

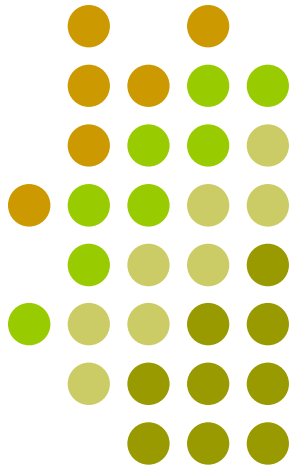


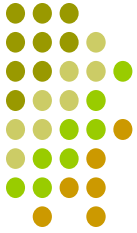
**CCNA**

640-801



# Enhanced IGRP (EIGRP) and Open Shortest Path First (OSPF)

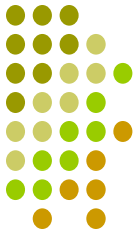




# EIGRP Features and Operation

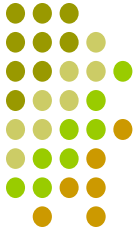
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- ❑ Enhanced IGRP (EIGRP) is a classless, enhanced distance-vector protocol that gives us a real edge over another Cisco proprietary protocol, Interior Gateway Routing Protocol (IGRP).
- ❑ Like IGRP, EIGRP uses the concept of an autonomous system to describe the set of contiguous routers that run the same routing protocol and share routing information.
- ❑ Unlike IGRP, EIGRP includes the subnet mask in its route updates.
- ❑ EIGRP is sometimes referred to as a hybrid routing protocol because it has characteristics of both distance-vector and link-state protocols.



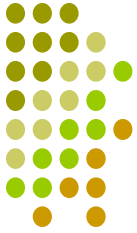
## EIGRP Features and Operation (contd.)

- ❑ EIGRP has link-state characteristics as well—it synchronizes routing tables between neighbors at startup, and then sends specific updates only when topology changes occur. This makes EIGRP suitable for very large networks. EIGRP has a maximum hop count of 255.
- ❑ There are a number of powerful features that make EIGRP a real standout from IGRP and other protocols. The main ones are listed here:
  - Support for IP, IPX, and AppleTalk via protocol-dependent modules
  - Efficient neighbor discovery
  - Communication via Reliable Transport Protocol (RTP)
  - Best path selection via Diffusing Update Algorithm (DUAL)



# Protocol-Dependent Modules

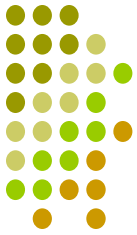
- ❑ One of the most interesting features of EIGRP is that it provides routing support for multiple Network layer protocols: IP, IPX, and AppleTalk.
- ❑ The only other routing protocol that comes close and supports multiple network layer protocols is *Intermediate System-to-Intermediate System (IS-IS)* , but it only supports IP and *Connectionless Network Service (CLNS)*
- ❑ EIGRP supports different Network layer protocols through the use of *protocol-dependent modules (PDMs)*
- ❑ Each EIGRP PDM will maintain a separate series of tables containing the routing information that applies to a specific protocol. This means there will be IP/EIGRP tables, IPX/EIGRP tables, and AppleTalk/EIGRP tables.



# Neighbor Discovery

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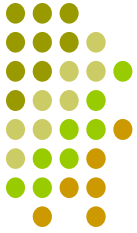
- ❑ Before EIGRP routers are willing to exchange routes with each other, they must become neighbors.
- ❑ There are three conditions that must be met for neighborship establishment:
  1. Hello or ACK received
  2. AS numbers match
  3. Identical metrics (K values)



## Neighbor Discovery (contd.)

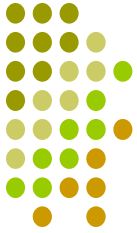
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- Hello or ACK received
  - Link-state protocols tend to use Hello messages to establish neighborhood because they normally do not send out periodic route updates.
  - There has to be some mechanism to help neighbors realize when a new peer has moved in, or an old one has left or gone down.
  - To maintain the neighborhood relationship, EIGRP routers must also continue receiving Hellos from their neighbors.



