Dynamic Routing Protocol : EIGRP

Enhanced Interior Gateway Routing Protocol

1. Introduction

- **EIGRP** = Enhanced Interior Gateway Routing Protocol.

- Developed by **Cisco** (proprietary until 2013; then parts of it were made open).

- **Type**: Advanced Distance Vector (also has some Link-State features → "Hybrid Protocol").

- **Uses DUAL (Diffusing Update Algorithm)** for loop-free, efficient routing.

- **Supports multiple protocols**: IPv4, IPv6, IPX, AppleTalk (historically).

- **Protocol Number**: Uses protocol number **88** (not TCP/UDP).

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2. Features of EIGRP

- **Classless protocol** (supports VLSM, CIDR).

- **Fast convergence** with DUAL.

- **Unequal-cost load balancing** (unique among IGPs).

- **Supports summarization** (manual + automatic).

- **Scalable** – suitable for large networks.

- **Metric calculation** based on bandwidth, delay, reliability, load, MTU.

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3. EIGRP Administrative Distance (AD)

- **Internal EIGRP routes** → AD = **90** (very reliable, preferred over OSPF/RIP).

- **External EIGRP routes** → AD = **170** (learned via redistribution from another protocol).

- **Summary routes** → AD = **5**.

👉 AD values make **EIGRP one of the best Interior Gateway Protocols (IGPs)** in Cisco-only networks.

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4. Best Interior Routing Protocol

- **EIGRP** is often considered the **best IGP in Cisco-only environments** due to:

    o Faster convergence than OSPF.

    o Loop-free backup paths (Feasible Successors).

    o Unequal-cost load balancing (unique feature).

- However, in **multi-vendor networks**, **OSPF/IS-IS** is preferred because EIGRP was Cisco-proprietary.

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5. EIGRP Packet Types

EIGRP runs directly over IP, and uses different packet types:

1. **Hello** – Neighbor discovery & keepalive (multicast 224.0.0.10).

2. **Update** – Sends routing updates (only partial & bounded, not full table).

3. **Query** – When no feasible successor exists, asks neighbors for alternative path.

4. **Reply** – Response to a query.

5. **ACK** – Acknowledges receipt of updates.

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6. EIGRP Tables

EIGRP maintains **three tables**:

1. **Neighbor Table** – List of directly connected EIGRP routers (formed via Hello).

2. **Topology Table** – All possible routes learned (successors + feasible successors).

3. **Routing Table** – Best routes (successors) chosen and installed in the global routing table.

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7. EIGRP Route Selection (DUAL Algorithm)

- **Successor**: Best (lowest metric) route.

- **Feasible Successor (FS)**: Backup route, must satisfy **Feasibility Condition**:

- o   Advertised Distance (AD) < Feasible Distance (FD).

- **Feasibility Distance (FD)**: Lowest calculated metric to reach a destination.

- **Advertised Distance (AD)**: Neighbor's reported distance to reach a destination.

👉 This ensures **loop-free paths**.

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8. EIGRP Metric Calculation

EIGRP metric uses formula (by default only bandwidth + delay considered):

Metric=(Bandwidth+Delay)×256\text{Metric} = \left(\text{Bandwidth} + \text{Delay} \right) \times 256Metric=(Bandwidth+Delay)×256

Where:

- **Bandwidth** = 10^7 / (min bandwidth in kbps)

- **Delay** = sum of delays (in tens of microseconds)

(Load and Reliability can also be included but usually left default.)

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9. EIGRP Administrative Distance

- **Internal EIGRP routes**: AD = 90

- **External EIGRP routes**: AD = 170

- **Summary routes**: AD = 5

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10. EIGRP Operation Steps

1. **Neighbor Discovery** (via Hello packets).

2. **Topology Exchange** (updates exchanged, neighbors build topology table).

3. **Route Selection** (DUAL picks best successor and feasible successor).

4. **Convergence** (fast, loop-free via FS or query-reply if needed).

5. **Route Maintenance** (Hello/ACK keeps neighbors alive).

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11. EIGRP Configuration (Cisco IOS Example)

Basic IPv4 Config

Router(config)# router eigrp 100   # 100 = AS number (must match)

Router(config-router)# network 10.0.0.0

Router(config-router)# network 192.168.1.0

Router(config-router)# no auto-summary

Router(config-router)# end

Router# show ip eigrp neighbors

Router# show ip eigrp topology

Router# show ip route eigrp

IPv6 Config

Router(config)# ipv6 unicast-routing

Router(config)# interface g0/0

Router(config-if)# ipv6 eigrp 10

Router(config)# ipv6 router eigrp 10

Router(config-rtr)# no shutdown

Router(config-rtr)# end

Router# show ipv6 eigrp neighbors

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12. EIGRP Load Balancing

- Supports **Equal-cost load balancing** (default like OSPF, RIP).

