Cabrillo College

CCNP – Advanced Routing

Ch. 4 - OSPF, Single Area – Part 3 or 3

Rick Graziani, Instructor

Feb. 26, 2002

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Format of the presentation

- Instructors: If you find any misinformation or mistakes, or if you have any questions regarding the content, please email me, Rick Graziani, graziani@cabrillo.cc.ca.us - Thanks!
- I added new information for clarity and interest from Alex Zinin's book, Cisco IP Routing
- Combined different sections of McGregor's Ch. 4 on OSPF, to create a single flow of information. (Tried to.)
- Added some information from Jeff Doyle's "Routing TCP/IP Vol. I," John Moy's book on OSPF and RFC 2328, OSPF version 2 (current version).

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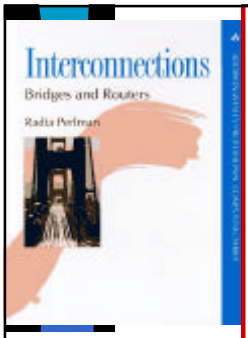
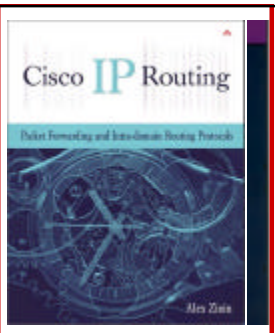
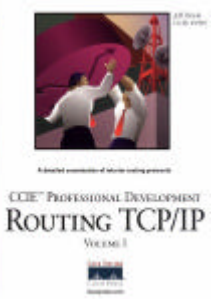


Interconnections : Bridges and Routers by Radia Perlman

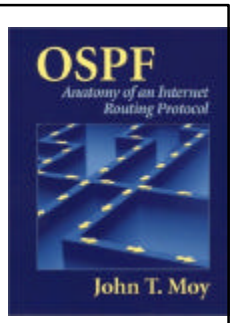


Cisco IP Routing: Packet Forwarding & Intra-domain Routing Protocols by Alex Zinin

This book has been especially helpful for information contained in these presentations.



Routing TCP/IP Volume I by Jeff Doyle



OSPF, Anatomy of an Internet Routing Protocol by John Moy (creator of OSPF)

- For more information on OSPF, link-state routing protocol, Dijkstra's algorithm and routing in general, check out these sources.

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Configuring OSPF within a Single Area

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Configuring OSPF within a Single Area

```
Rtr(config)# router ospf process-id
Rtr(config-router)#network address wildcard-mask area
   area-id
Rtr(config-router)# area area authentication [message-
   digest]


Rtr(config)# interface type slot/port
Rtr(config-if)# ip ospf priority <0-255>
Rtr(config-if)# bandwidth kbps
RTB(config-if)# ip ospf cost cost
Rtr(config-if)# ip ospf hello-interval seconds
Rtr(config-if)# ip ospf dead-interval seconds
Rtr(config-if)# ip ospf authentication-key passwd
Rtr(config-if)# ip ospf message-digest-key key-id md5
   [encryption-type] password
```

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Configuring the Process ID

```
Rtr(config)# router ospf process-id
```

- process-id: 1 - 65,535
- Cisco feature, which allows you to run multiple, different OSPF routing processes on the same router.
- **Note**: FYI - Cisco IOS limits the number of dynamic routing processes to 30. This is because it limits the number of protocol descriptors to 32, using one for connected route sources, one for static route sources, and 30 for dynamic route sources.
- Process-id is locally significant, and does **not** have to be the same number on other routers (they don't care).
- This is different than the process-id used for IGRP and EIGRP which must be the same on all routers sharing routing information.

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Network command

```
Rtr(config)# router ospf process-id
Rtr(config-router)#network address wildcard-mask
  area area-id
```

- Tells OSPF which interfaces to send and receive updates on, matching the address and wildcard mask..
- Wildcard is necessary because OSPF supports CIDR and VLSM
- Most of the time you can just use an inverse-mask (like access-lists) as the network wildcard mask.

```
Rtr(config-if)#ip add 10.5.1.1 255.255.255.0

Rtr(config)# router ospf 10
Rtr(config-router)#network 10.5.1.0 0.0.0.255 area 0
```

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Other times you may wish to get more specific or less specific.

