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A study of WAN design, routing protocols and connectivity between Head office to Branch office

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ABSTRACT

An organization has 'N' numbers of remote offices (Branch offices). The organization plans to connect all branch offices to head office through Wide Area Network (Internet). Our goal is to explain how to connect both ends (Head office and Branch Office). We discuss how Internet Service Providers (ISPs) exchange routing information, packets, between each others. We will design the WAN environment and demonstrate the configuration of routers and other routing protocols i.e. Static Routing, Dynamic routing (RIP, OSPF, EIGRP) with the help of Packet tracer (Simulator). This paper will help to understand how do WAN Works.

Key Words: CSU, DSU, DCE, DTE, RIP, OSPF, EIGRP, encapsulation

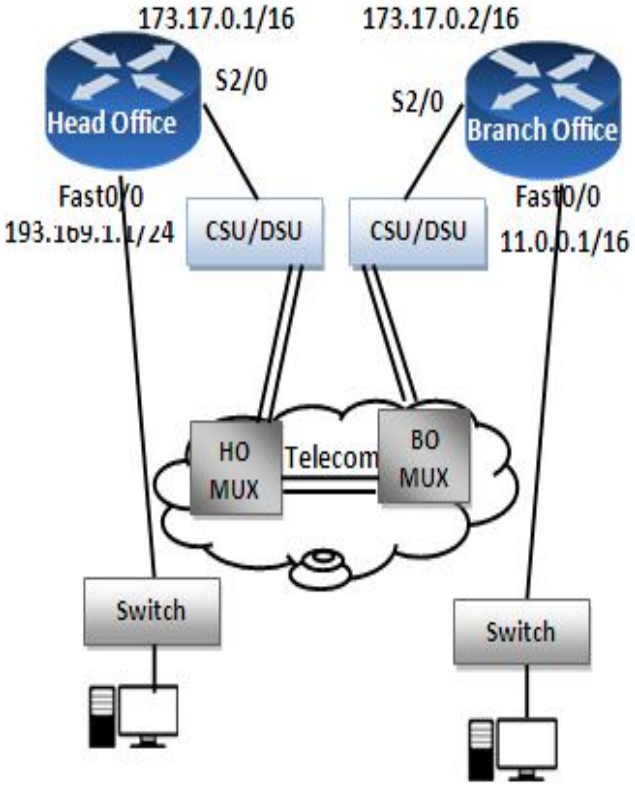


Fig. 1.0 Shows WAN Design (Head office to Branch Office Connectivity)

2.REQUIREMENTS

Packet tracer 5.0, Cisco routers (2 No.), Switches, Computers (6 No.) Cisco DTE-DCE Cable (V.35 CABLE) (Back-to-back cable), strait cables

3.LAB SETUP

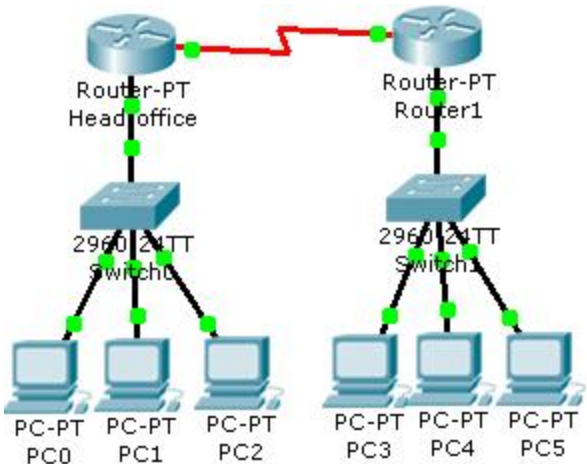


FIG. 2.0 SETUP OF LAB

3.0.1 V.35 CABLES

For communication one device should be DCE and other should be DTE. V.35 Cables can carry data for a distance of 5 Meters. Where the distance between two routers is less than 5 meters a v.35 back-to- back cable is used to replace the copper wire CSU, DSU and MUX.