- Supports **Unequal-cost load balancing** using **variance** command:

Router(config-router)# variance 2

(This allows routes up to 2× metric of successor to be used.)

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13. Advantages of EIGRP

- Faster convergence than RIP/OSPF.

- Low CPU and bandwidth usage (partial, bounded updates).

- Loop-free due to DUAL.

- Supports VLSM, summarization.

- Unequal cost load balancing.

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14. Disadvantages of EIGRP

- Cisco proprietary (limited use with non-Cisco devices).

- More complex than RIP.

- Less popular in multi-vendor networks (OSPF/IS-IS preferred there).

✅ **Summary**:
EIGRP is a hybrid, Cisco-proprietary routing protocol that combines the simplicity of distance vector with the efficiency of link-state. Using DUAL, it ensures loop-free and rapid convergence, making it highly scalable and reliable for medium-to-large Cisco-based networks.

⚙️ **Working of EIGRP**

EIGRP operates in a **step-by-step cycle**:

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1. Neighbor Discovery (Hello Protocol)

- Routers send **Hello packets** (multicast 224.0.0.10) to discover other EIGRP routers.

- Conditions to become neighbors:

    o Must be in the **same Autonomous System (AS)**.

    o Must use the **same K-values** (metric weights).

    o Must be in the **same primary subnet**.

- Once established, they exchange **Hello messages periodically** (default 5s on high-speed links, 60s on low-speed).

👉 Output: **Neighbor Table** is formed.
Command:

show ip eigrp neighbors

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2. Topology Exchange

- After forming neighbors, routers send **Update packets** (only partial, not full tables).

- Each router advertises routes it knows to its neighbors.

- Updates are **reliable** (ACK required).

👉 Output: **Topology Table** is created with all possible routes.
Command:

show ip eigrp topology

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3. Route Selection (DUAL Algorithm)

- For every destination, EIGRP calculates:

    o **Feasible Distance (FD)** → best total metric from this router to destination.

- o **Advertised Distance (AD)** → metric reported by neighbor.

- The router selects:

    - o **Successor** (best path, lowest FD).

    - o **Feasible Successor (backup)** if AD < FD.

- If no Feasible Successor exists → router sends **Query packets** asking for alternative paths → neighbors reply with **Reply packets**.

👉 Output: **Best routes installed in Routing Table**.
Command:

show ip route eigrp

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4. Convergence

- If a route fails:

    - o If **Feasible Successor exists** → router switches immediately (fast convergence).

    - o If no FS → router queries neighbors until an alternative route is found (slower, but still loop-free).

- Convergence is very fast compared to RIP or OSPF.

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5. Route Maintenance

- Routers keep exchanging **Hello packets** to ensure neighbors are alive.

- If a neighbor goes down (misses 3 Hellos → dead timer), EIGRP removes it from the neighbor table and recomputes routes.

🔄 Simplified Flow of EIGRP Working

1. **Hello** → Discover neighbors.

2. **Update** → Exchange routing info.

3. **DUAL** → Select best & backup routes.

4. **Routing Table** → Install successors.

5. **Maintenance** → Monitor neighbors, update when changes occur.

🖥️ **Example Scenario**

- **Router A** connects to **Router B** and **Router C**.

- Router A learns route **10.1.1.0/24** from both B and C.

- Metrics:

    o   From B → FD = 1500

    o   From C → FD = 2000

- **Successor** = B (best path).

- If C's Advertised Distance (AD) < 1500 → C becomes **Feasible Successor**.

- If B fails → A switches instantly to C.

- If no FS → A queries all neighbors to find a new path.

✅ In short:
EIGRP **discovers neighbors → shares partial updates → builds topology table → runs DUAL → installs loop-free best & backup paths → maintains routes with Hellos**.

🌐 Real Scenario: Indian ISP / Corporate Network with EIGRP

Imagine a large Indian Telecom or IT Company (e.g., Airtel, Jio, Infosys, TCS) that has offices and data centers across major cities. They use EIGRP for fast, loop-free routing between sites.

🏢 Company Setup

- Delhi (Head Office + Data Center) → Central hub, where the core servers and main internet uplink are located.

- Mumbai Branch → Large office, connected with high-speed 500 Mbps link to Delhi.

- Chennai Branch → Southern regional office, connected with 100 Mbps link.

- Nagpur Branch → Central India office, also 100 Mbps link.

- Pune Branch → Western regional office with users and local servers.

Each office has LANs (10.x.x.x networks) for PCs, laptops, and servers.

⚙️ How EIGRP Works Here

1. Neighbor Discovery

   o Routers in Delhi, Mumbai, Chennai, Nagpur, and Pune exchange Hello packets.

   o Neighbor relationships are established (Delhi ↔ Mumbai, Delhi ↔ Nagpur, etc.).

