Chapter 4

EIGRP

Enhanced Interior Gateway Routing Protocol (EIGRP) is a Cisco-proprietary routing protocol based on Interior Gateway Routing Protocol (IGRP).

Unlike IGRP, which is a classful routing protocol, EIGRP supports classless interdomain routing (CIDR), allowing network designers to maximize address space by using CIDR and variable-length subnet mask (VLSM). Compared to IGRP, EIGRP boasts faster convergence times, improved scalability, and superior handling of routing loops.

Furthermore, EIGRP can replace Novell Routing Information Protocol (RIP) and AppleTalk Routing Table Maintenance Protocol (RTMP), serving both IPX and AppleTalk networks with powerful efficiency.

EIGRP is often described as a hybrid routing protocol offering the best of distance-vector and link-state algorithms. Technically, EIGRP is an advanced distance-vector routing protocol that relies on features commonly associated with link-state protocols. Some of the best features of OSPF, such as partial updates and neighbor discovery, are similarly used by EIGRP. However, EIGRP is easier to configure than OSPF.

EIGRP is an ideal choice for large multiprotocol networks built primarily on Cisco routers.

This chapter compares EIGRP and IGRP. It surveys the key concepts, technologies, and data structures of EIGRP. This conceptual overview is followed by a study of EIGRP convergence and basic operation using the EIGRP state-of-the-art routing algorithm called Diffusing Update Algorithm (DUAL).

Concept Questions

Demonstrate your knowledge of these concepts by answering the following questions in the space provided.

1. At what layer of the OSI model does path determination take place, and what is that layer's function?

   Path determination occurs at Layer 3, the network layer. The path determination function enables a router to evaluate the available paths to a destination network and to establish the preferred path of a packet across the network.

2. How does a router determine on which interface to forward a data packet?

   The router examines the packet header to determine the destination network and then references the routing table that associates networks with outgoing interfaces.

3. What does the term *multiprotocol routing* mean?

   In multiprotocol routing, routers are capable of supporting multiple independent routing protocols and maintaining routing tables for several routed protocols concurrently. This capability allows a router to deliver packets from several routed protocols, such as IP and IPX, over the same data links.

4. What two basic router factors does a dynamic routing protocol depend on?

   - **Maintenance of a routing table**
   - **Timely distribution of knowledge—in the form of routing updates—to other routers (that is, convergence)**

5. What does the term *convergence* mean in network implementation?

   When all routers in a network are operating with the same knowledge, the network is said to have converged.

Vocabulary Exercise

Define the following terms as completely as you can. Use the online curriculum or Chapter 4 of the *Cisco Networking Academy Program CCNA 3 and 4 Companion Guide*, Third Edition, for help.

Diffusing Update Algorithm (DUAL)—EIGRP routers converge quickly because they rely on a state-of-the-art routing algorithm called the Diffusing Update Algorithm (DUAL). DUAL guarantees loop-free operation at every instant throughout a route computation and allows all routers involved in a topology change to synchronize at the same time

feasible distance—the lowest calculated metric to each destination.

Feasible successor—A backup route. These routes are selected at the same time the successors are identified, but they are kept in the *topology* table. Multiple feasible successors for a destination can be retained in the topology table.

Hold Time—The interval to wait without receiving anything from a neighbor before considering the link unavailable.

Neighbor address—The network-layer address of the neighbor router.

neighbor table—Each EIGRP router maintains a neighbor table that lists adjacent routers. This table is comparable to the adjacency database used by OSPF. There is a neighbor table for each protocol that EIGRP supports.

Queue count—Indicates the number of packets waiting in queue to be sent. If

4. EIGRP is sometimes called a(n) _____ routing protocol.

   Some of the specific advantages of EIGRP include the following:

   _____ _____. EIGRP routers store every path they have learned to every destination in the network. Therefore, a router running EIGRP can quickly _____ on an alternative route after any topological change.

   Efficient use of _____ *during convergence*. EIGRP does not make periodic updates. Instead, it sends partial updates about a route when the path changes or when the metric for that route changes.

   When path information changes, the _____ algorithm sends an update about that link only, rather than about the entire table. In addition, the information is sent to only the routers that need it, in contrast to link-state protocol operation, which sends a change update to all routers in an area. In EIGRP, this is known as a _____, _____ _____.