## Neighbor Discovery (contd.)

- AS numbers match
  - EIGRP routers that belong to different AS don't automatically share routing information and they don't become neighbors.
  - This behavior can be a real benefit when used in larger networks to reduce the amount of route information propagated through a specific AS.
  - The only catch is that you might have to take care of redistribution between the different AS manually.
  - The only time EIGRP advertises its entire routing table is when it discovers a new neighbor and forms an adjacency with it through the exchange of Hello packets.
  - The only time EIGRP advertises its entire routing table is when it discovers a new neighbor and forms an adjacency with it through the exchange of Hello packets.



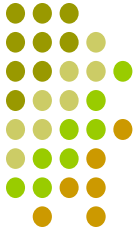
# Neighbor Discovery (contd.)

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## □ Feasible Distance

- This is the best metric along all paths to a remote network, including the metric to the neighbor that is advertising that remote network.
- This is the route that you will find in the routing table, because it is considered the best path.
- The metric of a feasible distance is the metric reported by the neighbor (called reported distance), plus the metric to the neighbor reporting the route.

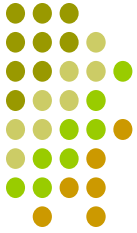




# Neighbor Discovery (contd.)

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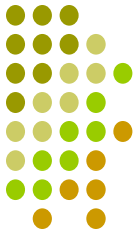
- Reported Distance
  - This is the metric of a remote network, as reported by a neighbor.
- Feasible Successor
  - A feasible successor is a path whose reported distance is less than the feasible distance, and it is considered a backup route.
  - EIGRP will keep up to six feasible successors in the topology table. Only the one with the best metric is placed in the routing table.



# Reliable Transport Protocol (RTP)

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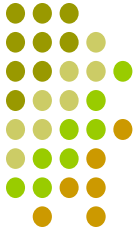
- ❑ EIGRP uses a proprietary protocol, called *Reliable Transport Protocol (RTP)*, to manage the communication of messages between EIGRP-speaking routers.
- ❑ As the name suggests, reliability is a key concern of this protocol.
- ❑ Cisco has designed a mechanism that leverages multicasts and unicasts to deliver updates quickly, and to track the receipt of the data.
- ❑ When EIGRP sends multicast traffic it uses the Class D address 224.0.0.10.



## Reliable Transport Protocol (RTP) (contd.)

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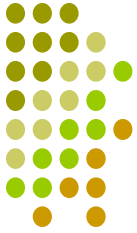
- ❑ Each EIGRP router is aware of who its neighbors are, and for each multicast it sends out, it maintains a list of the neighbors who have replied.
- ❑ If EIGRP doesn't get a reply from a neighbor, it will switch to using unicasts to resend the same data.
- ❑ If it still doesn't get a reply after 16 unicast attempts, the neighbor is declared dead. People often refer to this process as reliable multicast.



# Diffusing Update Algorithm (DUAL)

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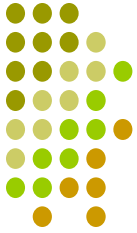
- EIGRP uses *Diffusing Update Algorithm (DUAL)* for selecting and maintaining the best path to each remote network. This algorithm allows for the following:
  - Backup route determination if one is available
  - Support of Variable-Length Subnet Masks (VLSMs)
  - Dynamic route recoveries
  - Sending out queries for an alternate route if no route can be found



# Using EIGRP to Support Large Networks

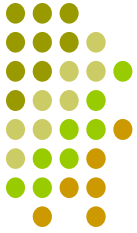
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- EIGRP includes a bunch of cool features that make it suitable for use in large networks:
  - Support for multiple AS on a single router
  - Support for VLSM and summarization
  - Route discovery and maintenance
  
- Each of these capabilities adds one small piece to the complex puzzle of supporting a huge amount of routers and multiple networks.



