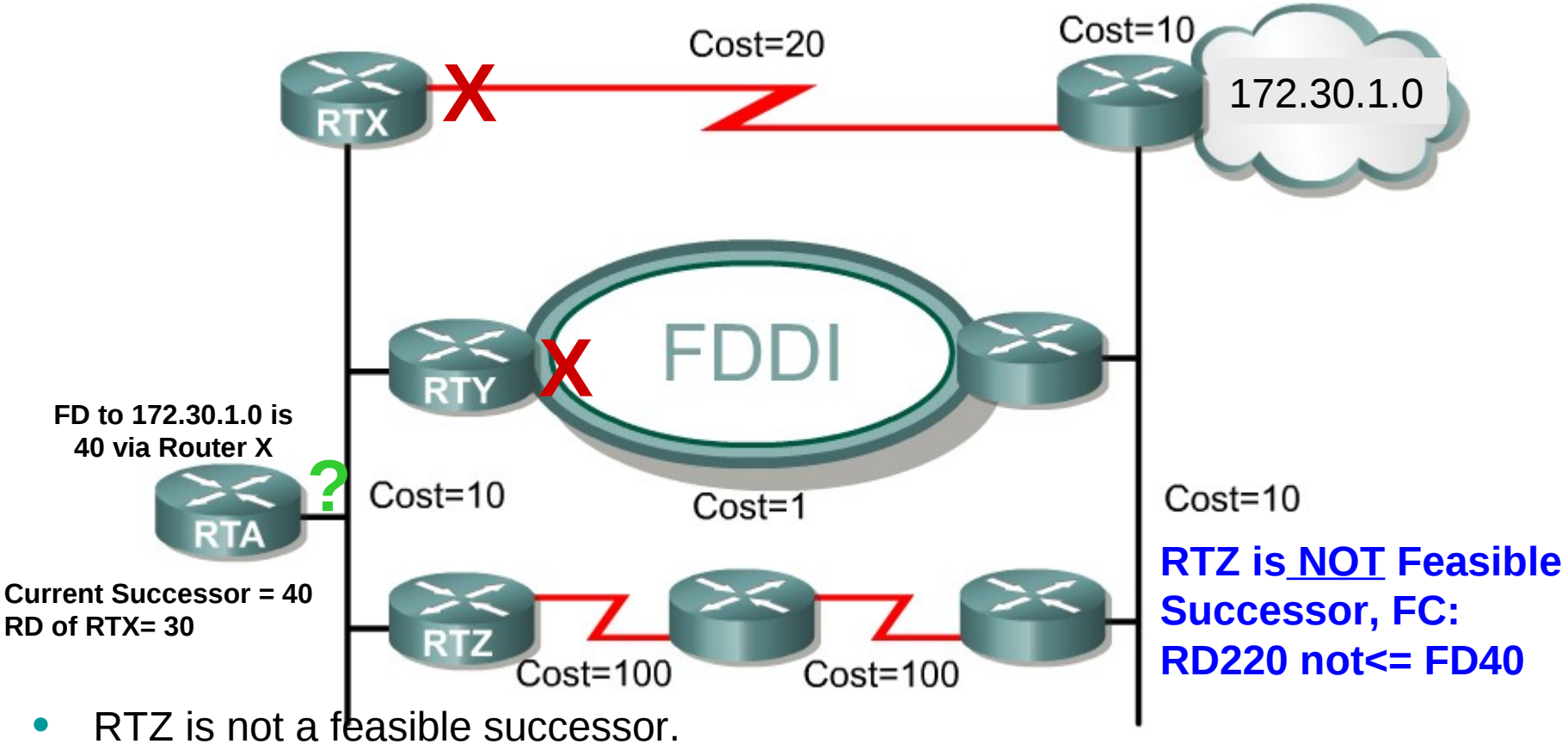
- This may be because the Reported Distance is greater than the Feasible Distance.
- Before this route can be installed, it must be placed in the ***active state*** and recomputed. (later)
- Routing of packets continue but with more of a delay.