   Minimal consumption of bandwidth when the network is stable. During normal, stable network operation, the only EIGRP packets exchanged between EIGRP nodes are _____ packets.

   Complete independence from routed protocols. EIGRP is designed to be completely independent of routed protocols. Support for routed protocols is via individual, protocol-specific _____.

   Multiple network-layer support. EIGRP supports _____ _____, _____, and _____ _____ through the use of protocol-dependent modules (PDMs).

5. EIGRP supports _____ RIP and SAP updates. EIGRP sends out RIP and SAP updates only when _____ _____, and it sends out only the _____ information.

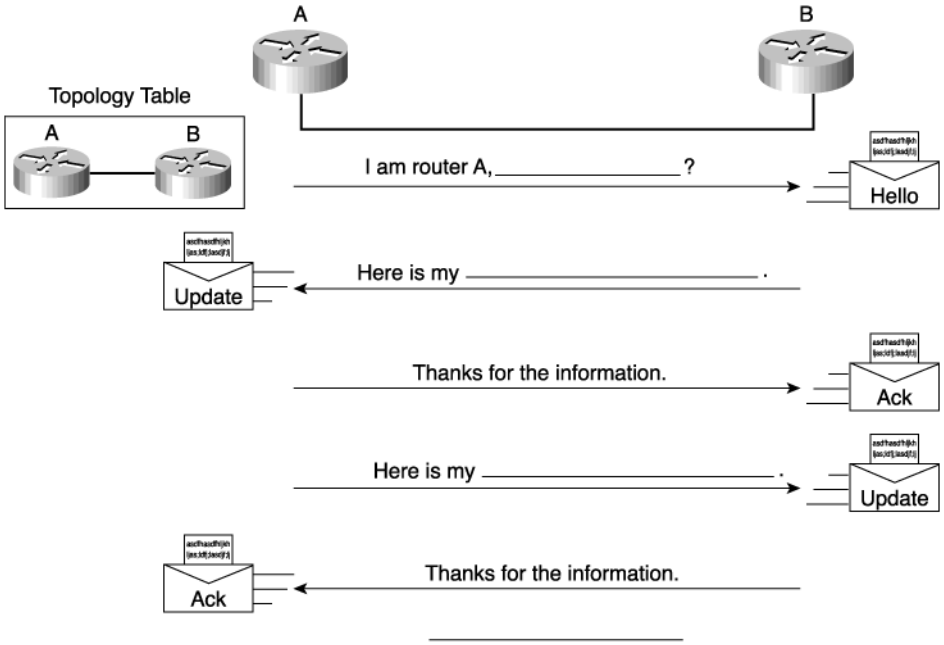
6. EIGRP IPX networks have a diameter of ____ hops, instead of IPX RIP's ___-hop diameter.

   EIGRP for Novell IPX provides optimal path selection. EIGRP for IPX uses _____ and _____ to determine the best route to a destination.

   Redistribution of NetWare Link Services Protocol (NLSP) is _____ starting with Cisco IOS Release _____. NLSP is Novell's link state routing protocol for IPX-based networks.

7. Fill in the steps in Figure 4-1 for EIGRP routers to converge.

Figure 4-1 Fill in the EIGRP Convergence Steps



8. EIGRP includes many new technologies, each of which represents an improvement in operating efficiency, rapidity of convergence, or feature/functionality relative to IGRP and other routing protocols. These technologies fall into one of the following four categories:

   Neighbor _____ and _____

   _____ Transport Protocol

   _____ finite-state machine

   Protocol-specific _____

9. The basis for maintaining routing tables is a _____ communication between EIGRP routers. They use this process to

   _____ learn of new routers that join their network

   _____ routers that become either unreachable or inoperable

   _____ routers that were previously unreachable

10. EIGRP was given a new protocol, the _____ _____ _____ (____), to provide reliable delivery of its own packets.

11. RTP is a transport-layer protocol that correlates to the functionality identified by Layer ___ of the OSI reference model.

12. RTP can support both reliable and unreliable delivery of _____.

13. The centerpiece of the new EIGRP technologies is _____, the EIGRP route-calculation engine.

    The full name of the EIGRP engine is _____ _____-_____ _____.