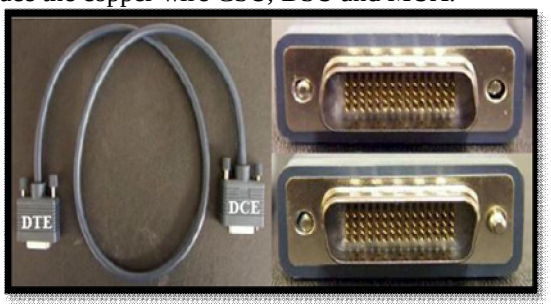


Fig. 2.0 v.35 (Back to back cable)

3.0.2 STRAIGHT CABLE

You usually use straight cable to connect different type of devices. This type of cable will be used most of the time and can be used to:

a. Connect a computer to a switch/hub's normal port.

b. Connect a computer to a cable/DSL modem's LAN port.

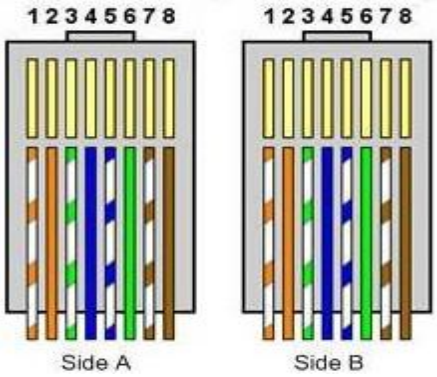
c. Connect a router's WAN port to a cable/DSL modem's LAN port.

d. Connect a router's LAN port to a switch/hub's uplink port. (Normally used for expanding network).

e. Connect 2 switches/hubs with one of the switch/hub using an uplink port and the other one using normal port. [1]

Fig. 3.0 Straight Cable

PIN ID	Side-A	Side-B
1.	Orange- White	Orange- White
2.	Orange	Orange
3.	Green-White	Green-White
4.	Blue	Blue
5.	Blue-White	Blue-White
6.	Green	Green
7.	Brown-White	Brown-White
8.	Brown	Brown



4. ENCAPSULATION

Encapsulation is a method of adding header or trailer to data. The header and trailer have information which is needed for proper conversion of data. For example, when you send an email using email program i.e. Outlook that email is sent from the Application layer to the Transport layer. The Transport layer encapsulates the data and adds its own header (with its own information, such as which port will be used) and passes the data to the Internet layer, which again encapsulates the received data and adds its own header, usually with information about the source and destination IP addresses. The Internet layer than passes the data to the Network Access layer. This layer is the only layer that adds both a header and a trailer. The data is then sent through a physical network link.
Each layer adds its own information: [2]

Frame Header	IP Header	TCP Header	Data	Frame trailer

4.0.1 TYPES OF ENCAPSULATION

4.0.1.1 Point to point protocol (PPP):

It is open standard protocol. Its supports authentication and compression. It can apply any router brands.

4.0.1.2 High Level Data Link Control (HDLC).

It is a vendor proprietary protocols it does not support for authentication and compression. It is a brand oriented. Both routers (Head office & Branch Office) should be same brand.

5.METHOD

5.0.1 HEAD OFFICE ROUTER - CONFIGURE

IOS Command Line Interface

```
Router#
Router#config ter
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostnam
Router(config)#hostname Head-Office
Head-Office(config)#interf
Head-Office(config)#interface fa0/0
Head-Office(config-if)#ip add 193.169.1.1 255.255.255.0
Head-Office(config-if)#no shut

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
o up
Head-Office(config-if)#exit
Head-Office(config)#interface s2/0
Head-Office(config-if)#ip add 173.17.0.1 255.255.0.0
Head-Office(config-if)#clock rate 64000
Head-Office(config-if)#encapsulation hdlc
Head-Office(config-if)#no shut
```