Successors and Feasible Successors



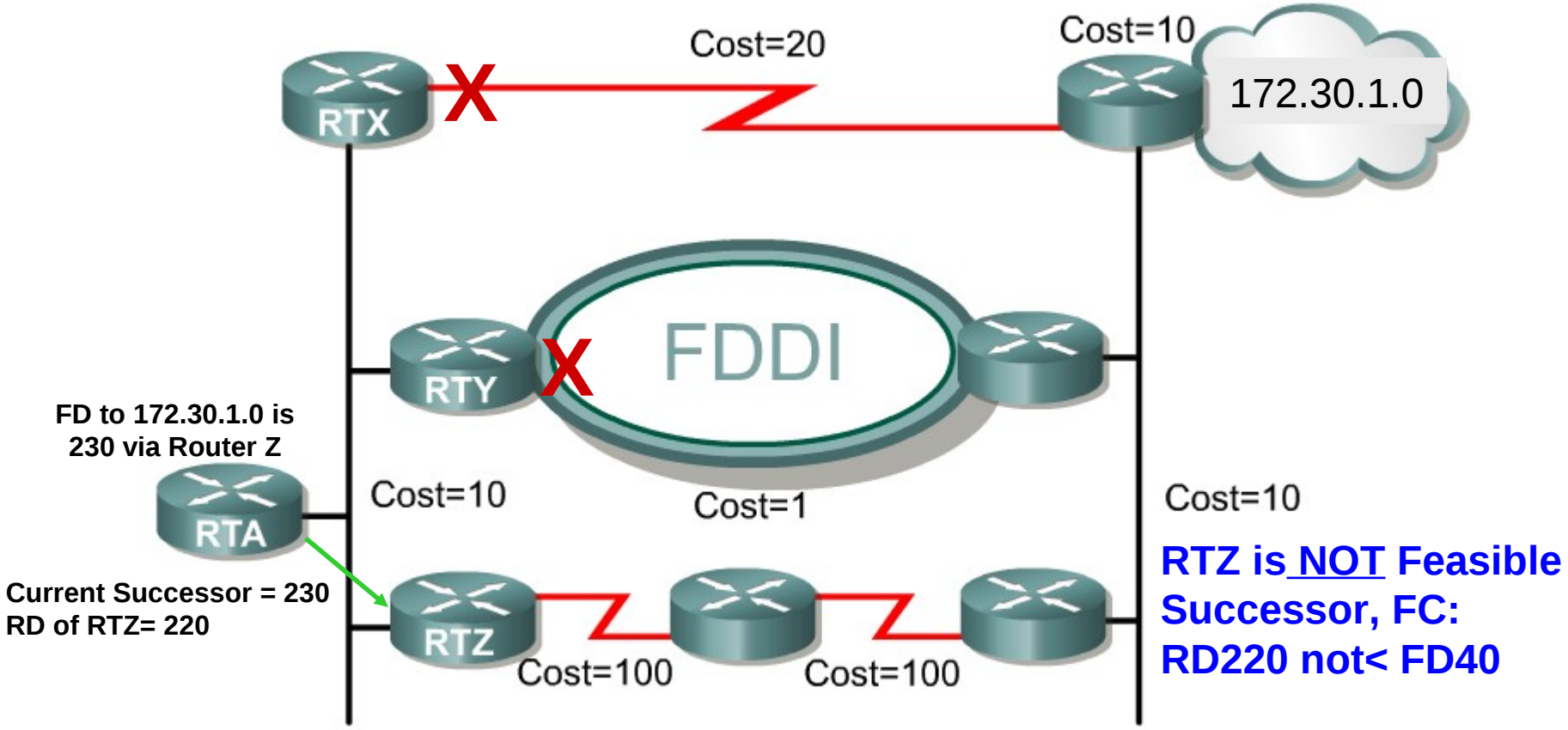
- Since RTX is the feasible successor, and becomes the successor.
- RTX is immediately installed from the topology table into the routing table (no recomputation of DUAL).
- RTA's new FD via RTX is 40.
- RTZ is not a feasible successor, because it's RD (220) is still greater than the new FD (40) for 172.30.1.0/24.