14. A _____ _____ is a neighbor router that is the next hop in a least-cost path to any given destination. It is a path that is loop-free according to the _____ ____.

15. EIGRP uses many different tables, each dedicated to organizing and storing data pertinent to a specific facet of the network. They are

    The _____ table

    The _____ table

    The _____ table

16. The single most important table in EIGRP is the _____ table. The _____ relationships tracked in this table are the basis of all the EIGRP routing update and convergence activity.

17. Additionally, a neighbor table is used to support reliable, _____ delivery of packets.

    _____ numbers are used to acknowledge specific packets that were delivered reliably.

    EIGRP records the number of the last message received from each _____.

18. The routing table contains the lowest-metric routes that _____ calculated for all known destinations. A _____ routing table is maintained for each _____ _____ that EIGRP is configured to support.

19. EIGRP uses its _____ table to store all the information it needs to calculate a set of distances and vectors to all known and reachable destinations. A _____ topology table is maintained for each protocol-dependent module being used by EIGRP. This table includes the following:

    The _____ of the slowest interface in the path to a destination effectively limits the route's performance and is used to calculate the route composite metric.

_____ _____. This field contains the sum total of delay values in that route.

The path's _____ is also recorded in the topology table.

The path's _____ level is another IGRP metric that has been retained by EIGRP.

The MTU field contains the size of the _____ maximum transmission unit (MTU) supported by the router interfaces in the path.

The path's _____ _____ is the distance given by an adjacent neighbor to a specific destination.

The _____ _____ is the lowest calculated metric to each destination.

_____ _____ is the identification number of the router that originally advertised that route. This field is populated only for routes learned _____ from the EIGRP network.

20. To see the entire contents of the EIGRP topology table, execute this command:
    _____

21. Entries in a topology table can be in one of two states: _____ or _____.

    An _____ route is one currently being recomputed.

22. Hello packets are used to _____ and track other EIGRP routers in the network.

    Rediscovering a lost neighbor is known as _____ or _____.

23. _____ packets are used to acknowledge the receipt of any EIGRP packet that requires reliable delivery. _____ packets are always multicast, whereas _____ are always sent to a single, specific IP address. This is known as _____.

24. The _____ packet is used to convey routing information to known destinations.

    _____ packets are used whenever a router needs specific information from one or all of its neighbors. They are sent only when a destination becomes _____. A _____ packet is used to respond to a query.

25. The command to see the neighbor table is

```
show ip eigrp neighbors
```

Focus Questions Answers

1. There is only one minor difference in the algorithm that calculates the composite metric: The IGRP metric is **20** bits long, whereas the EIGRP metric is **32** bits long.

2. IGRP and EIGRP metrics are directly comparable; therefore, they can be used **interchangeably** after translation. EIGRP does, however, track the translated IGRP routes as **external** routes.

3. Automatic **redistribution** between IGRP and EIGRP will occur only if the two protocols are configured with the same **autonomous system (AS**) number. If they have different **AS** numbers, they will assume that they are part of different networks

4. EIGRP is sometimes referred to as a **hybrid** routing protocol

5. Some of the specific advantages of EIGRP include the following:

   Rapid convergence --- EIGRP routers store every path they have learned to every destination in the network. Therefore, a router running EIGRP can quickly **converge** on an alternative route after any topological change.

   *Efficient use of **bandwidth** during convergence* --- EIGRP does not make periodic updates. Instead, it sends partial updates about a route when the path changes or when the metric for that route changes.

   When path information changes, the **DUAL** algorithm sends an update about that link only, rather than about the entire table. In addition, the information is sent only to the routers that need it, in contrast to link-state protocol operation, which sends a change update to all routers in an area. In EIGRP, this is known as a ***partial, bounded update***.

   Minimal consumption of bandwidth when the network is stable --- During normal, stable network operation, the only EIGRP packets exchanged between EIGRP nodes are **hello** packets.

   Support for VLSM and CIDR --- EIGRP supports the definition of network and host numbers on any bit boundary, per interface, for both IP addresses and subnet masks.

Complete independence from routed protocols --- EIGRP is designed to be completely independent of routed protocols. Support for routed protocols is via individual, protocol-specific **modules**.