Clock rate should be given only DCE router. To check the DCE router the following command is used. In real time environment no need of clock rate.
#show controllers serial interface no.

```
Head-Office#show controllers s2/0
Interface Serial2/0
Hardware is PowerQUICC MPC860
DCE V.35, clock rate 64000
```

```
Branch-Office#show controllers s2/0
Interface Serial2/0
Hardware is PowerQUICC MPC860
DTE V.35 TX and RX clocks detected
```

5.0.2 BRANCH OFFICE ROUTER - CONFIGURE

```
Router>enable
Router#config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname Branch-Office
Branch-Office(config)#interface fa 0/0
Branch-Office(config-if)#ip add 11.0.0.1 255.0.0.0
Branch-Office(config-if)#no shut

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
o up
Branch-Office(config-if)#exit
Branch-Office(config)#interface s2/0
Branch-Office(config-if)#ip add 173.17.0.2 255.255.0.0
Branch-Office(config-if)#no shut
```

6.CONNECTIVITY-VERIFICATION

Head office router and branch office router will communicate to each others.

```
Head-Office#ping 173.17.0.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 173.17.0.2, timeout is 2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max
```

```
Branch-Office#ping 173.17.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 173.17.0.1, timeout is
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max
```

But Head office LAN and Branch office LAN will not communicate to each other due to unavailability of routes.

```
Packet Tracer PC Command Line 1.0
PC>ping 11.0.0.2

Pinging 11.0.0.2 with 32 bytes of data:

Reply from 193.169.1.1: Destination host unreachable.
Reply from 193.169.1.1: Destination host unreachable.
Reply from 193.169.1.1: Destination host unreachable.
Reply from 193.169.1.1: Destination host unreachable.

Ping statistics for 11.0.0.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

PC>
```

```
Packet Tracer PC Command Line 1.0
PC>ping 193.169.1.2

Pinging 193.169.1.2 with 32 bytes of data:

Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.

Ping statistics for 193.169.1.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

PC>
```

For communication in between Head office LAN and Branch office LAN, we will have to create the route with the help of routing protocols.

7.ROUTING

A router passes data between multiple networks. It works at layer 3 of OSI model i.e. network link layer, which means that it must be able to understand the data packets so that it can route them to their destination. Routers are essentially computers optimized for handling packets that have to be transferred between separate networks. Routers attempt to send packets from their source to their destination in the fastest way possible, which is not always the absolute shortest path. [3]

Routing is the process of moving packets from one network to another network. Routing involves two basic activities.

(i) Determining best path

(ii) Forwarding packets through these path

7.0.1 Rules of routing

Head office Ethernet interface should be in the same network as your head office Local Area Network and similarly on branch office side.

Head office serial port and branch office serial port should be in same network. Head office LAN and Branch office LAN should be in different network. All interface of router should be in different network.

7.0.2 Types of routing

(i)Static Routing

(ii) Dynamic routing

(iii) Default routing

7.0.2.1 Static Routing

Routers forward packets using either route information from route table entries that we manually configure or the route information that is calculated using dynamic routing algorithms. Static routes, which define explicit paths between two routers, cannot be automatically updated; we must manually reconfigure static routes when topology changes happen. Static routes use less bandwidth than dynamic routes. No CPU cycles are used to calculate and analyze routing updates. In this types of routing routes are manually configured by the administrator. It is secure and fast routing. The administrative distance for the static routing is 1

Administrative distance: An administrative distance is the metric used by routers to wish the best path when there are two or more routes to the similar destination from two different routing protocols. An administrative distance directs the selection of one routing protocol (or static route) over another, when more than one protocol adds the same route to the unicast routing table. Each routing protocol is prioritized in order of most to least reliable using an administrative distance value. A router prefers a static route to a dynamic route because the router considers a route with a low number to be the shortest. If you want a dynamic route to take priority over a static route, you can specify an administrative distance for the static route. For example, if you have two dynamic routes with an administrative distance of 120, you would specify an administrative distance that is greater than 120 for the static route if you want the dynamic route to take priority over the static route [5]. It is the trustworthiness of the routing information Administrative distance range is 0-255, lesser the administrative distance higher the priority.