Successors and Feasible Successors



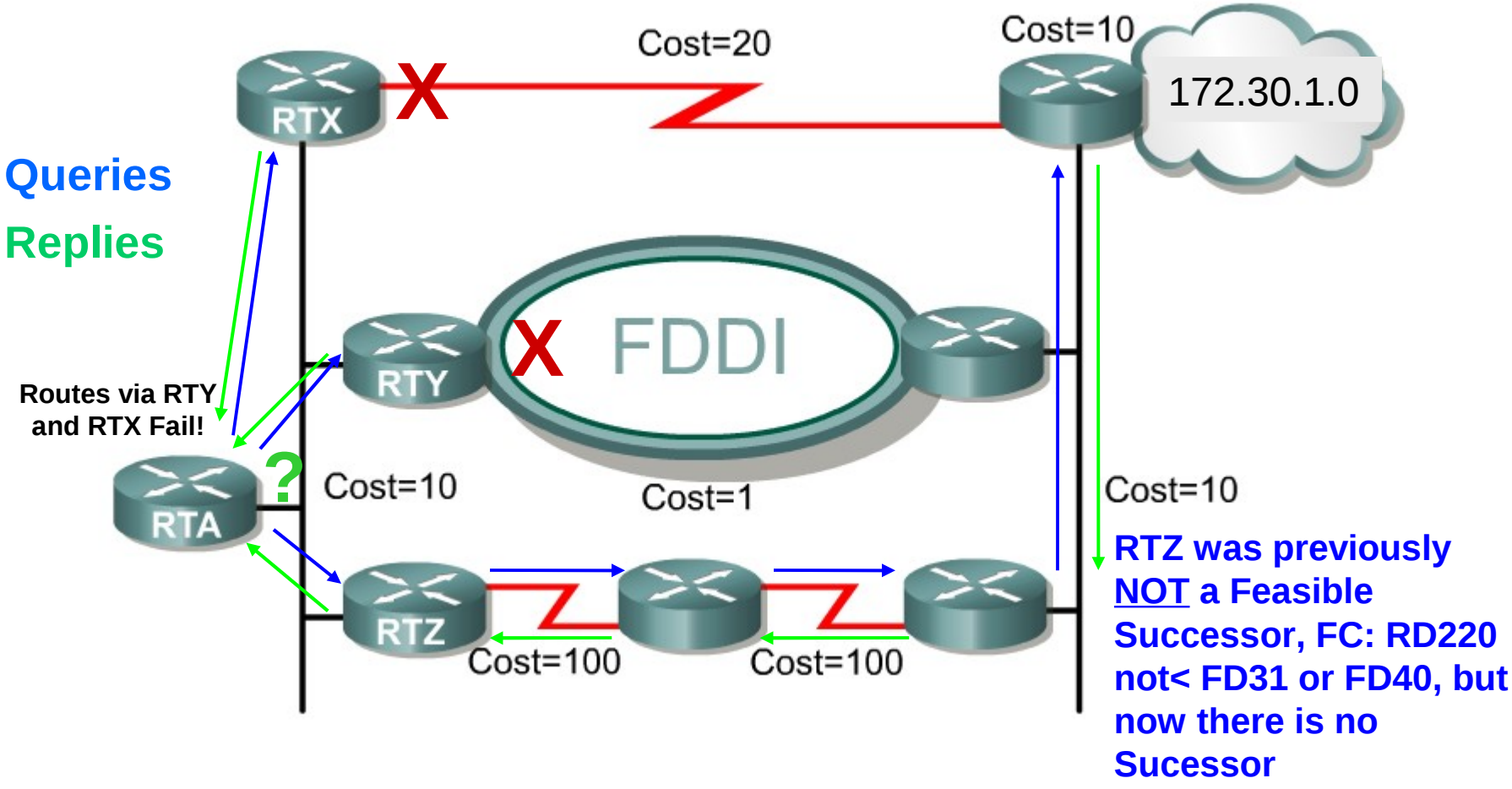
- RTZ is not a feasible successor.
- It's RD (220) is greater than the previous FD (40) for 172.30.1.0/24.
- Before this route can be installed, the route to net 24 must be placed in the ***active state*** and recomputed.
- ***Coming soon!***

Successors and Feasible Successors



- After a a series of EIGRP Queries and Replies (coming), and a recomputation of DUAL, RTZ becomes the successor.
- There is nothing better to prohibit it from being the successor.

Query and Reply Packets



RTZ replies that it still has a route to 172.30.1.0, while RTX and RTY reply that they do not.

Current Successor is now RTZ, with a FD of 230 and a RD of RTZ= 220.

One last reminder….

Topology table

- Each EIGRP router maintains a topology table for each configured network protocol.
- This table includes route entries for all destinations that the router has learned. All learned routes to a destination are maintained in the topology table.

