EIGRP

Routing Protocols and Concepts

Ola Lundh

Objectives

- Examine the basic EIGRP configuration commands and identify their purposes.
- Calculate the composite metric used by EIGRP.
- Describe the concepts and operation of DUAL.
- Describe the uses of additional configuration commands in EIGRP.

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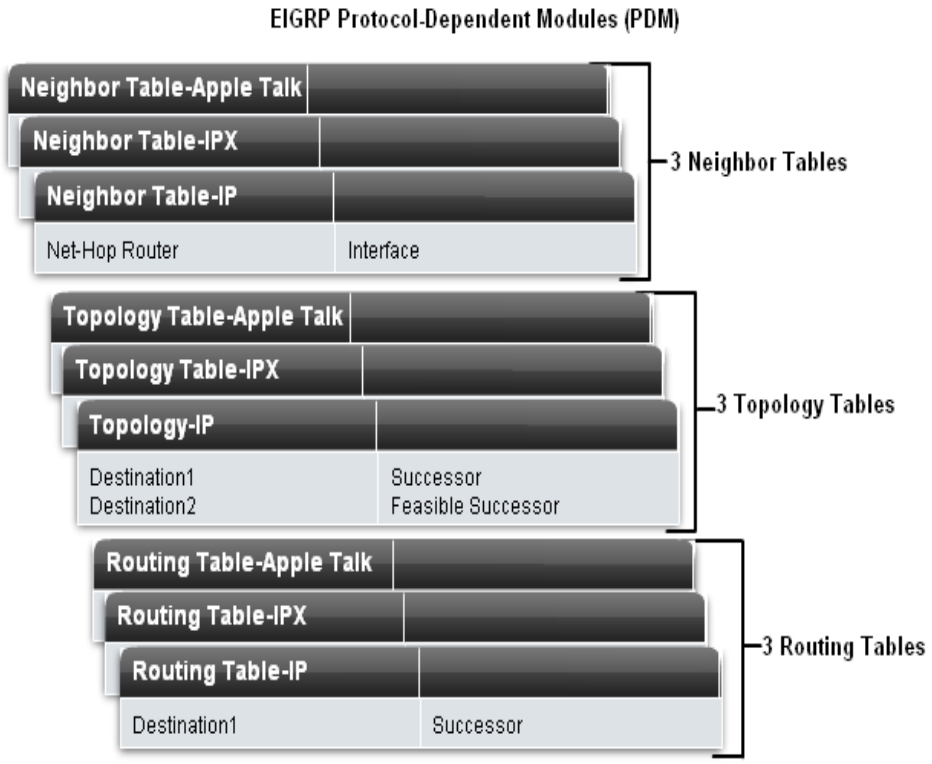
Protocol Dependent Modules (PDM)

- EIGRP uses PDM to route several different protocols i.e. IP, IPX & AppleTalk
- PDMs are responsible for the specific routing task for each network layer protocol



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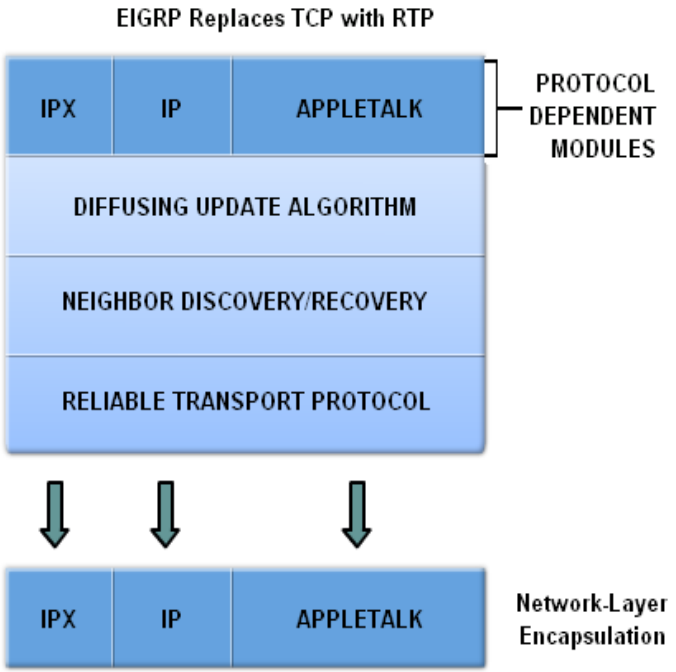
Reliable Transport Protocol (RTP)

- **Purpose of RTP**
  - Used by EIGRP to transmit and receive EIGRP packets
- **Characteristics of RTP**
  - Involves both reliable & unreliable delivery of EIGRP packet
    - Reliable delivery requires acknowledgment from destination
    - Unreliable delivery does not require an acknowledgement from destination
  - Packets can be sent
    - Unicast
    - Multicast
      - Using address 224.0.0.10



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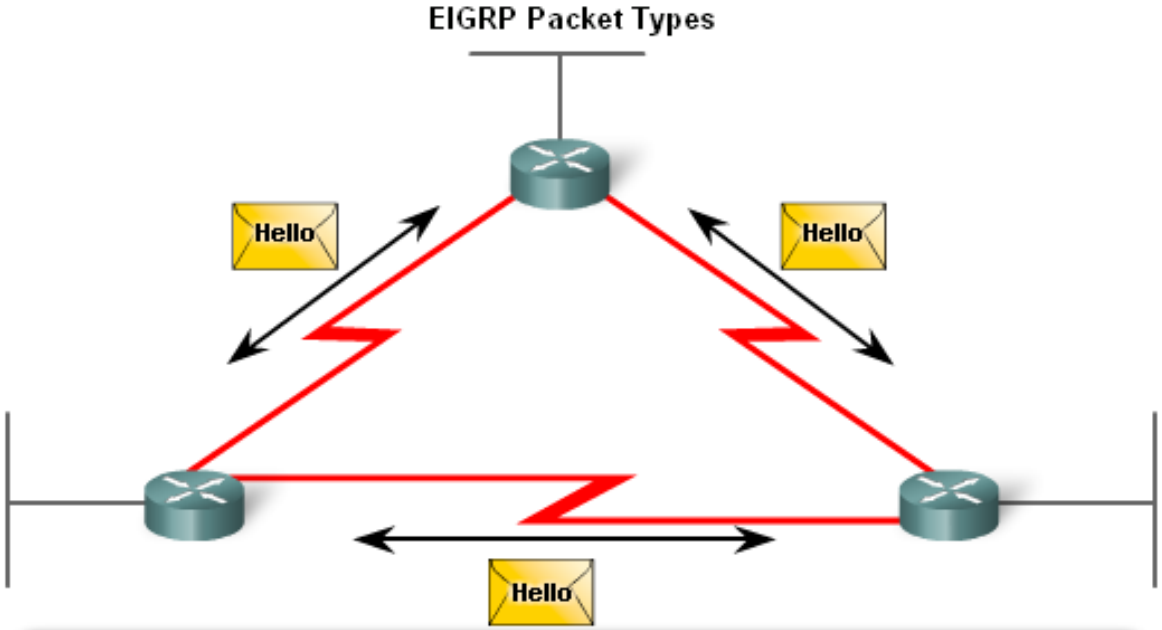
EIGRP's 5 Packet Types