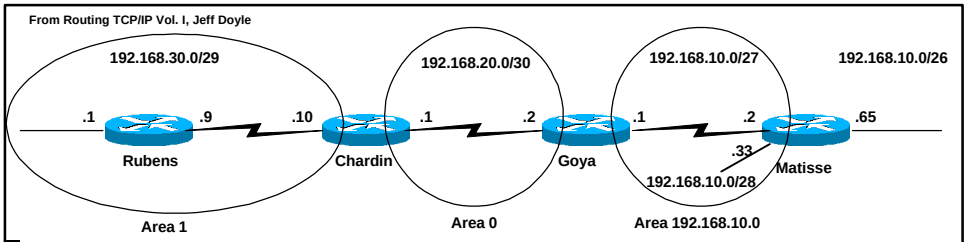
```
Rtr(config-if)#ip add 10.5.1.1 255.255.255.0

Rtr(config)# router ospf 10
Rtr(config-router)#network 0.0.0.0 255.255.255.255 area 0
```

- Matches all interfaces on this router

```
Rtr(config)# router ospf 10
Rtr(config-router)#network 10.5.1.2 0.0.0.0 area 0
```

- Matches only the interface 10.5.1.2 and not any other 10.5.1.n interfaces.

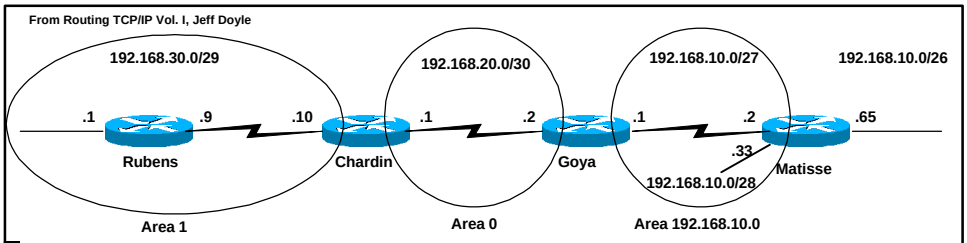
- Let's take a look at an example from Jeff Doyle's book, Routing TCP/IP Volume I.
- We will use Jeff's diagram and some of his explanations.
- Note: This is not a template of how to use the network command, but is an example showing you various options.



Rubens

```
router ospf 10
   network 0.0.0.0 255.255.255.255 area 1
```

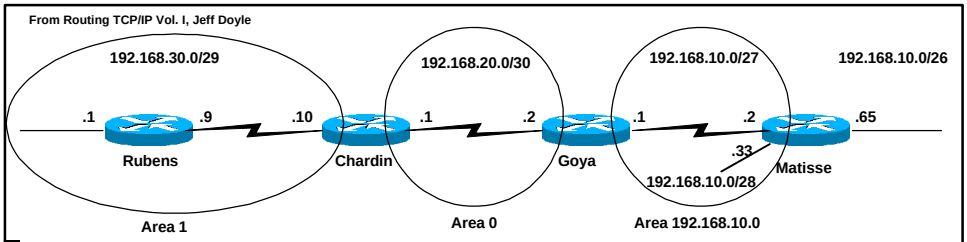
- This will match all interfaces on the router.
- The address 0.0.0.0 is just a placeholder, the inverse mask of 255.255.255.255 does the actual matching with "don't care" bits placed across the entire four octets of the address.
- This method provides the least precision control and is generally discouraged against, as you may bring up another interface on the router and you did not mean to run OSPF on that interface.



Chardin

```
router ospf 20
   network 192.168.30.0 0.0.0.255 area 1
   network 192.168.20.0 0.0.0.255 area 0
```

- Chardin is a ABR (Area Border Router) which we will discuss next chapter, and belongs to two different areas.
- We need to be more specific here as each interface belongs to a different area.
- Here we are saying that any interface that has 192.168.30.n in the first three octets belongs to area 1 and any interface that has 192.168.20.n in the first three octets belongs to area 0.
- Notice that the inverse mask does not have to inversely match the subnet mask of the interface (255.255.255.248 and 255.255.255.252).