Syntax of Static Route:

ip route <destination network ID> <destination subnet mask > <next hop IP address>

7.0.2.2 STATIC ROUTE - HEAD OFFICE

```
Head-Office#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Head-Office(config)#ip route 11.0.0.0 255.0.0.0 173.17.0.2
Head-Office(config)#
Head-Office#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
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

S    11.0.0.0/8 [1/0] via 173.17.0.2
C    173.17.0.0/16 is directly connected, Serial2/0
C    193.169.1.0/24 is directly connected, FastEthernet0/0
```

7.0.2.3 STATIC ROUTE - BRANCH OFFICE

```
Branch-Office(config)#ip route 193.169.1.0 255.255.255.0 173.17.0.1
Branch-Office(config)#
```

```
Branch-Office#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 inte
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    11.0.0.0/8 is directly connected, FastEthernet0/0
C    173.17.0.0/16 is directly connected, Serial2/0
S    193.169.1.0/24 [1/0] via 173.17.0.1
```

7.0.2.4 Communication –Head Office to Branch Office

```
PC>ping 11.0.0.2

Pinging 11.0.0.2 with 32 bytes of data:

Reply from 11.0.0.2: bytes=32 time=156ms TTL=126
Reply from 11.0.0.2: bytes=32 time=125ms TTL=126
Reply from 11.0.0.2: bytes=32 time=153ms TTL=126
Reply from 11.0.0.2: bytes=32 time=153ms TTL=126

Ping statistics for 11.0.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 125ms, Maximum = 156ms, Average = 146ms

PC>
```

7.0.2.5 Communication – Branch Office to Head Office

```
PC>ping 193.169.1.2

Pinging 193.169.1.2 with 32 bytes of data:

Reply from 193.169.1.2: bytes=32 time=156ms TTL=126
Reply from 193.169.1.2: bytes=32 time=156ms TTL=126
Reply from 193.169.1.2: bytes=32 time=156ms TTL=126
Reply from 193.169.1.2: bytes=32 time=156ms TTL=126

Ping statistics for 193.169.1.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 156ms, Maximum = 156ms, Average = 156ms

PC>
```

7.0.3 HOW TO DELETE THE ROUTE

```
Head-Office(config)#no ip route 11.0.0.0 255.0.0.0 173.17.0.2
Head-Office(config)#
```

7.0.4 DISADVANTAGES OF STATIC ROUTE

(i) Compulsory need of destination network id and destination subnet mask.

(ii) Administrative work is more due to the manual configuration of route.

(iii) It cannot dynamically updated topology change.

(iv) Used for only small organization.

7.1 DYNAMIC ROUTING

What exactly are dynamic routing protocols? Routing protocols are used to facilitate the exchange of routing information between routers. Routing protocols allow routers to dynamically learn information about remote networks and automatically add this information to their own routing tables [4]. Advertise only the directly connected network. Updates the topology changes dynamically. Administrative work is less due to automatically updates. Uses in medium and large organizations.

7.1.1 TYPES OF DYNAMIC PROTOCOLS

- **Distance vector protocol (Example: RIP)**
- **Link State protocol (Example: OSPF)**
- **Hybrid Protocol – Advance distance vector protocols (Example: EIGRP)**

7.1.1.1 Routing information protocol (RIP)

It is an open standard and class full routing protocol. Uses bellman- ford algorithm. Updates are periodically broadcast using ip address 255.255.255.255. Administrative distance is 120. Matrix: Hop count, maximum hop count 15. Load balancing on 4 equal cost paths (max 6 paths). Uses for small network. Routing updates supports maximum 25 routes. Also known as **"routing by rumor"**. Supports maximum of 16 routers.