show ip eigrp topology

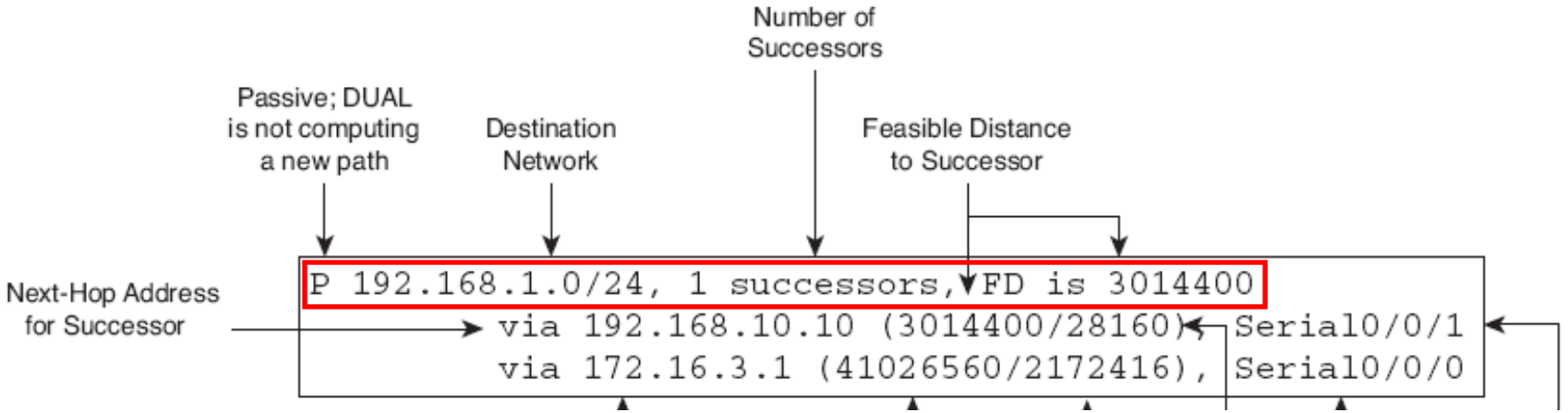
- (Feasible Distance/Reported Distance)
- 1 successor (route) if FDs are different
  - smaller FD metric, that route is the the only successor
  - larger FD metric, those routes are possible feasible successor
- 2 or more successors (routes) if FDs are the same
  - Load balancing happens automatically

Topology Table: Successor and Feasible Successor

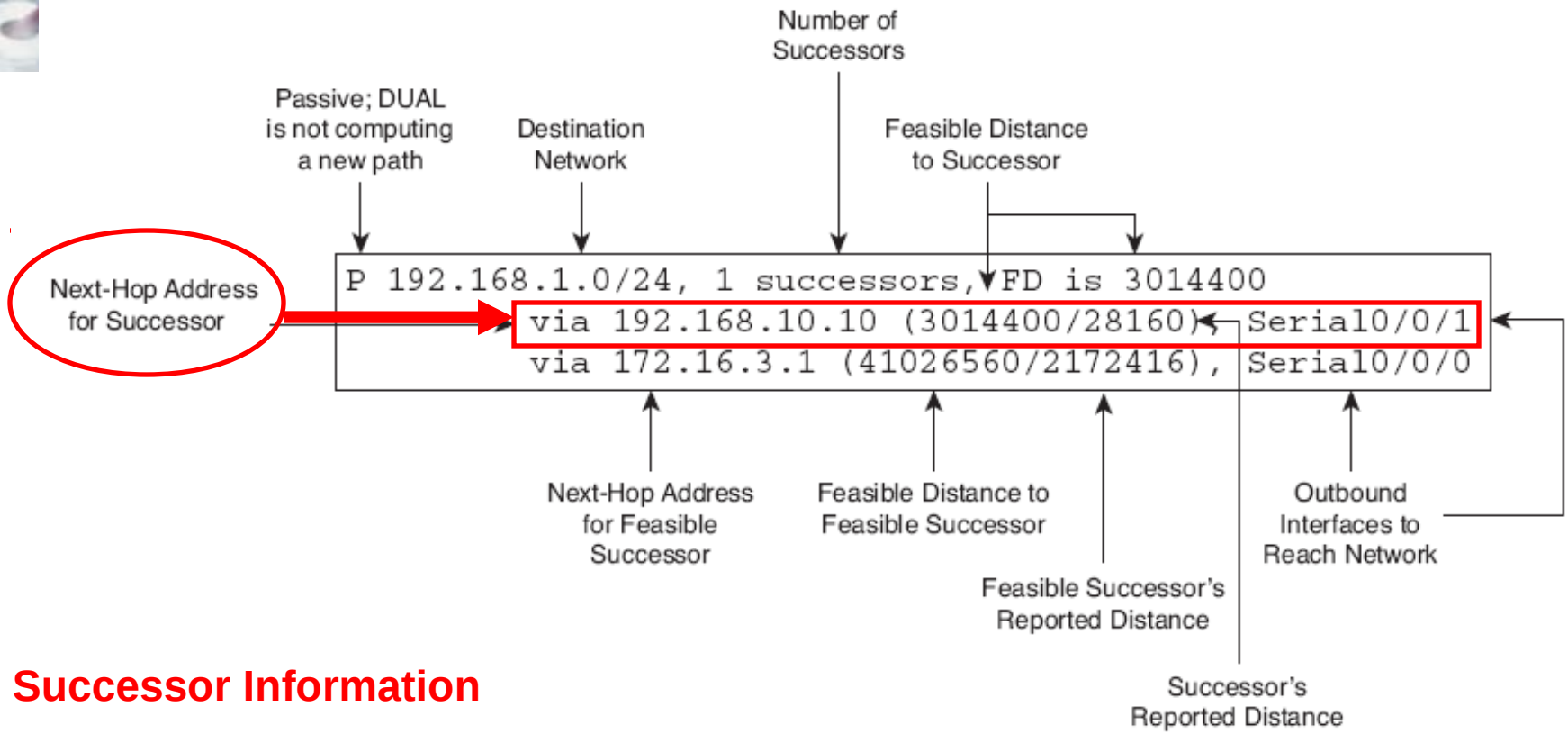
```
R2# show ip eigrp topology
IP-EIGRP Topology Table for AS(1)/ID(10.1.1.1)
 Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
r - reply Status, s - sia Status
<output omitted>

P 192.168.1.0/24, 1 successors, FD is 3014400
 Successor   via 192.168.10.10 (3014400/28160), Serial0/0/1
Feasible Successor via 172.16.3.1 (41026560/2172416), Serial0/0/0
P 192.168.10.8/30, 1 successors, FD is 3011840
          via Connected, Serial0/1
<output omitted>
```