2. Topology Exchange

   o Mumbai advertises its LAN (10.192.0.0/11).

   o Pune advertises 10.0.0.0/11.

   o Delhi advertises its HQ LAN (10.128.0.0/11).

- o Each router learns about all networks ➜ builds the topology table.

3. DUAL Route Selection

   - o Delhi chooses Mumbai link (500 Mbps) as the Successor route for faster access.

   - o Chennai and Nagpur links (100 Mbps) may be Feasible Successors (backups).

   - o Pune routes through Mumbai ➜ then into Delhi for HQ servers.

4. Failure Scenario

   - o If Delhi–Mumbai link fails, traffic can reroute Delhi ➜ Nagpur ➜ Mumbai (backup path).

   - o Users in Pune can still reach HQ servers through this alternative path.

   - o This ensures no downtime for business operations like banking apps, IT services, or telecom systems.

5. Route Maintenance

   - o Hello packets keep checking if routers are alive.

   - o If a router goes down, EIGRP immediately recalculates new routes.

📌 Real-World Example

Let's say this network belongs to Infosys (just as an example).

- Employees in Pune delivery center need to access ERP servers in Delhi HQ.

- Normally, traffic goes Pune ➜ Mumbai ➜ Delhi (fastest route).

- If the Mumbai–Delhi link fails, traffic automatically reroutes Pune ➜ Mumbai ➜ Nagpur ➜ Delhi.

- Employees don't notice downtime ➜ business continuity maintained.

🗾 Analogy for India

Think of this like the Indian Railway network:

- Main station = Delhi HQ.

- Other stations = Mumbai, Pune, Chennai, Nagpur.

- If the fastest train track (Delhi–Mumbai) is blocked, trains reroute via Nagpur.

- Passengers (data packets) still reach their destination, just with a slightly longer path.

✅ In short:

Your topology can represent a real Indian corporate WAN or ISP backbone, where EIGRP ensures fast, automatic rerouting between Delhi, Mumbai, Pune, Chennai, and Nagpur, keeping critical services like IT operations, telecom billing, or banking transactions always online.

🌐 **Current Scenario: Indian Company with Branches**

Imagine an Indian company with:

- **Head Office (HQ)** in **Delhi**.

- **Branch 1** in **Mumbai**.

- **Branch 2** in **Bengaluru**.

- All three are connected using Cisco routers running **EIGRP**.

[Delhi Router] ——— [Mumbai Router]
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[Bengaluru Router]

Step-by-Step EIGRP Working in this Scenario

1. Neighbor Discovery

- Each router (Delhi, Mumbai, Bengaluru) sends **Hello packets** (multicast 224.0.0.10).

- Delhi discovers neighbors: Mumbai and Bengaluru.

- Mumbai discovers Delhi. Bengaluru discovers Delhi.
  👉 **Neighbor table created.**

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2. Topology Exchange

- Mumbai advertises it knows about **Network 10.10.1.0/24** (its branch LAN).

- Bengaluru advertises it knows about **Network 10.20.1.0/24**.

- Delhi advertises it knows about **Network 192.168.0.0/24** (HQ LAN).
  👉 Now, all routers have a **topology table** with all possible routes.

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3. Route Selection (DUAL)

- Delhi calculates best paths:

    o To Mumbai's LAN → direct link = best route (Successor).

    o To Bengaluru's LAN → direct link = best route (Successor).

- If an alternative path exists (say, via Mumbai to reach Bengaluru), DUAL checks **Feasibility Condition** and keeps it as **Feasible Successor**.
  👉 **Routing table updated with loop-free best & backup routes.**

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4. Convergence Example

- Suppose the **link between Delhi and Bengaluru** goes down.

- Delhi can no longer reach Bengaluru directly.

- If a backup path via Mumbai exists:

    o Delhi instantly switches to that backup (fast convergence).

- If not, Delhi sends a **Query** to Mumbai: "Do you know how to reach Bengaluru?"

- Mumbai replies with an alternative if available.
  👉 Network heals automatically without downtime.

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5. Route Maintenance

- Delhi, Mumbai, and Bengaluru keep exchanging **Hello packets**.

- If one router fails, neighbors detect it quickly and remove it from their table.

- EIGRP recalculates routes automatically.
  👉 The Indian company's network stays **stable, loop-free, and always online**.

🏢 Real-Life Analogy (India Example)

Think of it like **Indian Railways network**:

- Stations = Routers.

- Train tracks = Links.

- Train timetable = Routing Table.

- Station masters send updates (Hello packets) to confirm connectivity.

- If one track (Delhi → Bengaluru) is blocked, trains automatically reroute via another station (Mumbai).

- If no alternate is known, station masters **ask others** (Query/Reply) until a safe track is found.

✅ **In short:**

EIGRP ensures that if one branch link fails (like Delhi–Bengaluru), traffic automatically reroutes via another path (Delhi–Mumbai–Bengaluru), keeping the **Indian company's network reliable**.