RIP Timer

Update times: 30 Sec – time between consecutive updates

Invalid timer: 180 Sec.

- Time a router waits to hear updates; the route is marked unreachable if there is no update during this interval.

Flush times

Time before the invalid route is purged (delete) from the routing table.

```
Head-Office#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 26 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive any version
  Interface             Send  Recv  Triggered RIP  Key-chain
  FastEthernet0/0       1     2 1
  Serial2/0             1     2 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
        173.17.0.0
        193.169.1.0
Passive Interface(s):
Routing Information Sources:
        Gateway         Distance      Last Update
        173.17.0.2           120      00:00:14
Distance: (default is 120)
```

7.1.1.2 RIP CONFIGURATION - HEAD OFFICE

```
Head-Office(config)#router rip
Head-Office(config-router)#network 173.17.0.0
Head-Office(config-router)#network 193.169.1.0
Head-Office(config-router)#^Z
%SYS-5-CONFIG_I: Configured from console by console
Head-Office#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 inte
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

R    11.0.0.0/8 [120/1] via 173.17.0.2, 00:00:13, Serial2/0
C    173.17.0.0/16 is directly connected, Serial2/0
C    193.169.1.0/24 is directly connected, FastEthernet0/0
```

7.1.1.3 RIP CONFIGURATION - BRANCH OFFICE

```
Branch-Office(config)#router rip
Branch-Office(config-router)#network 11.0.0.0
Branch-Office(config-router)#network 173.17.0.0
```

```
Branch-Office#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 inte
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    11.0.0.0/8 is directly connected, FastEthernet0/0
C    173.17.0.0/16 is directly connected, Serial2/0
R    193.169.1.0/24 [120/1] via 173.17.0.1, 00:00:14, Serial2/0
```

7.1.1.4 Comparison between RIP (v1) and RIP (v2)

RIP (v1) – It is class full routing protocol. Do not advertise subnet mask information in routing update. It works with broad casting (255.255.255.255). It does not support authentication

RIP (v2) – It is classless routing protocol. Advertise subnet mask information is routing update. It works with multicasting (224.0.0.9). Support authentication

7.1.1.5 Disadvantages of RIP - More bandwidth utilization for sending updates. Doesn't consider the bandwidth in metric calculation, uses only hop counts. Slow convergence (updates routing table). Formation of routing loops (routing by rumor –row information)

7.1.1.6 Routing loops

Routing loops are found due to the default behavior of RIP where it exchanges the complete routing tables with its neighbors or due to slow network convergence (updating the routing table).

7.1.1.7 Routing loop avoidance

Built in mechanisms to avoid routing loops in distance vector routing protocols.

- **Route Poisoning** – It is a mechanism to inform about unreachable routes to neighbors.
- **Split Horizon** – A Route learned through an interface is never advertised back on the same interface it learned.
- **Hold-down timer** – Timer set to avoid inconsistent updates.
- **Flash update (Triggered update)**: Route will use flash update to intimate topology changes to neighbor.

```
Head-Office(config-router)#time basic 10 60 60 80
Head-Office#show ip protocols
Routing Protocol is "rip"
Sending updates every 10 seconds, next due in 8 seconds
Invalid after 60 seconds, hold down 60, flushed after 80
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
```

7.1.2 EIGRP: Enhance Interior Gateway Routing Protocol

Cisco proprietary and Classless routing protocol. Metric (32 bit): Composite Metric (BW + Delay) by default. Administrative distance is 90. Updates are sent through Multicast IP address (224.0.0.10). Max Hop count is 224 (100 by default). Supports IP, IPX and Apple Talk protocols

Hello packets are sent every 5 seconds Convergence rate is fast

Autonomous System – It is a collection of networks with same routing policy, Single routing protocol, usually under single ownership, trust and administrative control, Identified by a unique number. An ASN is a 16 Bit integer. [6][7]