- The successor, FD, and any FSs with their RDs are kept by a router in its EIGRP topology table or ***topology database***.

Topology Table: Successor and Feasible Successor

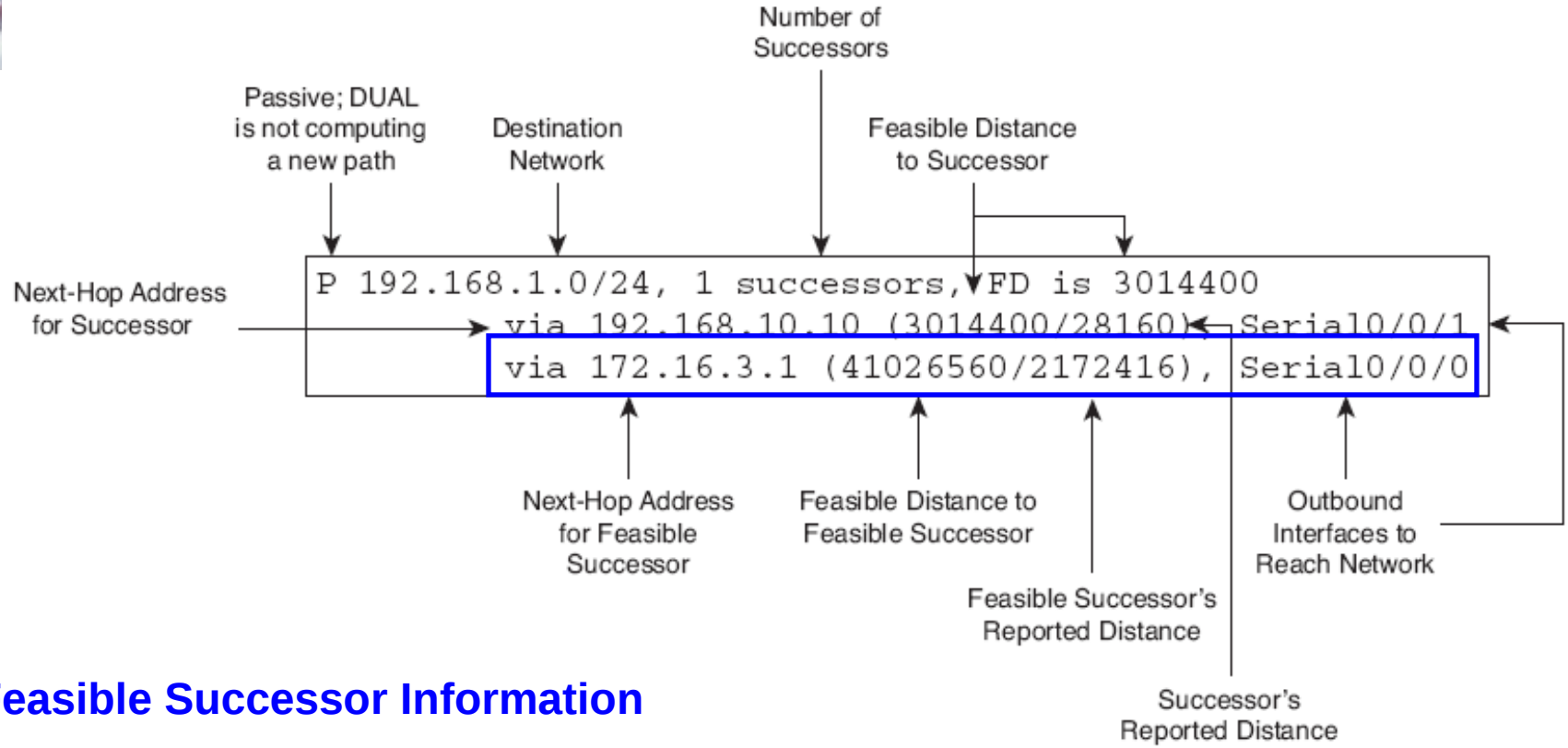


- **P:** This route is in the **passive state**.
  - **DUAL** is not performing its diffusing computations to determine a path for a network
    - The route is in a stable mode
    - All routes should be in this state for stable routing domain.
    - **active state** - DUAL is recalculating or searching for a new path,
  - **192.168.1.0/24:** This is the destination network that is also found in the routing table.
- **1 successors:** This shows the number of successors for this network.