- **Hello packets**
  - Used to discover & form adjacencies with neighbors



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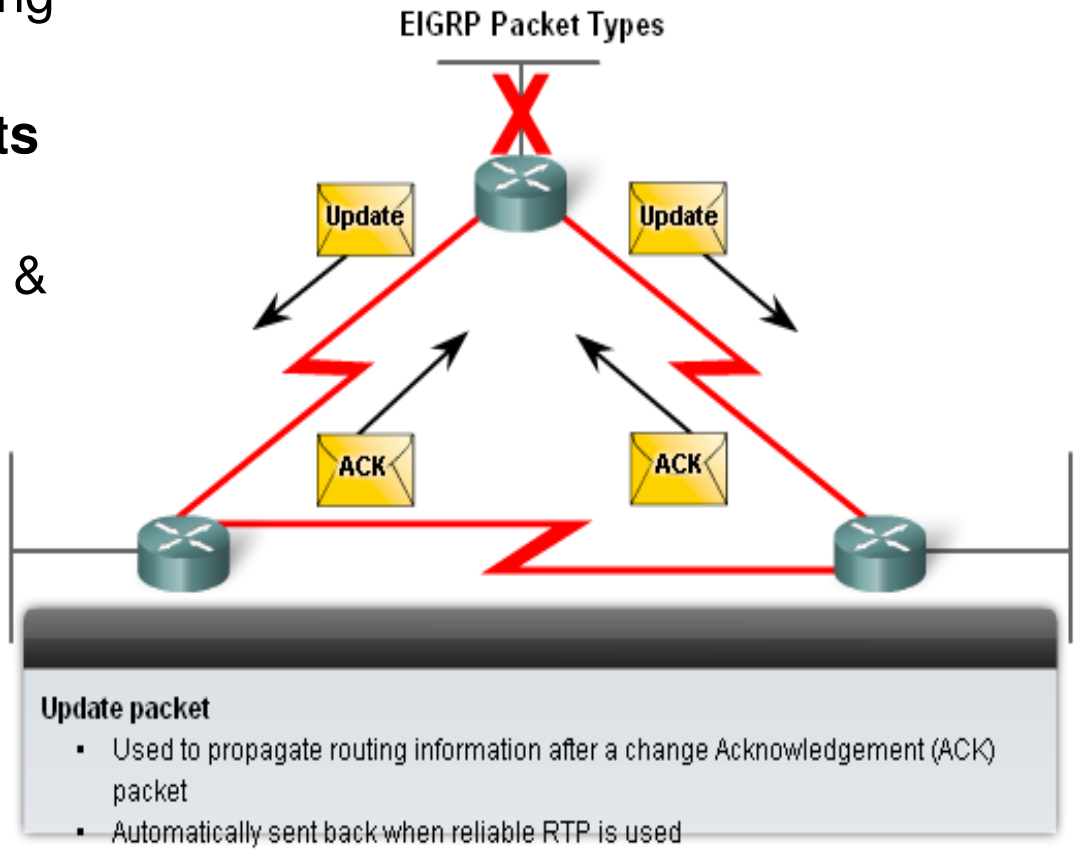
- **Update packets**
  - Used to propagate routing information
- **Acknowledgement packets**
  - Used to acknowledge receipt of update, query & reply packets



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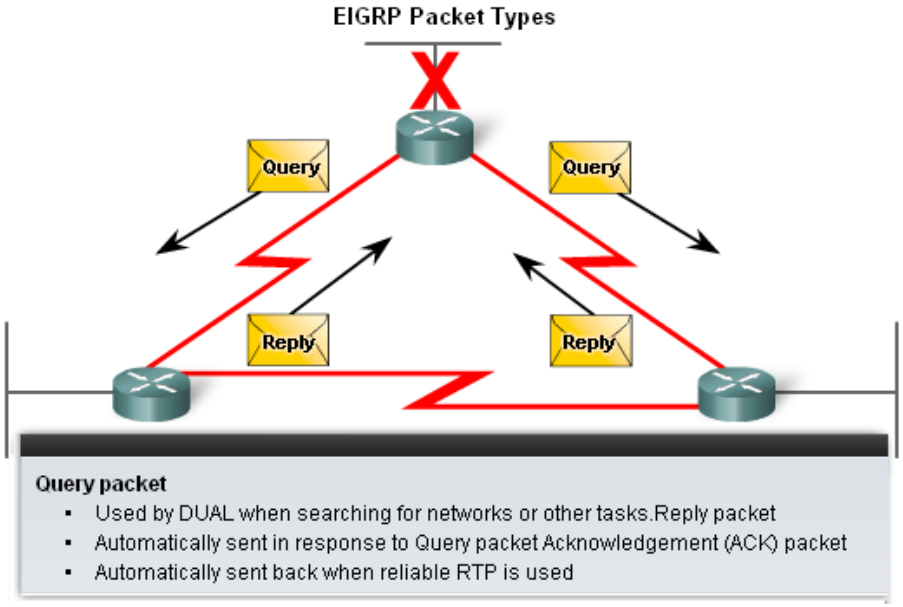
- **Query & Reply packets**
  - Used by DUAL for searching for networks
  - Query packets
    - -Can use
      - Unicast
      - Multicast
  - Reply packet
    - -Use only
      - unicast