4.4 Pool of Autonomous System Number- 1- 65535

- 0 and 65535 are reserved
- 1 – 64511 are available for use in Internet routing.
- 64512 – 65534 are designated for private use[8]

7.1.2.1 EIGRP CONFIGURATION - HEAD OFFICE

```
Head-Office(config)#router eigrp 10
Head-Office(config-router)#network 193.169.1.0
Head-Office(config-router)#network 173.17.0.0
```

```
Head-Office#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 inte
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

D    11.0.0.0/8 [90/20514560] via 173.17.0.2, 00:00:07, Serial2/0
C    173.17.0.0/16 is directly connected, Serial2/0
C    193.169.1.0/24 is directly connected, FastEthernet0/0
```

```
Head-Office#show ip eigrp topology
IP-EIGRP Topology Table for AS 10

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 193.169.1.0/24, 1 successors, FD is 28160
         via Connected, FastEthernet0/0
P 173.17.0.0/16, 1 successors, FD is 20512000
         via Connected, Serial2/0
P 11.0.0.0/8, 1 successors, FD is 20514560
         via 173.17.0.2 (20514560/28160), Serial2/0
```

```
Head-Office#show ip eigrp topology
IP-EIGRP Topology Table for AS 10

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 193.169.1.0/24, 1 successors, FD is 28160
         via Connected, FastEthernet0/0
P 173.17.0.0/16, 1 successors, FD is 20512000
         via Connected, Serial2/0
P 11.0.0.0/8, 1 successors, FD is 20514560
         via 173.17.0.2 (20514560/28160), Serial2/0
Head-Office#show ip eigrp nei
Head-Office#show ip eigrp neighbors
IP-EIGRP neighbors for process 10
H   Address         Interface       Hold Uptime    SRTT   RTO   Q   Seq
                                    (sec)          (ms)        Cnt Num
0   173.17.0.2      Se2/0           12   00:12:21  40     1000  0   6
```

7.1.2.2 EIGRP CONFIGURATION - BRANCH OFFICE

```
Branch-Office(config)#router eigrp 10
Branch-Office(config-router)#network 11.0.0.0
Branch-Office(config-router)#network 173.17.0.0
```

```
Branch-Office#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 int
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    11.0.0.0/8 is directly connected, FastEthernet0/0
C    173.17.0.0/16 is directly connected, Serial2/0
D    193.169.1.0/24 [90/20514560] via 173.17.0.1, 00:05:44, Serial2/0
```

```
Branch-Office#show ip eigrp topology
IP-EIGRP Topology Table for AS 10

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 11.0.0.0/8, 1 successors, FD is 28160
         via Connected, FastEthernet0/0
P 173.17.0.0/16, 1 successors, FD is 20512000
         via Connected, Serial2/0
P 193.169.1.0/24, 1 successors, FD is 20514560
         via 173.17.0.1 (20514560/28160), Serial2/0
```

```
Branch-Office#show ip eigrp neighbor
IP-EIGRP neighbors for process 10
H   Address         Interface      Hold Uptime    SRTT   RTO   Q   Seq
                                   (sec)          (ms)        Cnt  Num
0   173.17.0.1      Ser2/0         11   00:02:31  40     1000  0   6
```

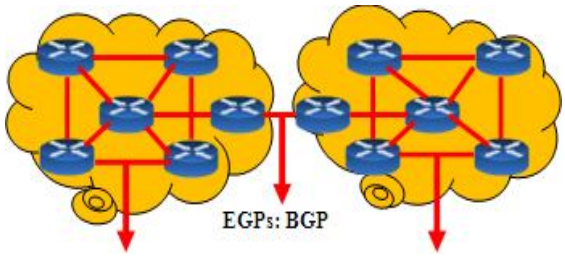
```
Branch-Office#show ip protocols

Routing Protocol is "eigrp  10 "
  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 10
  Automatic network summarization is in effect
  Automatic address summarization:
  Maximum path: 4
  Routing for Networks:
     11.0.0.0
     173.17.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    173.17.0.1      90            87153352
  Distance: internal 90 external 170
```