  - If there are multiple equal-cost paths to this network, there will be multiple successors.
- **FD is 3014400:** This is the FD, the EIGRP metric to reach the destination network.



Successor Information

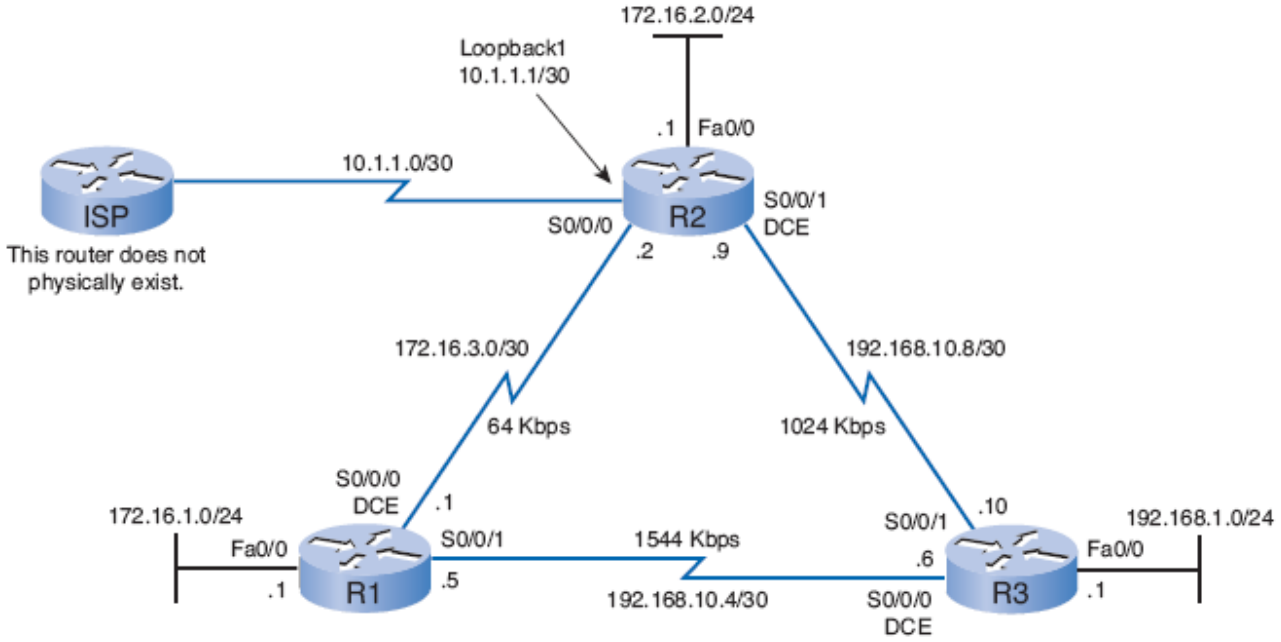
- **via 192.168.10.10:** This is the next-hop address of the successor, R3.
  - This address is shown in the routing table.
- **3,014,400:** This is the FD to 192.168.1.0/24.
  - It is the metric shown in the routing table.
- **28,160:** This is the **RD** of the successor
  - R3's cost to reach this network.
- **Serial0/0/1:** This is the outbound interface used to reach this network.
  - Also shown in the routing table.