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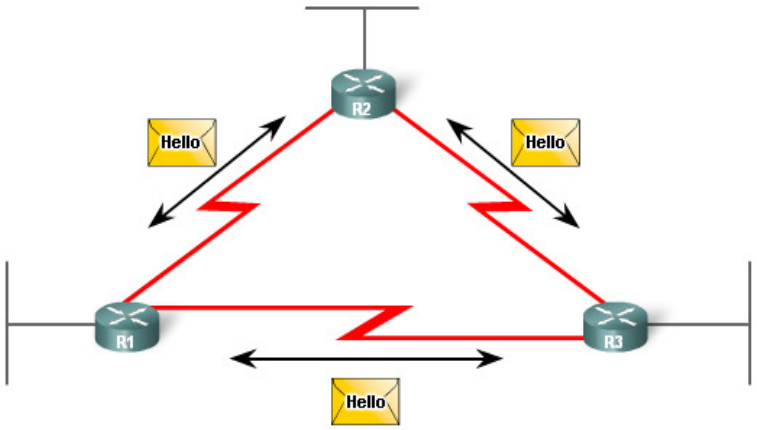
- **Purpose of Hello Protocol**
  - To discover & establish adjacencies with neighbor routers
- **Characteristics of hello protocol**
  - Time interval for sending hello packet
    - Most networks it is every 5 seconds
    - Multipoint non broadcast multi-access networks
      - Unicast every 60 seconds
- Holdtime
  - This is the maximum time router should wait before declaring a neighbor down
  - Default holdtime
    - 3 times hello interval

Default Hello Intervals and Hold Times for EIGRP



Bandwidth	Example Link	Default Hello Interval	Default Hold Time
1.544 Mbps	Multipoint Frame Relay	60 seconds	180 seconds
Greater than 1.544 Mbps	T1, Ethernet	5 seconds	15 seconds

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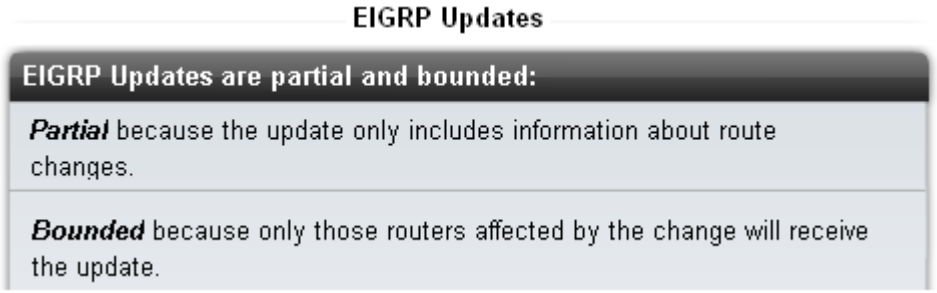
EIGRP Bounded Updates

- EIGRP only sends update when there is a change in route status
- Partial update
  - A partial update includes only the route information that has changed – the whole routing table is NOT sent
- Bounded update
  - When a route changes, only those devices that are impacted will be notified of the change
- EIGRP's use of partial bounded updates minimizes use of bandwidth



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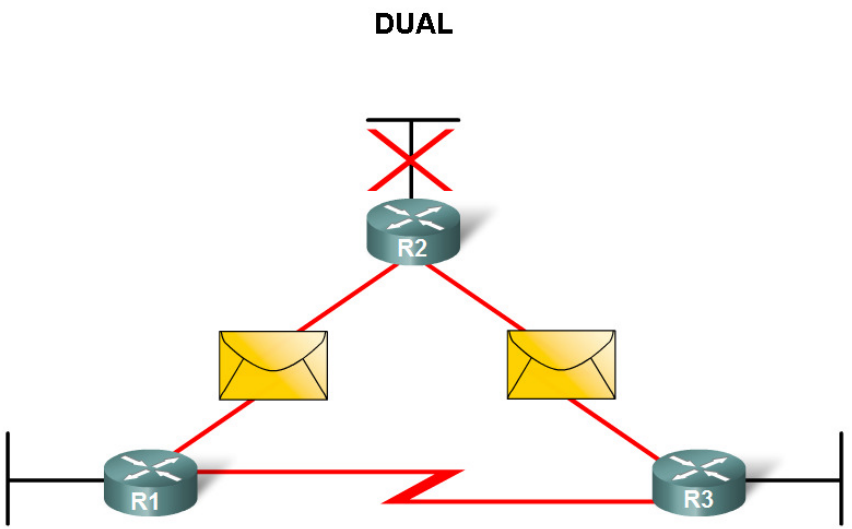
Diffusing **U**pdate **AL**gorithm (DUAL)

- Purpose
  - EIGRP's primary method for preventing routing loops
- Advantage of using DUAL
  - Provides for fast convergence time by keeping a list of loop-free backup routes



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- Administrative Distance (AD)
  - Defined as the trustworthiness of the source route
- EIGRP default administrative distances
  - Summary routes = 5
  - Internal routes = 90
  - Imported routes = 170

Default Administrative Distances

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

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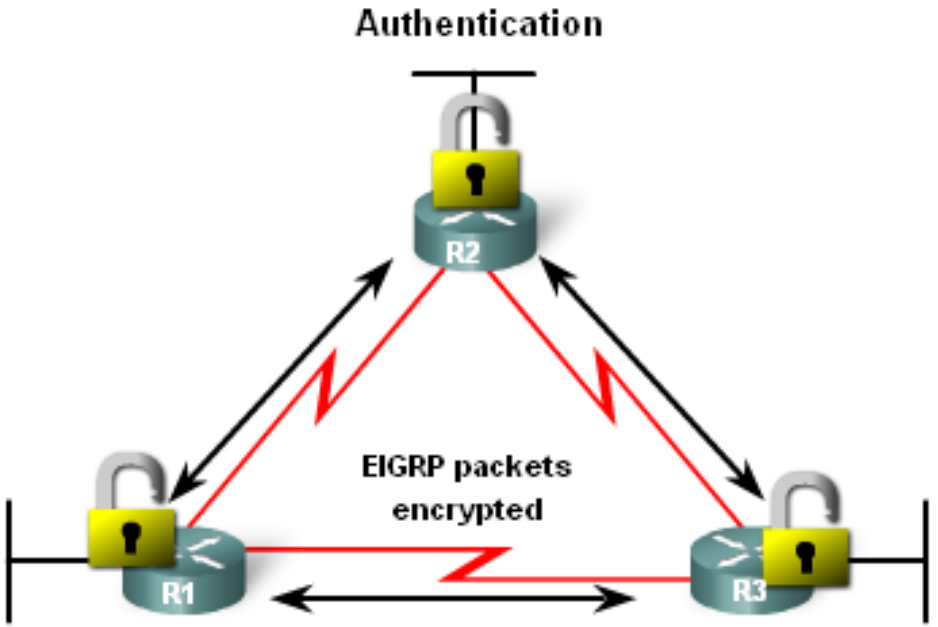
Authentication