7.1.2.3 ROUTING PROTOCOL CLASSIFICATION

IGP - Interior Gateway Protocol- Routing protocols used within an autonomous system. All routers will be routing within the same Autonomous boundary (RIP, IGRP, EIGRP, OSPF, IS-IS)

EGP - Exterior Gateway Protocol- Routing protocol used between different autonomous systems. Routers in different AS need an EGP. Border Gateway Protocol is extensively used as EGP



EGPs: BGP

IGPs: RIP, OSPF, IGRP, EIGRP EIGRP **IGPs:** RIP,OSPF, IGRP,

HO- AS 100 **BO- AS 200**

Fig. 4.0 IGPs and EGPs

IGPs protocols operate within the autonomous system.
EGPs connect different autonomous system

7.1.2.4 EIGRP TABLES

(i)**Neighbor Table:** Contains information about directly neighbors.

(ii) **Topology Table:** Contains entries for all the destinations, along with feasible distance, any feasible successor, Advertised distance, and the calculated cost.

(iii) **Routing Table:** Entries with the best path for each destination from the Topology Table are moved into Routing Table.

7.1.2.5 EIGRP TERMINOLOGY

Feasible Distance: Feasible distance (FD) is the cost of the best route to a destination, including the local link cost.

Reported Distance: The cost of a route as advertised by the neighbor, so it does not include the local link cost if the advertised distance is less than the feasible distance, the route is tagged as a feasible successor.

Successor: The neighbor with best cost to the destination.

Feasible Successor: The neighbor with second best cost to the destination.

Disadvantages of EIGRP - Works only on Cisco Routers

7.1.3 OPEN SHORTEST PATH FIRST (OSPF) -Link State, open standard Protocol, Successor of RIP, Classless routing protocol, It uses Dijkstra (Shortest Path First (SPF)) Algorithm. Updates are sent through Multicast IP address 224.0.0.5

Administrative distance is 110. Metric = Cost $=10^8$/Bandwidth in bps (CISCO). Unlimited Hop Count. Hello packets are sent every 10 seconds. Triggered Updates. Faster Convergence. Hierarchical design with Multiple Areas. One area has to be designated as Area 0. The Area 0 is called the backbone area

Router ID- Router ID is used to identify the Router. The highest IP assigned to a logical interface (loopback) is the Router ID. If no logical interface is created then the highest IP assigned to an active physical interface.

Neighbor - Routers that share a common link become neighbors. Neighbors are created by Hello Packets. To become neighbors the following should match Area ID, Authentication, Hello and Dead Intervals

OSPF Tables - It maintains three tables:

Neighbor Table - Neighbor table contains information about the directly connected OSPF neighbors forming adjacency.

Database table- Database table contains information about the entire view of the topology with respect to each router.

Routing information Table- Routing table contains information about the best path calculated by the shortest path first algorithm in the database table.

Wild Card Mask - A wild card mask can be calculated using the formula:

Global Subnet Mask
- Customized Subnet Mask

Wild Card Mask

Example: 255.255.255.255 255.255.255.255
– 255.255.255. 0 – 255.255.255.240
---
0. 0. 0. 255 0. 0. 0. 15

7.1.3.1 DR and BDR Elections

Designated Router (DR) - Designated Router is elected whenever OSPF routers are connected to the same multi-access (broadcast) networks. This is done to reduce the number of adjacencies formed. If there is a change in topology the initial router will only update the DR and BDR but not other router. The DR or BDR in turn will update the remaining routers.

Backup Designated Router (BDR) - This is a backup to the DR and will only receive updates but will not update the other routers. If the DR goes down then the BDR will act as the DR.