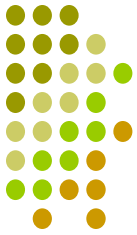
## Multiple AS

- ❑ EIGRP uses autonomous system numbers to identify the collection of routers that share route information.
- ❑ Only routers that have the same autonomous system numbers share routes.
- ❑ In large networks, you can easily end up with really complicated topology and route tables, and that can markedly slow convergence during diffusing computation operations.
- ❑ It's possible to divide the network into multiple distinct EIGRP autonomous systems, or AS.
- ❑ Each AS is populated by a contiguous series of routers, and route information can be shared among the different AS via redistribution.



## Multiple AS (contd.)

- ❑ The use of redistribution within EIGRP leads us to another interesting feature. Normally, the administrative distance of an EIGRP route is 90, but this is true only for what is known as an *internal EIGRP route*.
- ❑ These are routes originated within a specific autonomous system by EIGRP routers that are members of the same autonomous system. The other type of route is called an *external EIGRP route* and has an administrative distance of 170, which is not so good.
- ❑ These routes appear within EIGRP route tables courtesy of either manual or automatic redistribution, and they represent networks that originated outside of the EIGRP autonomous system.

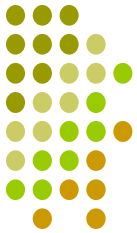


# VLSM Support and Summarization

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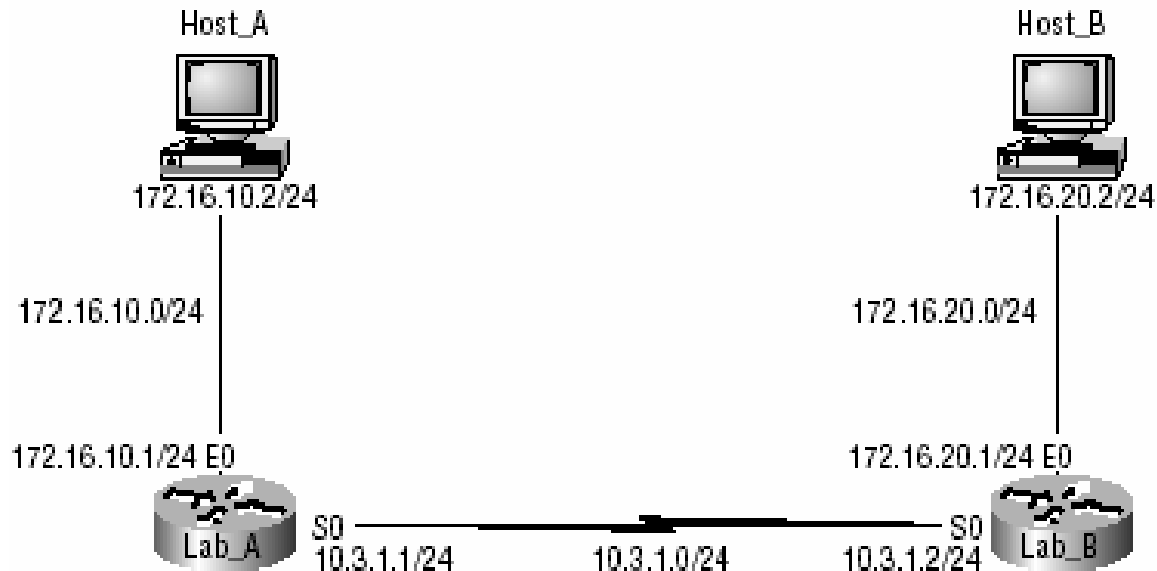
- ❑ As one of the more sophisticated classless routing protocols, EIGRP supports the use of Variable-Length Subnet Masks.
- ❑ This is really important because it allows for the conservation of address space through the use of subnet masks that more closely fit the host requirements such as using 30-bit subnet masks for point-to-point networks.
- ❑ The subnet mask is propagated with every route update, EIGRP also supports the use of discontinuous subnets, something that gives us a lot more flexibility when designing the network's IP address plan.