- EIGRP can
  - Encrypt routing information
  - Authenticate routing information



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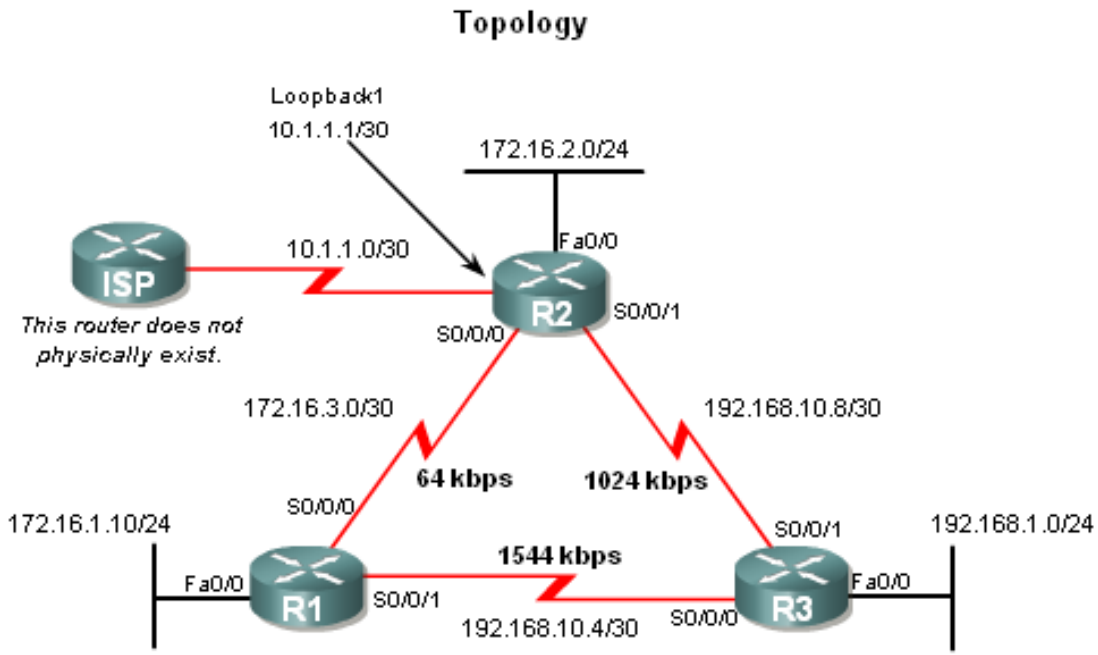
Network Topology

- Topology used is the same as previous chapters with the addition of an ISP router



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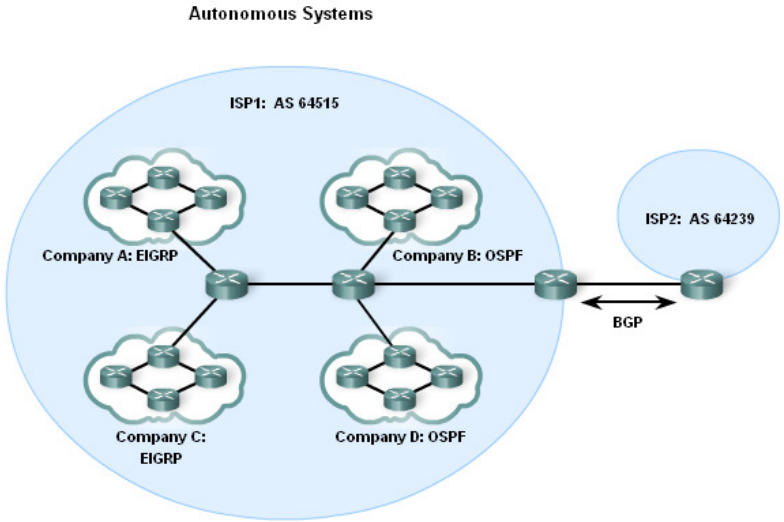
Basic EIGRP Configuration

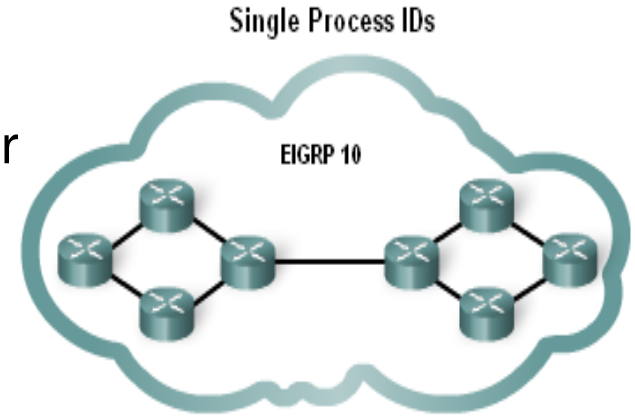
- Autonomous System (AS) & Process IDs
  - This is a collection of networks under the control of a single authority (reference RFC 1930)
  - AS Numbers are assigned by IANA
  - Entities needing AS numbers
    - ISP
    - Internet Backbone providers
    - Institutions connecting to other institutions using AS numbers



Basic EIGRP Configuration

- EIGRP autonomous system number actually functions as a process ID
- Process ID represents an instance of the routing protocol running on a router
- Example

Router(config)#router eigrp *autonomous-system*




```
R1(config)#router eigrp ?
  <1-65535>  Autonomous system number
R1(config)#router eigrp 10
```

Although the Cisco IOS refers to the router eigrp parameter as an "Autonomous system number", this parameter configures an EIGRP process-an instance of EIGRP running on the router-and has nothing to do with AS configurations in ISP routers.