Feasible Successor Information

- **via 172.16.3.1:** This is the next-hop address of the **FS, R1**.
- **41,026,560:** This would be R2's new FD to 192.168.1.0/24 if R1 became the new successor.
- **2,172,416:** This is the RD of the FS or R1's metric to reach this network.
  - This value, RD, must be less than the current FD of 3,014,400 to meet the FC.
- ■ **Serial0/0/0:** This is the outbound interface used to reach the FC, if this router becomes the successor.

Network configurations: From CIS 82 Routing



R1

```
router eigrp 1
 network 172.16.0.0
 network 192.168.10.4
```

R2

```
router eigrp 1
 network 172.16.0.0
 network 192.168.10.8 0.0.0.3
```

R3

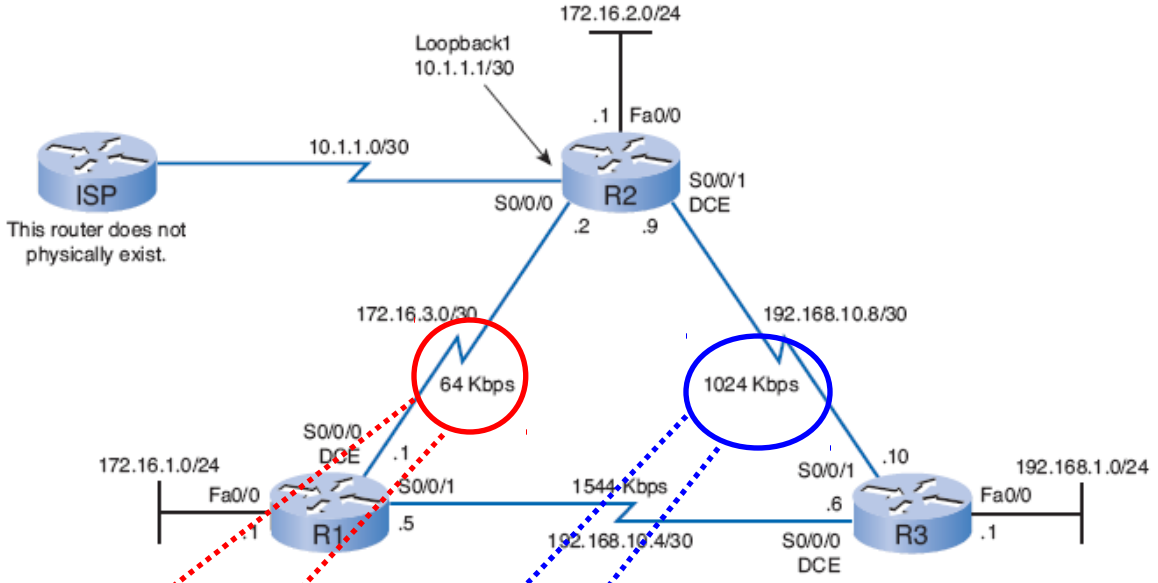
```
router eigrp 1
 network 192.168.1.0
 network 192.168.10.0
```

Examining the Routing Table: R3

```
R3# show ip route
<Output omitted>

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:11, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
D    172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, S0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, S0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

- By **default**, EIGRP automatically summarizes routes at the major network boundary.
- You can disable the automatic summarization with the `no auto-summary` command, just as you can for RIPv2.
- **Null0** summary routes will be explained next.

Using the bandwidth Command




```
R1(config)# inter s 0/0/0
R1(config-if)# bandwidth 64
```

```
R2(config)# inter s 0/0/0
R2(config-if)# bandwidth 64

R2(config)# inter s 0/0/1
R2(config-if)# bandwidth 1024
```

```
R3(config)# inter s 0/0/1
R3(config-if)# bandwidth 1024
```

- Modify the bandwidth on the appropriate serial interfaces.
- Be sure to modify both ends of the link.

Verify changes

```
R2# show interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 172.16.3.2/30
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  <some output omitted>
```

```
R2# show interface serial 0/0/1
Serial0/0/1 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.10.9/30
  MTU 1500 bytes, BW 1024 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  <some output omitted>
```

- Verify the change using the **`show interface`** command.

Disabling Automatic Summarization