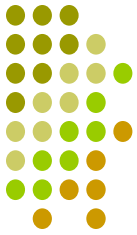




## VLSM Support and Summarization (contd.)

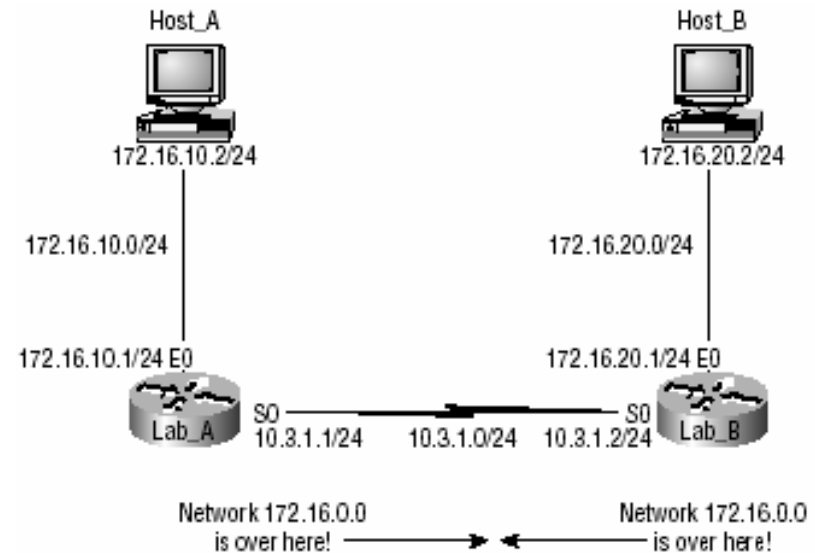
- Discontiguous network
  - It's one that has two subnetworks of a classful network connected together by different networks.
- A discontiguous network

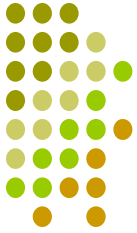




## VLSM Support and Summarization (contd.)

- EIGRP also supports the manual creation of summaries at any and all EIGRP routers, which can substantially reduce the size of the route table.
- However, EIGRP automatically summarizes networks at their classful boundaries.

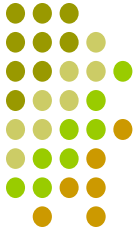




# Route Discovery and Maintenance

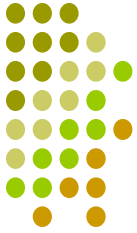
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- ❑ The hybrid nature of EIGRP is fully revealed in its approach to route discovery and maintenance.
- ❑ Like many link-state protocols, EIGRP supports the concept of neighbors that are discovered via a Hello process, and whose state is monitored.
- ❑ Like many distance-vector protocols, EIGRP uses the routing-by-rumor mechanism which implies many routers never hear about a route update firsthand. Instead, they hear about it from another router that may also have heard about it from another one, and so on.



## Route Discovery and Maintenance (contd.)

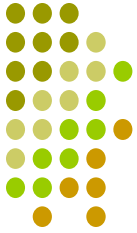
- EIGRP uses a series of tables to store important information about its environment:
  - The neighborhood table
    - (usually referred to as the neighbor table) records information about routers with whom neighborhood relationships have been formed.
  - The topology table
    - stores the route advertisements about every route in the internetwork received from each neighbor.
  - The route table
    - stores the routes that are currently used to make routing decisions. There would be separate copies of each of these tables for each protocol that is actively being supported by EIGRP, whether it's IP, IPX, or AppleTalk.