Basic EIGRP Configuration

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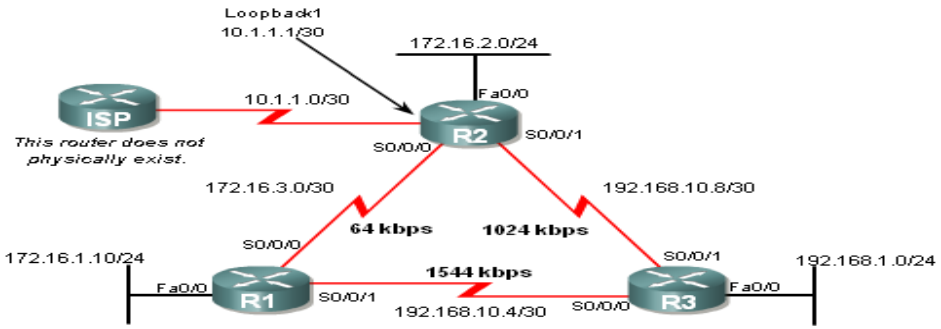
The *router eigrp* command

- The global command that enables eigrp is
  - *router eigrp autonomous-system*
  - -All routers in the EIGRP routing domain must use the same process ID number (autonomous-system number)

Enabling EIGRP Routing




```
R1(config)#router eigrp 1
R1(config-router)#
```

```
R2(config)#router eigrp 1
R2(config-router)#
```

```
R3(config)#router eigrp 1
R3(config-router)#
```

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Basic EIGRP Configuration

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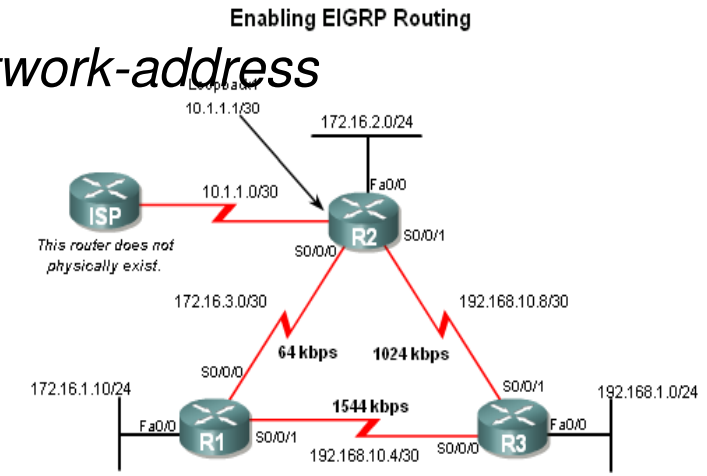
The Network Command

- Functions of the network command
  - Enables interfaces to transmit & receive EIGRP updates
  - Includes network or subnet in EIGRP updates
- Example
  - Router(config-router)#network *network-address*




```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
```

```
R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
```

Basic EIGRP Configuration

- The network Command with a Wildcard Mask
  - This option is used when you want to configure EIGRP to advertise specific subnets
  - Example
  - Router(config-router)#network network-address [wildcard-mask]

```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
```

```
R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
R2(config-router)#network 192.168.10.8 0.0.0.3
```

```
R3(config)#router eigrp 1
R3(config-router)#network 192.168.10.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.5 (Serial0/0/0) is up: new adjacency
R3(config-router)#
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.9 (Serial0/0/1) is up: new adjacency
R3(config-router)#network 192.168.1.0
```

Basic EIGRP Configuration

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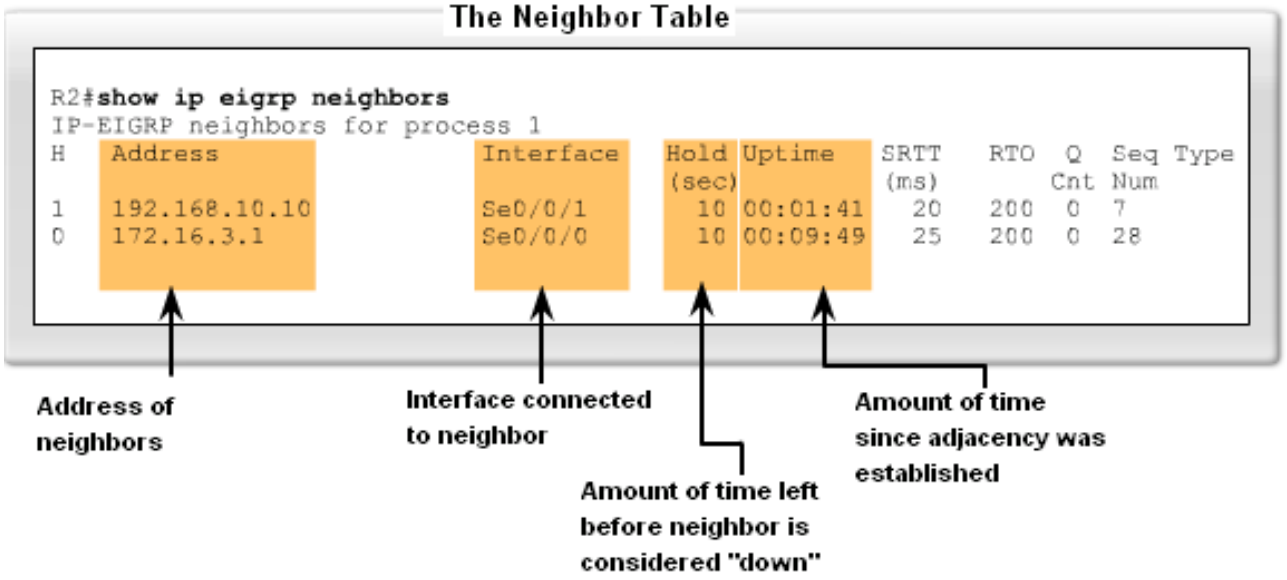
Verifying EIGRP

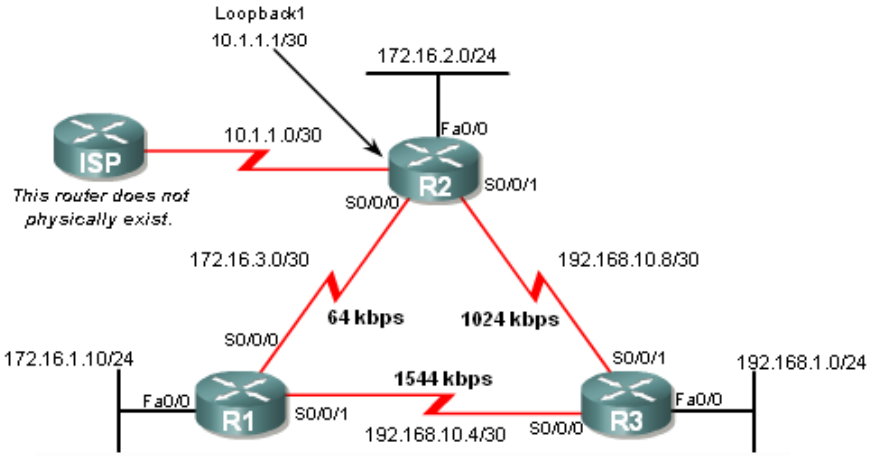
- EIGRP routers must establish adjacencies with their neighbors before any updates can be sent or received
- Command used to view neighbor table and verify that EIGRP has established adjacencies with neighbors is
  - ***show ip eigrp neighbors***