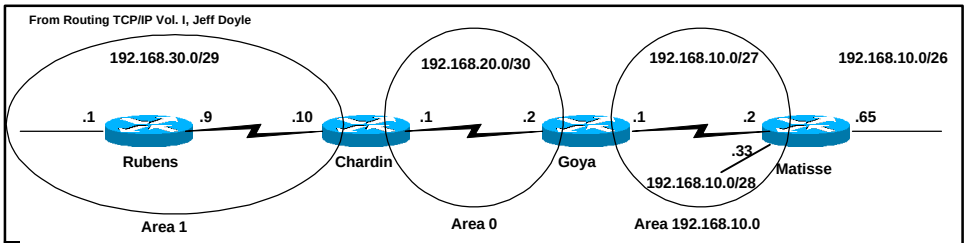


Goya

```
router ospf 30
   network 192.168.20.0 0.0.0.3 area 0.0.0.0
   network 192.168.10.0 0.0.0.31 area 192.168.10.0
```

- Goya is also an ABR.
- The network statements will only match the specific subnets configured on the two interfaces.

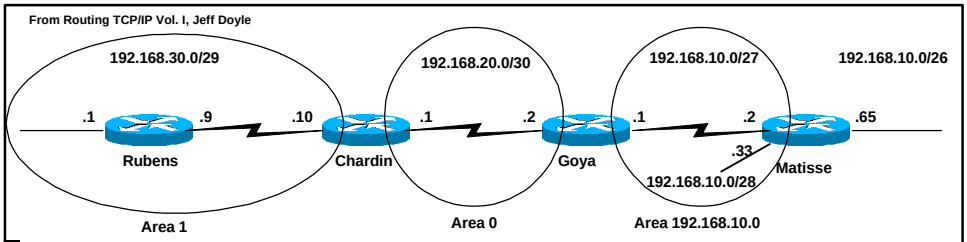
```
/30 = 255.255.255.252 = 11111100  00 = host bits
3  = 00000011  - Match last two bits of subnet mask

/27 = 255.255.255.224 = 11100000  00000 = host bits
31 = 00011111  - Match last five bits of subnet mask
```



Goya

```
router ospf 30
   network 192.168.20.0 0.0.0.3 area 0.0.0.0
   network 192.168.10.0 0.0.0.31 area 192.168.10.0
```

- Goya is also an ABR.
- Also notice that you can use an dotted decimal notation to represent an area.
- In my experience it is not very common, but when it is used, most people use the network address.
- Area 0 can be represented as 0 or 0.0.0.0.
  - When the dotted decimal is used OSPF packets are converted to "0" so the two can be compatible.



Matisse

```
router ospf 40
   network 192.168.10.2 0.0.0.0 area 192.168.10.0
   network 192.168.10.33 0.0.0.0 area 192.168.10.0
```

- Matisse has one interface, 192,168,10.65/26, which is not running OSPF.
- The network statements for this router are configured specifically for the individual addresses and the inverse mask indicates that all 32 bits must match exactly.
- This method provides the most precise control over which interfaces will run OSPF.

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Bandwidth command

```
Rtr(config-if)# bandwidth 128    (in Kbps)
```

- Set the bandwidth metric on a specific interface.

ip ospf cost command

```
RTB(config-if)# ip ospf cost 1000
```

- Configures the cost metric for a specific interface

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Loopback interface

```
Rtr(config)# interface loopback 0
Rtr(config-if)# ip add 10.1.1.1 255.255.255.0
```

- Very useful in setting Router IDs.

Configuring OSPF Router Priority (DR/BDR)

```
Rtr(config)# interface fastethernet 0
Rtr(config-if)# ip ospf priority <0-255>
```

- Higher priority becomes DR/BDR
- Default = 1
- 0 = Ineligible to become DR/BDR

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Configuring Authentication

```
Rtr(config-if)# ip ospf authentication-key passwd
or
Rtr(config-if)# ip ospf message-digest-key key-id
  md5 [encryption-type] password
```

- *password* = Clear text unless message-digest is used.
- *Key-id* = 1 to 255, must match on each router to authenticate.
- *Encryption-type* = 0 to 7, 0 is default, 7 is Cisco proprietary encryption
- After a password is configured, you enable authentication for the area on all participating area routers with:

```
Rtr(config-router)# area area authentication
  [message-digest]
```

- **message-digest** option must be used if using **message-digest-key**
- If optional message-digest is used, a message digest, or hash, of the password is sent.