## EIGRP Metrics

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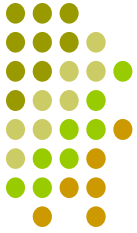
- EIGRP is that unlike many other protocols that use a single factor to compare routes and select the best possible path, EIGRP uses a combination of four:
  - Bandwidth
  - Delay
  - Load
  - Reliability
  
- Like IGRP, EIGRP uses only bandwidth and delay of the line to determine the best path to a remote network by default. Cisco sometimes likes to call these path bandwidth value and cumulative line delay



# Configuring EIGRP

---

- ❑ There are two modes from which EIGRP commands are entered: router configuration mode and interface configuration mode.
- ❑ Router configuration mode enables the protocol, determines which networks will run EIGRP, and sets global characteristics.
- ❑ Interface configuration mode allows customization of summaries, metrics, timers, and bandwidth.



# Configuring EIGRP (contd.)

```
Router#config t
```

```
Router(config)#router eigrp 20
```

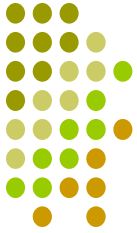
```
Router(config-router)#network 172.16.0.0
```

```
Router(config-router)#network 10.0.0.0
```

- The following command shows you how to make interface Serial 0/1 a passive interface:

```
Router(config)#router eigrp 20
```

```
Router(config-router)#passive-interface serial 0/1
```



# Verifying EIGRP

## □ EIGRP Troubleshooting Commands

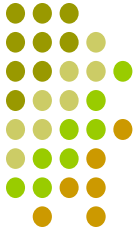
### Command

- show ip route
- show ip route eigrp
- show ip eigrp neighbors
- show ip eigrp topology

### Description/Function

- Shows the entire routing table
- Shows only EIGRP entries in the routing table
- Shows all EIGRP neighbors
- Shows entries in the EIGRP topology table

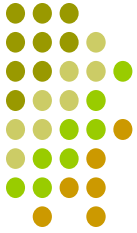




# Open Shortest Path First (OSPF) Basics

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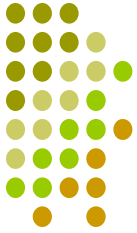
- ❑ *Open Shortest Path First (OSPF)* is an open standards routing protocol that's been implemented by a wide variety of network vendors, including Cisco.
- ❑ OSPF converges quickly, although perhaps not as quickly as EIGRP, and it supports multiple, equal-cost routes to the same destination.
- ❑ OSPF is the first link-state routing protocol that most people are introduced to, so it's useful to see how it compares to more traditional distance-vector protocols such as RIPv1.
- ❑ Refer Table 6.3 in book for comparison between OSPF AND RIPv1



## Open Shortest Path First (OSPF) Basics (contd.)

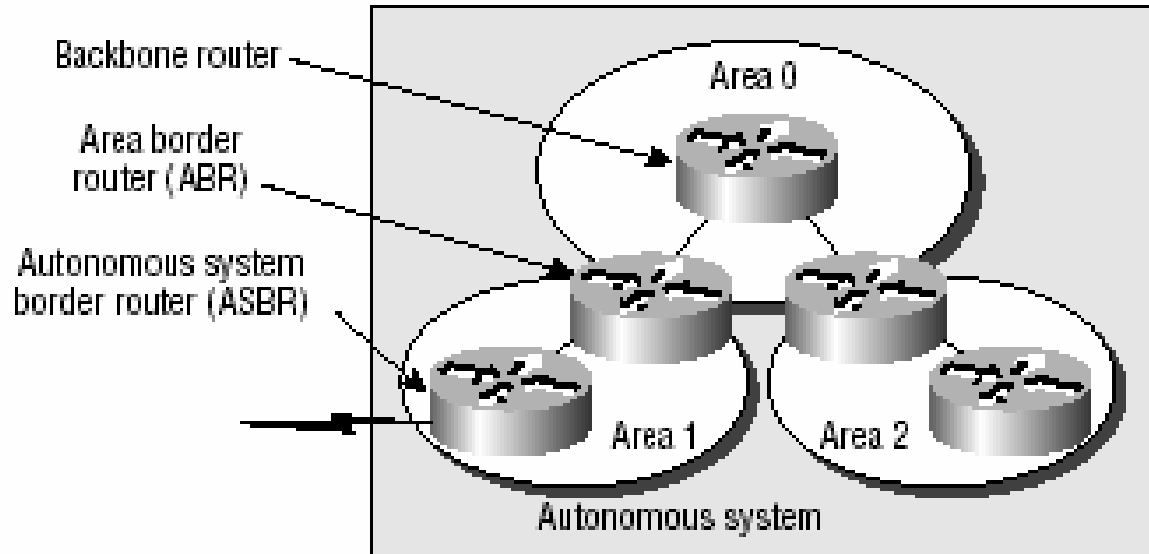
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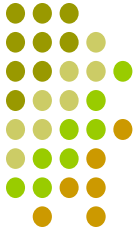
- ❑ OSPF is supposed to be designed in a hierarchical fashion, which basically means that you can separate the larger internetwork into smaller internetworks called areas.
- ❑ This is the best design for OSPF. The reasons for creating OSPF in a hierarchical design include:
  - To decrease routing overhead
  - To speed up convergence
  - To confine network instability to single areas of the network