Multiple network-layer support --- EIGRP supports **AppleTalk**, **IP**, and **Novell NetWare** through the use of protocol dependent modules (PDMs).

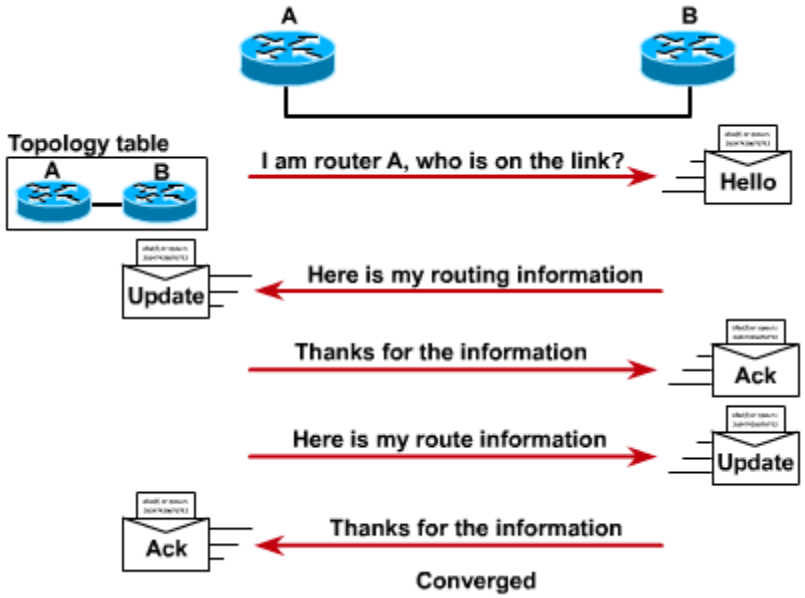
6. EIGRP supports **incremental** RIP and SAP updates. EIGRP sends out RIP and SAP updates only when **changes occur**, and only sends out the **changed** information.

7. EIGRP IPX networks have a diameter of **224** hops, instead of IPX RIP's **15**-hop diameter.

   EIGRP for Novell IPX provides optimal path selection. EIGRP for IPX uses **bandwidth** and **delay** to determine the best route to a destination.

   Redistribution of NetWare Link Services Protocol (NLSP) is **automatic** starting with Cisco IOS Release **11.1**. NLSP is Novell's link state routing protocol for IPX-based networks.

8. Fill in the steps for EIGRP routers to converge:



9. EIGRP includes many new technologies, each of which represents an improvement in operating efficiency, rapidity of convergence, or feature/functionality relative to IGRP and other routing protocols. These technologies fall into one of the following four categories:
   -----Neighbor **discovery** and **recovery**

-----**Reliable** Transport Protocol
-----**DUAL** finite-state machine
-----Protocol-specific **modules**

10. The basis for maintaining routing tables is a **periodic** communication between EIGRP routers. They use this process to:
    -----**Dynamically** learn of new routers that join their network
    -----**Identify** routers that become either unreachable or inoperable
    -----**Rediscover** routers that had previously been unreachable

11. EIGRP was given a new protocol, the **Reliable Transport Protocol** (**RTP**), to provide reliable delivery of its own packets.

12. RTP is a transport-layer protocol that correlates to the functionality identified by Layer **4** of the (OSI) reference model

13. RTP can support both reliable and unreliable delivery of **datagrams**

14. The centerpiece of the new EIGRP technologies is **DUAL**, the EIGRP route-calculation engine.
    The full name of the EIGRP engine is **DUAL finite-state machine**.

15. A ***feasible successor*** is a neighbor router that is the next hop in a least-cost path to any given destination. It is a path that is loop free according to the **DUAL FSM**

16. EIGRP uses many different tables, each dedicated to organizing and storing data pertinent to a specific facet of the network. They are:
    The **neighbor** table
    The **routing** table
    The **topology** table

17. The single most important table in EIGRP is the **neighbor** table. The **neighbor** relationships tracked in this table are the basis for all of the EIGRP routing update and convergence activity.

18. Additionally, a neighbor table is used to support reliable, **sequenced** delivery of packets.
    Sequence numbers are used to acknowledge specific packets that were delivered reliably.
    EIGRP records the number of the last message received from each **neighbor**.