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Configuring timers

```
Rtr(config-if)# ip ospf hello-interval seconds
Rtr(config-if)# ip ospf dead-interval seconds
```

- For OSPF routers to be able to exchange information, the must have the same hello intervals and dead intervals.
- By default, the hello interval is 4 times the dead interval, so the a router has four chances to send a hello packet being declared dead. (not required)

Defaults

- On broadcast networks hello interval = 10 seconds, dead interval 40 seconds.
- On non-broadcast networks hello interval = 30 seconds, dead interval 120 seconds.

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Show commands

- We will be looking at these commands in much more detail in the next chapter on Multi-area OSPF.
- Many of these commands give us specific information about areas and the routes in those areas.
- Since we have not discussed areas yet, we will only take a brief look at the command now.

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OSPF Routing Protocol Information

```
Rtr# show ip protocols
```

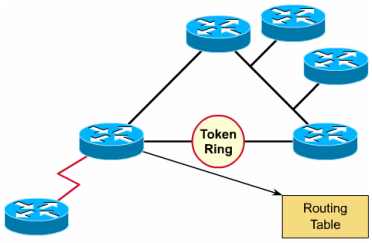
OSPF Specific Information

```
Rtr# show ip ospf
```

- Number of SPF calculations, timers, area information,...

OSPF Routing Table

```
Rtr# show ip route
```



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OSPF Interface Information

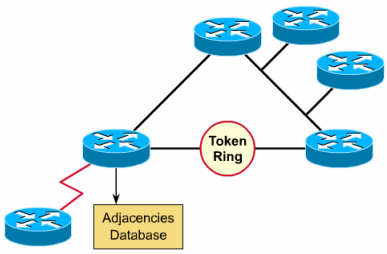
```
Rtr# show ip ospf interface
Ethernet0 is up, line protocol is up
  Internet Address 206.202.2.1/24, Area 1
  Process ID 1, Router ID 1.2.202.206, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 2.2.202.206, Interface address 206.202.2.2
  Backup Designated router (ID) 1.2.202.206, Interface address 206.202.2.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 2.2.202.206  (Designated Router)
  Suppress hello for 0 neighbor(s)
Serial0 is up, line protocol is up
  Internet Address 206.202.1.2/24, Area 1
  Process ID 1, Router ID 1.2.202.206, Network Type POINT_TO_POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:04
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 2.0.202.206
  Suppress hello for 0 neighbor(s)
```

Displaying adjacencies

```
RouterB#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.5.202.206       1   FULL/DROTHER    00:00:33    206.202.0.3     Ethernet0
1.10.202.206      1   FULL/BDR        00:00:32    206.202.0.4     Ethernet0
1.0.202.206       1   FULL/DROTHER    00:00:30    206.202.0.1     Ethernet0
1.2.202.206       1   FULL/  -        00:00:32    206.202.1.2     Serial0
```

- OSPF routers keep a list of all neighbors that they have established bi-directional communication with.



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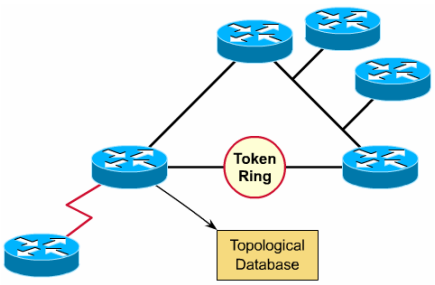
Displaying the Link State Database

```
Rtr# show ip ospf database
```

- Displays the link state database
- OSPF routers keep track of all other routers in the internetwork.
- Much more next chapter on multi-area ospf.



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NBMA

- Non-Broadcast Multi-access Access Networks.
  - Frame Relay
  - X.25
- NOTE: Consult CCNA Semester 4 or CCNP Remote Access information for specifics on Frame Relay and X.25 router configurations.
- OSPF over Frame Relay