# Open Shortest Path First (OSPF) Basics (contd.)

- OSPF runs inside an autonomous system, but can also connect multiple autonomous systems together. The router that connects these AS together is called an Autonomous System Boundary Router (ASBR).





# OSPF Terminology

---

**The following are important OSPF terms to familiarize yourself with before you proceed:**

Link

Router ID

Neighbors

Adjacency

Neighborhood database

Topology database

Link State Advertisement

Designated router

Backup designated router

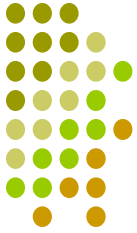
OSPF areas

Broadcast (multi-access)

No broadcast multi-access

Point-to-point

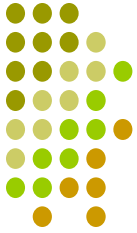
Point-to-multipoint



## SPF Tree Calculation

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- ❑ Each router calculates the best/shortest path to every network in that same area. This calculation is based upon the information collected in the topology database and an algorithm called *shortest path first (SPF)*.
- ❑ One of the key criteria considered during the route selection process of the SPF algorithm is the metric or cost of each potential path to a network. But this SPF calculation doesn't apply to routes from other areas.
- ❑ SPF calculation doesn't apply to routes from other areas.
- ❑ OSPF uses a metric referred to as cost. A cost is associated with every outgoing interface included in an SPF tree. The cost of the entire path is the sum of costs of the outgoing interfaces along the path.



# Configuring OSPF

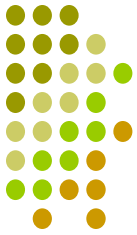
- ❑ Enabling OSPF
  - The easiest and also least scalable way to configure OSPF is to just use a single area. Doing this requires a minimum of two commands.
- ❑ The command you use to activate the OSPF routing process is:
  - ❑ Lab\_A(config)#router ospf ?
  - ❑ <1-65535>
  - ❑ Configuring OSPF Areas
  - ❑ Lab\_A#config t
  - ❑ Lab\_A(config)#router ospf 1
  - ❑ Lab\_A(config-router)#network 10.0.0.0 0.255.255.255 area ?
  - ❑ <0-4294967295> OSPF area ID as a decimal value
  - ❑ A.B.C.D OSPF area ID in IP address format
  - ❑ Lab\_A(config-router)#network 10.0.0.0 0.255.255.255 area 0



# Verifying OSPF Configuration

---

- ❑ show ip route
- ❑ show ip ospf
- ❑ show ip ospf database
- ❑ show ip ospf interface
- ❑ show ip ospf neighbor
- ❑ show ip protocols

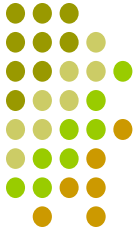


# OSPF and Loopback Interfaces

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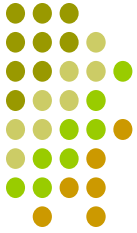
- ❑ Configuring loopback interfaces when using the OSPF routing protocol is important, and Cisco suggests using them whenever you configure OSPF on a router.
- ❑ Loopback interfaces are logical interfaces, which means they are not real router interfaces.
- ❑ The reason you want to configure a loopback interface on a router is because if you don't, the highest IP address on a router will become that router's RID.
- ❑ The RID is used to advertise the routes as well as elect the DR and BDR.