EIGRP

Verifying EIGRP Routing

- The ***show ip protocols*** command is also used to verify that EIGRP is enabled




```
R1#show ip protocols
Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.10.0/24 for FastEthernet0/0, Serial0/0/0
      Summarizing with metric 2169856
    172.16.0.0/16 for Serial0/0/1
      Summarizing with metric 28160
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)          90      00:03:29
    192.168.10.6           90      00:02:09
    Gateway         Distance      Last Update
    172.16.3.2             90      00:02:12
  Distance: internal 90 external 170
```

Basic EIGRP Configuration

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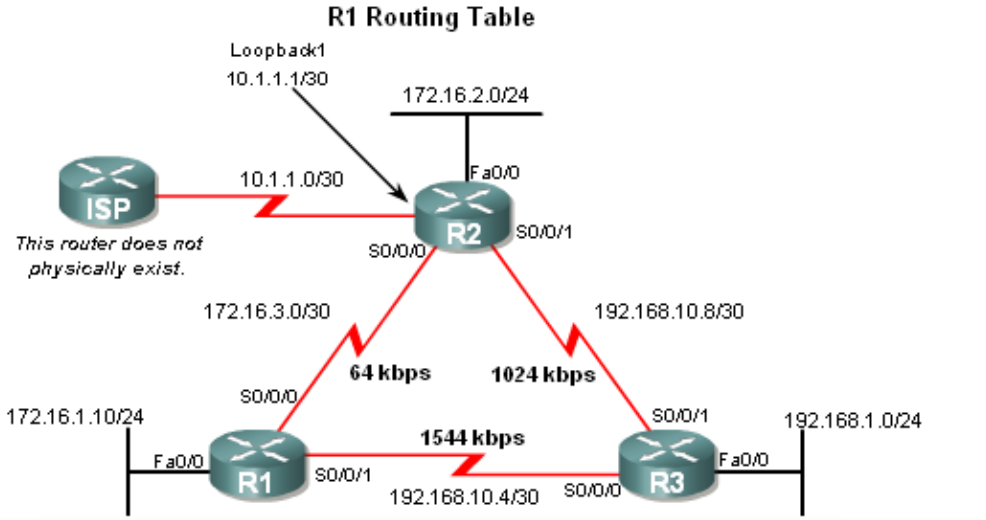
Examining the Routing Table

- The **show ip route** command is also used to verify EIGRP
- EIGRP routes are denoted in a routing table by the letter "**D**"
- By default , EIGRP automatically summarizes routes at major network boundary




```
R1#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
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:50, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/1
D       192.168.10.8/30 [90/2681856] via 192.168.10.6, 00:02:43, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:10:52, Null0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
D       172.16.2.0/24 [90/2172416] via 172.16.3.2, 00:10:47, Serial0/0/0
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, 00:02:31, Serial0/0/1
```

Basic EIGRP Configuration

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- **Introducing the Null0 Summary Route**
  - Null0 is not a physical interface
  - In the routing table summary routes are sourced from Null0
    - Reason: routes are used for advertisement purposes
  - EIGRP will automatically include a null0 summary route as child route when 2 conditions are met
    - At least one subnet is learned via EIGRP
    - Automatic summarization is enabled

R2 Routing Table

```
R2#show ip route
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10, 00:03:05, Serial0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, Serial0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Loopback1
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, Serial0/0/1
```

Summary Routes to Null0

Summary Routes to Null0

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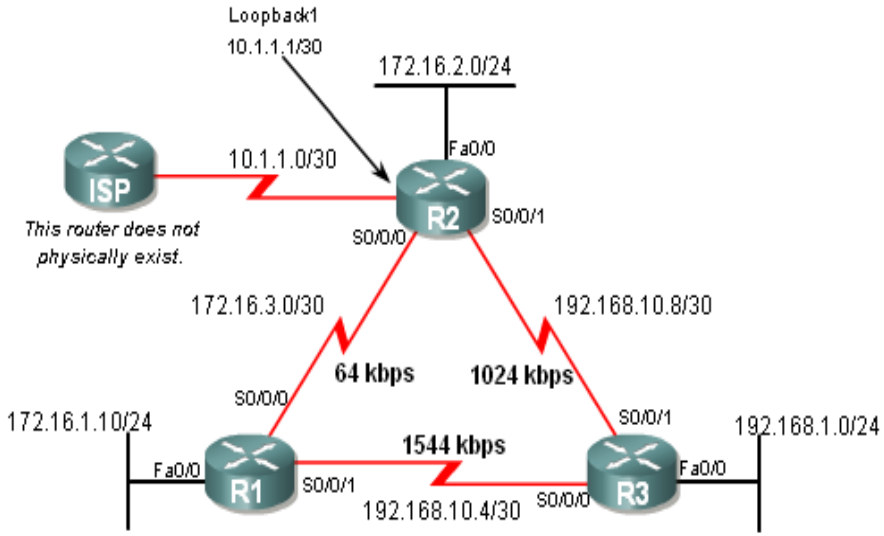
Basic EIGRP Configuration

- R3's routing table shows that the 172.16.0.0/16 network is automatically summarized by R1 & R3



R3 Routing Table

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

Gateway of last resort is not set

     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, Serial0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, Serial0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

Equal cost routes to 172.16.0.0/16

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EIGRP Metric Calculation

EIGRP Composite Metric & the K Values

- EIGRP uses the following values in its composite metric
  - Bandwidth, delay, reliability, and load
- The composite metric used by EIGRP
  - formula used has values
  - K1 →K5
  - K1 & K3 = 1
  - all other K values = 0

EIGRP Composite Metric

Default Composite Formula:
metric = **[K1*bandwidth + K3*delay]**

Complete Composite Formula:
metric = **[K1*bandwidth + (K2*bandwidth)/(256 - load) + K3*delay] * [K5/(reliability + K4)]**
(Not used if "K" values are 0)

Default values:
K1 (bandwidth) = 1
K2 (load) = 0
K3 (delay) = 1
K4 (reliability) = 0
K5 (reliability) = 0

"K" values can be changed with the **metric weights** command.

```
Router(config-router)#metric weights tos k1 k2 k3 k4 k5
```

EIGRP Metric Calculation

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- Use the **sh ip protocols** command to verify the K values

```
R1#show ip protocols
Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.10.0/24 for FastEthernet0/0, Serial0/0/0
      Summarizing with metric 2169856
    172.16.0.0/16 for Serial0/0/1
      Summarizing with metric 28160
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)           90      00:03:29
    192.168.10.6            90      00:02:09
    Gateway         Distance      Last Update
    172.16.3.2              90      00:02:12
  Distance: internal 90 external 170
```