DR and BDR Election is done by the Hello Packets. The router with the highest OSPF priority will become the DR and the router with the second highest priority will become BDR. On all routers the default priority is 1. In that case, the router with the highest Router ID will become the DR and the Router with the second highest ID will become the BDR.

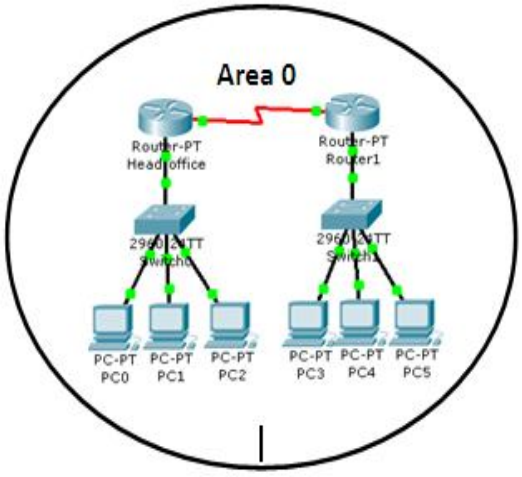


Fig. 5.0 showing area 0

7.1.3.2 OSPF CONFIGURATION - HEAD OFFICE

```
Head-Office(config)#router ospf 6
Head-Office(config-router)#network 193.169.1.0 0.0.0.255 area
Head-Office(config-router)#network 173.17.0.0 0.0.255.255 are
Head-Office#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

O    11.0.0.0/8 [110/782] via 173.17.0.2, 00:01:43, Serial2/0
C    173.17.0.0/16 is directly connected, Serial2/0
C    193.169.1.0/24 is directly connected, FastEthernet0/0
Head-Office#show ip ospf database
            OSPF Router with ID (193.169.1.1) (Process ID 6)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
193.169.1.1     193.169.1.1     204         0x80000003 0x00b8d4 3
173.17.0.2      173.17.0.2      204         0x80000003 0x008d0d 3
Head-Office#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
173.17.0.2        1   FULL/-          00:00:39    173.17.0.2      Serial2/0
```

7.1.3.3 OSPF CONFIGURATION - BRANCH OFFICE

```
Branch-Office(config)#router ospf 4
Branch-Office(config-router)# network 11.0.0.0 255.255.255.0 area 0
Branch-Office(config-router)# network 173.17.0.0 0.0.255.255 area 0
Branch-Office#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    11.0.0.0/8 is directly connected, FastEthernet0/0
C    173.17.0.0/16 is directly connected, Serial2/0
O    193.169.1.0/24 [110/782] via 173.17.0.1, 00:00:00, Serial2/0
Branch-Office#show ip ospf database
            OSPF Router with ID (173.17.0.2) (Process ID 4)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
173.17.0.2      173.17.0.2      183         0x80000003 0x008d0d 3
193.169.1.1     193.169.1.1     183         0x80000003 0x00b8d4 3
Branch-Office#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
193.169.1.1       1   FULL/-          00:00:35    173.17.0.1      Serial2/0
```

7.1.3.4 Disadvantages of OSPF - Consumes More Memory and CPU processing. Complex configuration

8.RESULT AND DISCUSSION

After WAN-Lab setup. We have seen that both routers (Head office and Branch office) are communicating to each other but their respective LANs are not communicating to each other. Then we have configured the STATIC (manually) routing protocols. But still Head office PCs is not communicating to Branch office PC. Subsequently we have configured the gateway IP address (IP address of their respective router's Ethernet port) in both ends PC. Once again I tried to ping Head office PC to Branch office PC and I found successful reply.

Besides of Static routing protocol, we have also configured the different types of dynamic routing protocols i.e. RIP, EIGRP, OSPF, and we have found the successful result. The EIGRP protocol works only CISCO routers.

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