## Configuring Loopback Interfaces (contd.)

- Configuring loopback interfaces rocks mostly because it's the easiest part of OSPF configuration.
  - Lab\_A#config t
  - Enter configuration commands, one per line. End with CNTL/Z.
  - Lab\_A(config)#int loopback 0
  - Lab\_A(config-if)#ip address 172.16.10.1 255.255.255.0
  - Lab\_A(config-if)#no shut
  - Lab\_A(config-if)# ^Z



# Verifying Loopbacks and RIDs

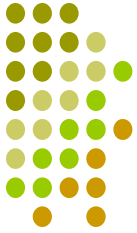
- ❑ To verify your loopback addresses, use `show running-config`—it's the easiest way to do it:

```
Lab_A#show running-config
!  
hostname Lab_A  
!  
interface Loopback0  
ip address 172.16.30.1 255.255.255.0  
!
```

```
Lab_A#show ip ospf database
```

```
  OSPF Router with ID (172.16.30.1) (Process ID 64999)  
  Router Link States (Area 0)
```

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.1	172.16.10.1	689	0x80000002	0xB404 3	
172.16.20.1	172.16.20.1	139	0x8000000A	0x4AB1 5	
172.16.30.1	172.16.30.1	138	0x80000002	0x2B14 3	



## Verifying Loopbacks and RIDs (contd.)

---

Lab\_A#**show ip ospf interface**

FastEthernet0/0 is up, line protocol is up

Internet Address 192.168.50.1/24, Area 0

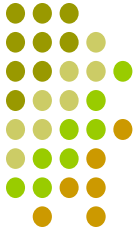
Process ID 64999, Router ID 172.16.30.1, Network Type  
BROADCAST, Cost: 10

Transmit Delay is 1 sec, State DR, Priority 1

Designated Router (ID) 172.16.30.1, Interface address  
192.168.50.1

No backup designated router on this network

*[output cut]*



## Verifying Loopbacks and RIDs (contd.)

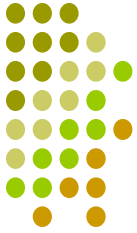
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- The show ip ospf command shows the RID in the first line of output:

```
Lab_A#show ip ospf
```

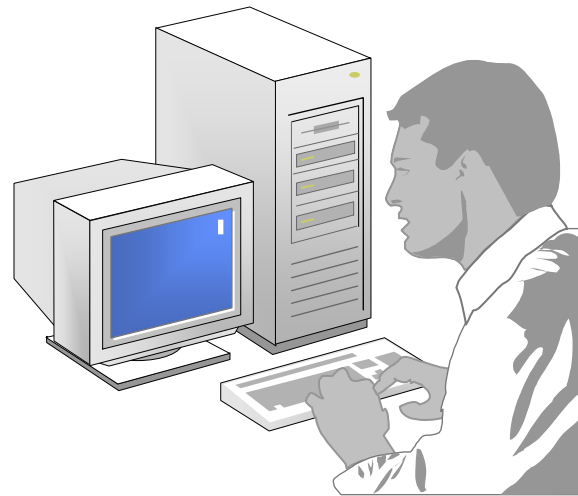
```
Routing Process "ospf 64999" with ID 172.16.30.1 and Domain ID  
0.0.253.231
```

```
[output cut]
```



## *Hands On Lab*

- ❑ *Hands On Lab 6.1 Configuring and Verifying EIGRP*
- ❑ *Hands On Lab 6.2 Enabling the OSPF process*
- ❑ *Hands On Lab 6.3 Configuring Neighbors*
- ❑ *Hands On Lab 6.4 Verifying OSPF Operation*



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