19. The routing table contains the lowest-metric routes that **DUAL** calculated for all known destinations. A **separate** routing table is maintained for each **routed protocol** that EIGRP is configured to support.

20. EIGRP uses its **topology** table to store all the information it needs to calculate a set of distances and vectors to all known and reachable destinations. A **separate** topology table is maintained for each protocol-dependent module being used by EIGRP This table includes:

    -----The **bandwidth** of the slowest interface in the path to a destination effectively limits the performance of the route and is used to calculate the route composite metric.
    -----*Total delay* --- This field contains the sum total of delay values in that route.
    ----- The **reliability** of the path is also recorded in the topology table.
    ----- The **load** level of the path is another of the IGRP metrics that has been retained by EIGRP.
    ----- *MTU* --- This field contains the size of the **smallest** maximum transmission unit (MTU) supported by the router interfaces in the path.
    ----- The **reported distance** of the path is the distance given by an adjacent neighbor to a specific destination.
    ----- The **feasible distance** is the lowest calculated metric to each destination.
    ----- ***Route source*** --- This is the identification number of the router that originally advertised that route. This field is populated only for routes learned **externally** from the EIGRP network.

21. To see the entire contents of the EIGRP topology table, execute this command:
    show ip eigrp topology all

22. Entries in a topology table can be in one of two states: **active** or **passive**. An **active** route is one currently being recomputed.

23. Hello packets are used to **discover** and track other EIGRP routers in the network.
    Rediscovering a lost neighbor is known as ***recovery*** or ***rediscovery***.

24. **Acknowledgment** packets are used to acknowledge receipt of any EIGRP packet that requires reliable delivery. **Hello** packets are always multicast, whereas **acknowledgments** are always sent to a single, specific IP address. This is known as ***unicasting***.

25. The **update** packet is used to convey routing information to known destinations.
    Query packets are used whenever a router needs specific information from one or all of its neighbors. They are only sent when a destination becomes **active**. A **reply** packet is used to respond to a query.

CCNA Exam Review Questions

The following questions help you review for the CCNA exam. The answers appear in Appendix A, "Answers to CCNA Exam Review Questions."

1. How do you configure automatic redistribution between IGRP and EIGRP?

   A. Configure the two protocols with different AS numbers.
   B. Configure the two protocols with different DS numbers.
   C. Configure the two protocols with the same AS numbers.
   D. Configure the two protocols with the same DS numbers.

2. Which protocol combines the advantages of link-state and distance-vector routing protocols?

   A. RIP
   B. OSPF
   C. IGRP
   D. EIGRP

3. Which algorithm is used to achieve rapid convergence?

   A. Dijkstra's algorithm
   B. Diffusing Update Algorithm
   C. Convergence algorithm
   D. Dual convergence algorithm

4. Which protocol does EIGRP support through the use of protocol-dependent modules (PDMs)?

   A. IS-IS
   B. SNMP
   C. Novell NetWare
   D. DHCP

5. Which table includes route entries for all destinations that the router has learned and is maintained for each configured routing protocol?

   A. Topology table
   B. Routing table

C. Neighbor table

D. Successor table

6. Which of the following establishes adjacencies in EIGRP?

A. DUAL finite-state machine

B. Hello packets

C. Topology table

D. Reliable transport protocol

7. Which of the following guarantees ordered delivery of EIGRP packets to all neighbors?

A. DUAL finite-state machine

B. Hello packets

C. Topology table

D. Reliable transport protocol

8. What does DUAL do after it tracks all routes, compares them, and guarantees that they are loop-free?

A. Inserts lowest-cost paths into the routing table

B. Determines the optimal path and advertises it to the neighbor routers using hello packets

C. Supports other routed protocols through PDMs

D. Sends a unicast query to the neighboring routers

9. How does EIGRP prevent routing loops from occurring with external routes?

A. By rejecting external routes tagged with a router ID identical to their own

B. By storing the identities of neighbors that are feasible successors

C. By rejecting all neighboring routers that have an advertised composite metric that is less than a router's best current metric

D. By storing all neighboring routes that have loops identified in a special table

10. On higher-bandwidth connections, such as point-to-point serial links or multipoint circuits, how long is the hello interval used by EIGRP?

A. 5 seconds

B. 10 seconds

C. 60 seconds

D. 120 seconds