  http://www.cisco.com/warp/public/104/22.html

  http://www.cisco.com/warp/public/125/26.html

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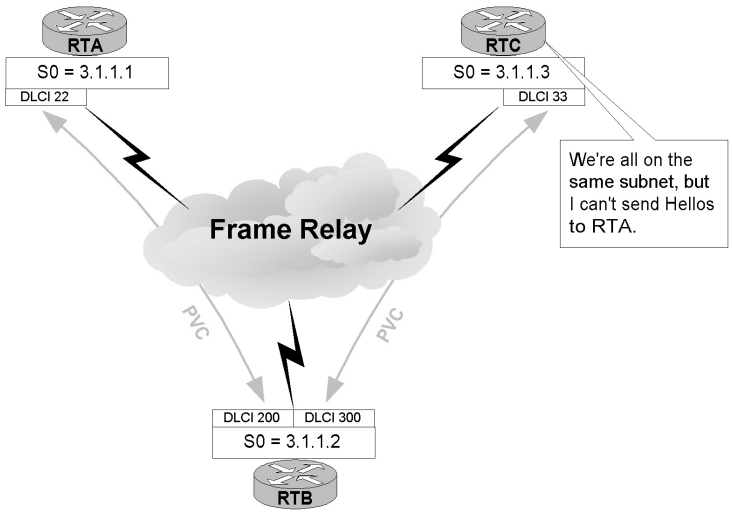
NBMA Networks and OSPF



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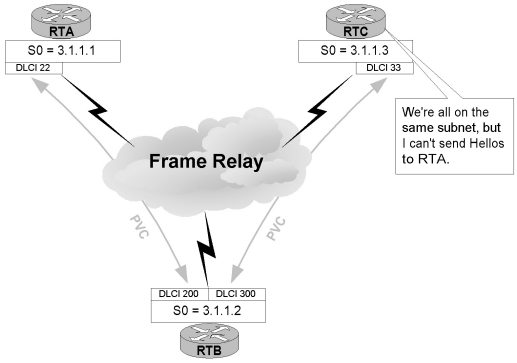
NBMA Networks and OSPF

Two issues of concern regarding Frame Relay and OSPF:

- network type mismatches
- hello and dead timer mismatches

- Both ends of the PVC must be configured the same.



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NBMA Networks and OSPF

Network Types

```
Router#  show ip ospf interface interface number
Router(config-if)# ip ospf network ?
   – Broadcast
   – nonbroadcast
   – point-to-point
   – point-to-mulitpoint
   – loopback
```

Network Type	Determined Characteristics	DR Election?
Broadcast multiaccess	Ethernet, Token Ring, or FDDI	Yes
Nonbroadcast multiaccess	Frame Relay, X.25, SMDS	Yes
Point-to-point	PPP, HDLC	No
Point-to-multipoint	Configured by an administrator	No

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NBMA Networks and OSPF

Network Types

Cisco routers can treat NBMA interfaces using any of the following:

Non-Broadcast

- OSPF is aware that multicast packets cannot be sent over the interface and sends OSPF packets directly to neighbors using unicast addresses.
- DR and BDR are elected
- DR represent the NBMA cloud as a transit network, using network LSAs
- Suitable only for when the VCs are fully meshed

Broadcast

- OSPF tread the interface as belonging to a broadcast segment, thus using multicasts to send OSPF packets.
- DR and BDR are elected
- Suitable only for when the VCs are fully meshed.

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NBMA Networks and OSPF

Network Types

Cisco routers can treat NBMA interfaces using any of the following:

Point-to-multipoint

- OSPF treats the interface as a placeholder for a set of point-to-point adjacencies.
- No DR/BDR is elected
- Very much like point-to-point interfaces, except that every router announces a host route to its own IP address.

Point-to-point

- OSPF treats the interface as a set of point-to-point adjacencies
- No DR/BDR is elected.

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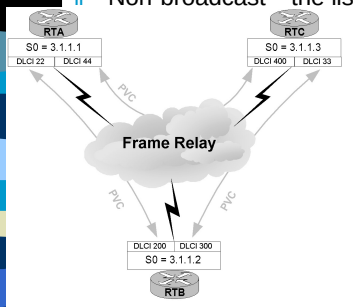
NBMA Networks and OSPF

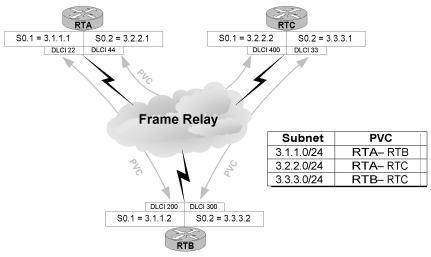
So, which should I use?