```
R1(config)# router eigrp 1
R1(config-router)# no auto-summary
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.3.2 (Serial0/0/0) is
resync: summary configured
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.3.2 (Serial0/0/0) is
down: peer restarted
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.3.2 (Serial0/0/0) is
up: new adjacency
<output omitted>
```

```
R2(config)# router eigrp 1
R2(config-router)# no auto-summary
```

```
R3(config)# router eigrp 1
R3(config-router)# no auto-summary
```

- Automatic summarization can be disabled with the **`no auto-summary`**.
- The router configuration command **`eigrp log-neighborchanges`** is on by default on some IOS implementations.
  - If on, you will see output similar to that shown for R1.

Disabling Automatic Summarization

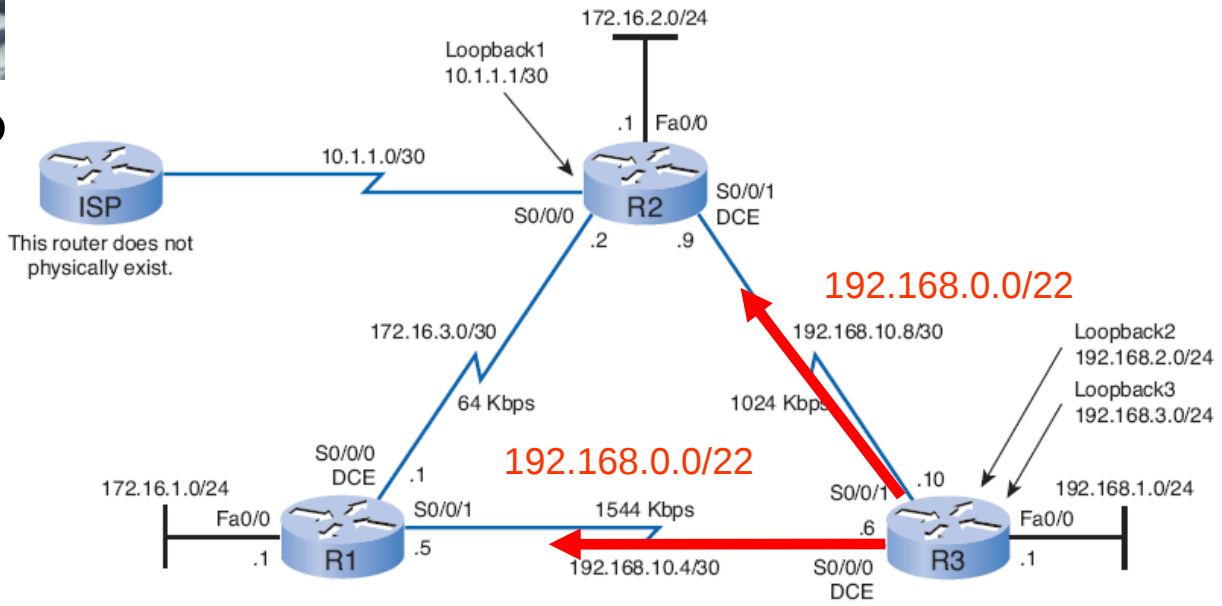
```
R1# show ip route

   192.168.10.0/30 is subnetted, 2 subnets
C     192.168.10.4 is directly connected, Serial0/0/1
D     192.168.10.8 [90/3523840] via 192.168.10.6, 00:16:55, S0/0/1
   172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C     172.16.1.0/24 is directly connected, FastEthernet0/0
D     172.16.2.0/24 [90/3526400] via 192.168.10.6, 00:16:53, S0/0/1
C     172.16.3.0/30 is directly connected, Serial0/0/0
D  192.168.1.0/24 [90/2172416] via 192.168.10.6, 00:16:52, Serial0/0/1
```

- R1 **no** more Null0 summary routes:

```
D     192.168.10.0/24 is a summary, 00:45:09, Null0
D     172.16.0.0/16 is a summary, 00:46:10, Null0
```

- This mean any packets for their parent networks that do not match a child route, the routing table will check supernet and default routes.
  - Unless **`no ip classess`** is used

Configure EIGRP Manual Summarization




```
Router(config-if)# ip summary-address eigrp as-number network-address subnet-mask
```

```
R3(config)# interface serial 0/0/0
R3(config-if)# ip summary-address eigrp 1 192.168.0.0 255.255.252.0
R3(config-if)# interface serial 0/0/1
R3(config-if)# ip summary-address eigrp 1 192.168.0.0 255.255.252.0
```

- Because R3 has two EIGRP neighbors, the EIGRP manual summarization in configured on both **Serial 0/0/0** and **Serial 0/0/1**.