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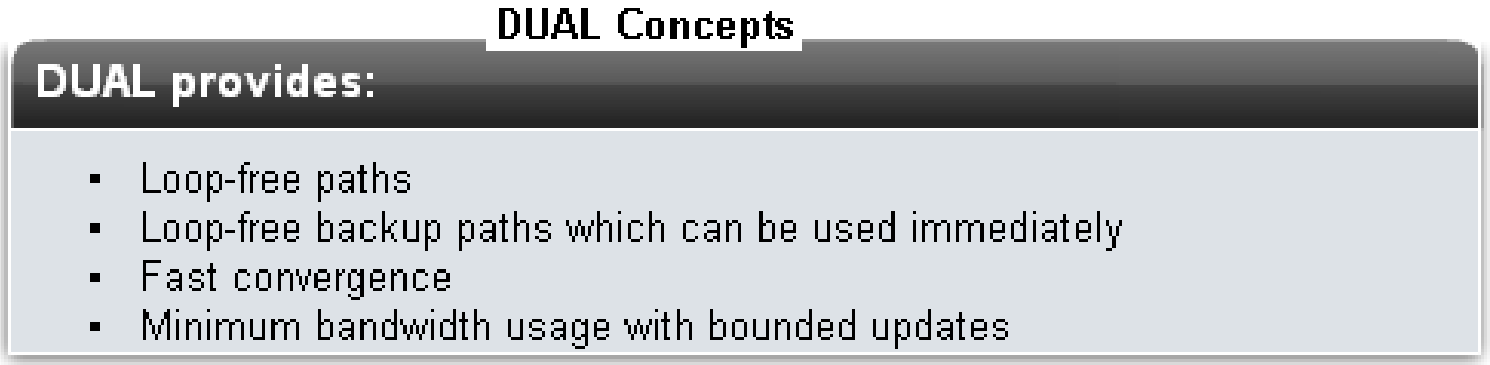
DUAL Concepts

- The **D**iffusing **U**pdate **Al**gorithm (DUAL) is used to prevent looping



DUAL Concepts

- Successor
  - The best least cost route to a destination found in the routing table
- Feasible distance
  - The lowest calculated metric along a path to a destination network

Feasible Distance and Successor

```
R2#show ip route
<code output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:00:15, Null0
D       192.168.10.4/30 [90/21024000] via 192.168.10.10, 00:00:15,
Serial0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:00:15, Null0
D       172.16.1.0/24 [90/40514560] via 172.16.3.1, 00:00:15, Serial0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Loopback1
D    192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
```

feasible distance — successor

R3 at 192.168.10.10 is the successor for network 192.168.1.0/24. This route has a feasible distance of 3014400.

DUAL Concepts

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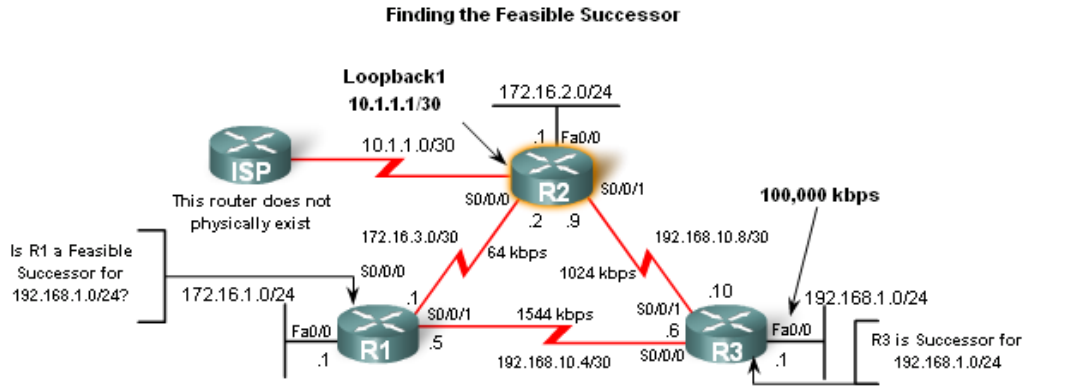
Feasible Successors, Feasibility Condition & Reported Distance

- Feasible Successor
  - This is a loop free backup route to the same destination as the successor route




```
R2#show ip route
<code output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:00:15, Null0
D       192.168.10.4/30 [90/21024000] via 192.168.10.10, 00:00:15, Serial0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:00:15, Null0
D       172.16.1.0/24 [90/40514560] via 172.16.3.1, 00:00:15, Serial0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Loopback1
D    192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
```

DUAL Concepts

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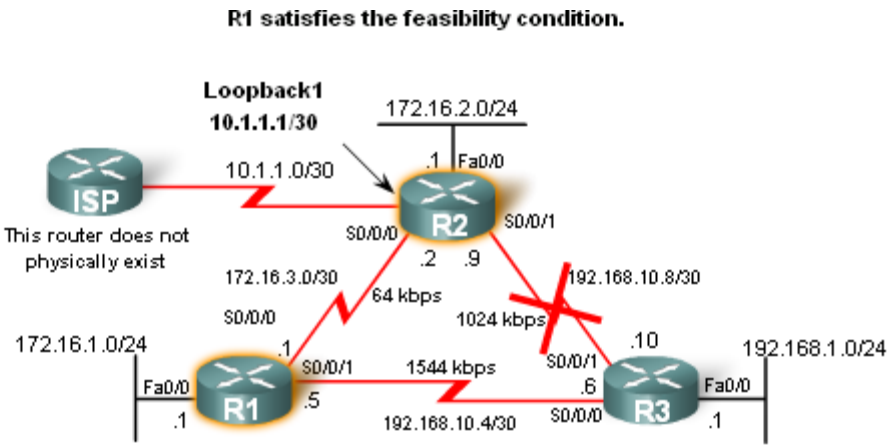
Feasible Successors, Feasibility Condition & Reported Distance

- Reported distance (RD)
  - The metric that a router reports to a neighbor about its own cost to that network




```
R2#show ip route
<output omitted for brevity>

D    192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
----------------------------------------------------------------------------

R1#show ip route
<output omitted for brevity>

D    192.168.1.0/24 [90/2172416] via 192.168.10.6, 01:12:26, Serial0/0/1
```