- "It depends."
- It is important that the network type match on all interfaces in the NBMA network or you will get a 'network type mismatch' error message.

Fully meshed

- Can use Broadcast or Non-broadcast.
- The main difference between these two is in the way routers discover their neighbors.
- Broadcast – routers send broadcast packets and the data link layer is responsible for replicating them.
- Non-broadcast – the list of neighbors must be configured manually.



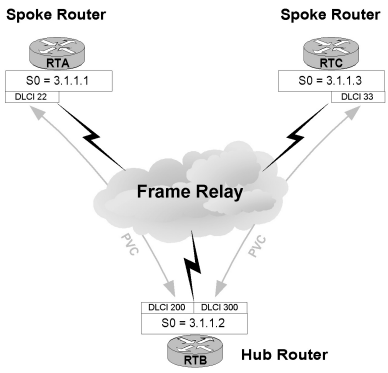


Subnet	PVC
3.1.1.0/24	RTA– RTB
3.2.2.0/24	RTA– RTC
3.3.3.0/24	RTB– RTC

NBMA Networks and OSPF

Partial Meshed

- Can use point-to-point or point-to-multipoint.
- For most Hub/Spoke, partial meshed, networks (unless there is a large number of routers), configuring the network type as **point-to-multipoint** on all interfaces works just fine.



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NBMA Networks and OSPF

```
Interface              Hello/Dead Interval    Elects DR/BDR?
Broadcast                  10/40                DR/BDR
Point-to-Point             10/40                no DR/BDR
Non-Broadcast (Def.)       30/120               DR/BDR
Point-to-Multipoint        30/120               no DR/BDR
```

- If timers don't match, routers can't form adjacencies!

```
Router(config-if)# ip ospf network ?
```

  - Broadcast
  - nonbroadcast
  - point-to-point
  - point-to-mulitpoint
  - loopback

Network Type	Determined Characteristics	DR Election?
Broadcast multiaccess	Ethernet, Token Ring, or FDDI	Yes
Nonbroadcast multiaccess	Frame Relay, X.25, SMDS	Yes
Point-to-point	PPP, HDLC	No
Point-to-multipoint	Configured by an administrator	No

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Troubleshooting

Why Are OSPF Neighbors Stuck in Exstart/Exchange State?

- http://www.cisco.com/warp/public/104/12.html
- The problem occurs most frequently when attempting to run OSPF between a Cisco router and another vendor's router. The problem occurs when the maximum transmission unit (MTU) settings for neighboring router interfaces don't match. If the router with the higher MTU sends a packet larger that the MTU set on the neighboring router, the neighboring router ignores the packet.
- Since the problem is caused by mismatched MTUs, the solution is to change either router's MTU to match the neighbor's MTU. Note that Cisco IOS doesn't support changing the physical MTU on a LAN interface (such as Ethernet or Token Ring).

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Troubleshooting

Why Does the show ip ospf neighbor Command Reveal Neighbors Stuck in 2-Way State? (This is normal in this situation.)

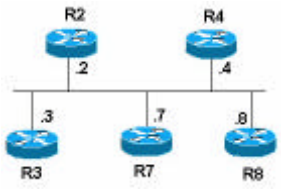
In the following topology, all routers are running OSPF neighbors over the Ethernet network:

Following is sample output of the **show ip ospf neighbor** command on R7:

```
router-7#show ip ospf neighbor

Neighbor ID     Pri       State           Dead Time   Address         Interface
170.170.3.2       1       FULL/BDR        00:00:37    170.170.3.2     Ethernet0
170.170.3.3       1       2WAY/DROTHER    00:00:30    170.170.3.3     Ethernet0
170.170.10.8      1       FULL/DR         00:00:39    170.170.3.8     Ethernet0
170.170.7.4       1       2WAY/DROTHER    00:00:39    170.170.3.4     Ethernet0
router-7#
```

Notice that R7 establishes full adjacency only with the Designated Router (DR) and the Backup Designated



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Issues with large OSPF networks

- Frequent SPF calculations
- Large routing table
- Large link-state table

- *This will be discussed next week as we discuss the advantages of OSPF and multiple areas!*

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Cabrillo College

CCNP – Advanced Routing

Ch. 4 - OSPF, Single Area

Rick Graziani, Instructor

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