DUAL Concepts

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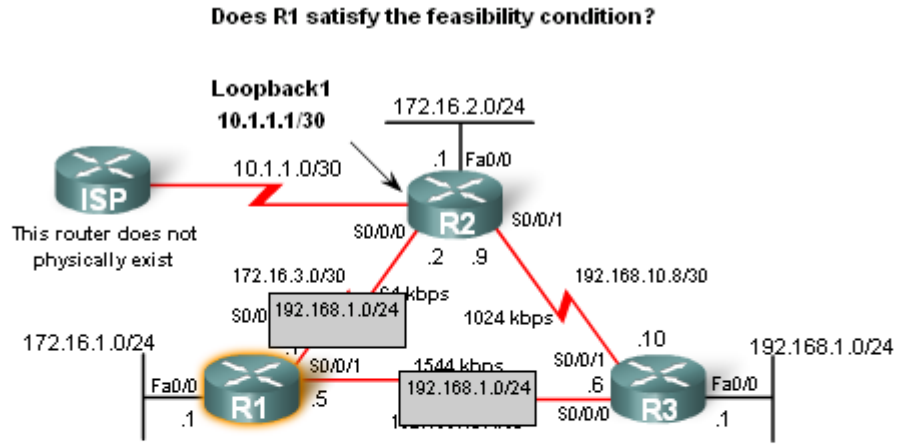
- Feasibility Condition (FC)
  - Met when a neighbor's RD is less than the local router's FD to the same destination network




```
R1#show ip route
<output omitted for brevity>

D    192.168.1.0/24 [90/2172416] via 192.168.10.6, 01:12:26, Serial0/0/1
```

R1 reports to R2 that its feasible distance to 192.168.1.0/24 is 2172416

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Successor & Feasible Successor

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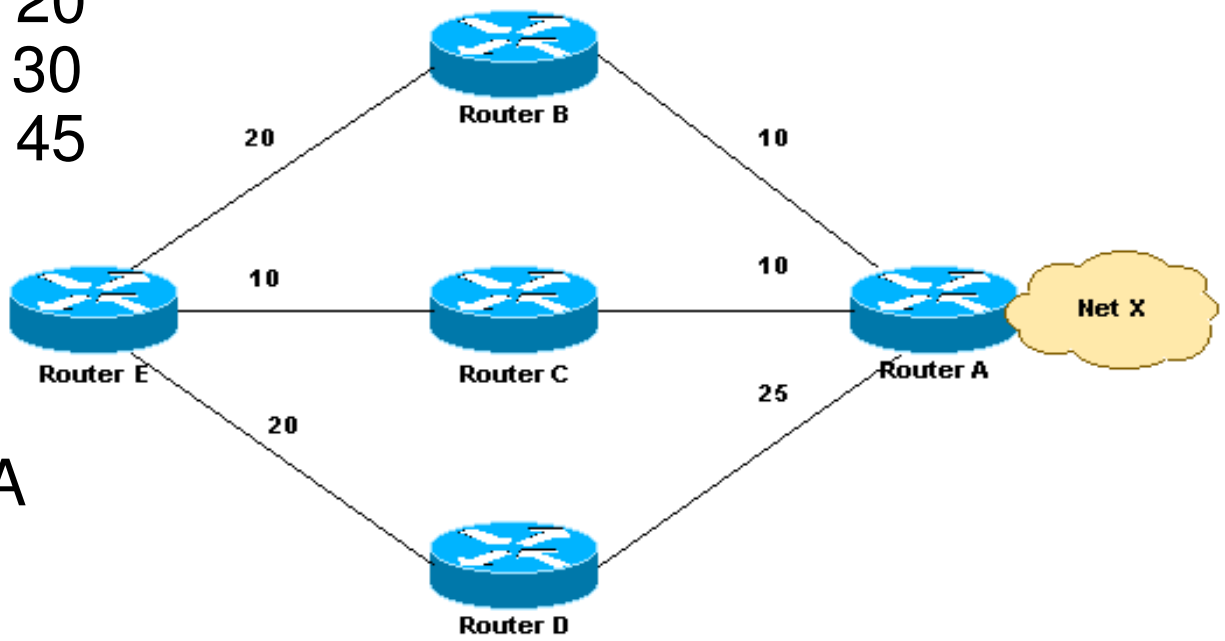
Example:

E-C-A = 10 + 10 = 20
E-B-A = 20 + 10 = 30
E-D-A = 20 + 25 = 45
RDb = 10
RDc = 10
RDd = 25

Successor = E-C-A
FS = E-B-A



More EIGRP Configurations

The Null0 Summary Route

- By default, EIGRP uses the Null0 interface to discard any packets that match the parent route but do not match any of the child routes
- EIGRP automatically includes a null0 summary route as a child route whenever both of the following conditions exist
  - One or subnets exists that was learned via EIGRP
  - Automatic summarization is enabled

Summary

- **Background & History**
  - EIGRP is a derivative of IGRP
    - EIGRP is a Cisco proprietary distance vector routing protocol released in 1994
- **EIGRP terms and characteristics**
  - EIGPR uses RTP to transmit & receive EIGRP packets
  - EIGRP has 5 packet type:
    - Hello packets
    - Update packets
    - Acknowledgement packets
    - Query packets
    - Reply packets
  - Supports VLSM & CIDR

Summary

- **EIGRP terms and characteristics**
  - EIGRP uses a hello protocol
    - Purpose of hello protocol is to discover & establish adjacencies
  - EIGRP routing updates
    - Aperiodic
    - Partial and bounded
    - Fast convergence

Summary

- **EIGRP commands**
  - The following commands are used for EIGRP configuration
    - RtrA(config)#router eigrp [autonomous-system #]
    - RtrA(config-router)#network *network-number*
  - The following commands can be used to verify EIGRP
    - Show ip protocols
    - Show ip eigrp neighbors
    - Show ip route

Summary

- **EIGRP metrics include**
  - Bandwidth (default)
  - Delay (default)
  - Reliability
  - Load

Summary

- **DUAL**
  - Purpose of DUAL
    - To prevent routing loops
  - Successor
    - Primary route to a destination
  - Feasible successor
    - Backup route to a destination
  - Feasible distance
    - Lowest calculated metric to a destination
  - Reported distance
    - The distance towards a destination as advertised by an upstream neighbor

Summary

- **Choosing the best route**
  - After router has received all updates from directly connected neighbors, it can calculate its DUAL
    - 1st metric is calculated for each route
    - 2nd route with lowest metric is designated successor & is placed in routing table
    - 3rd feasible successor is found
      - Criteria for feasible successor: it must have lower reported distance to the destination than the installed route's feasible distance
      - Feasible routes are maintained in topology table