

OSPF

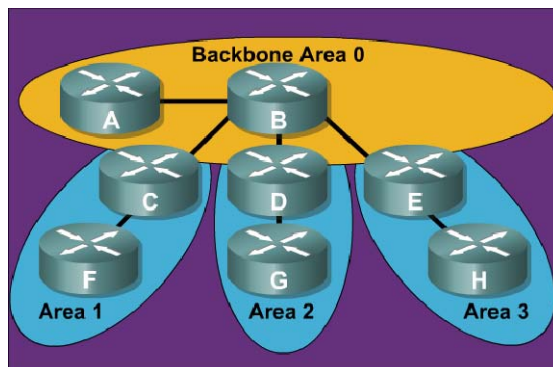
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OSPF Areas

Review of OSPF area characteristics:

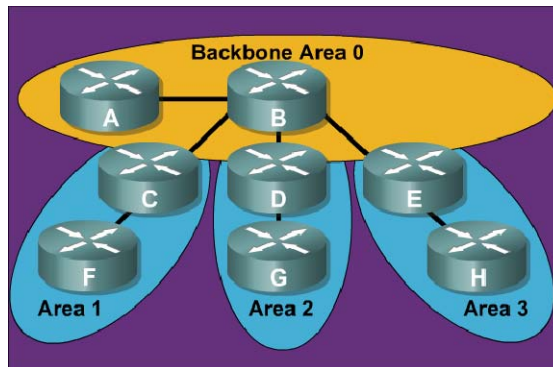
- Minimizes routing table entries
- Localizes impact of a topology change within an area
- Detailed LSA flooding stops at the area boundary
- Requires a hierarchical network design



OSPF Areas

New terminology for areas:

- Transit Area
Also known as
Backbone Area 0
- Regular Area
Also known as
Nonbackbone areas



OSPF Database

- OSPF maintains three databases
- Adjacency Database (`show ip ospf neighbor`)
- Link-state Database (`show ip ospf database`)
- Forwarding Database (`show ip route`)



LSA Sequence Numbering



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- Each LSA in the LSDB maintains a sequence number.
- The sequence numbering scheme is a 4-byte number that begins with 0x80000001 and ends with 0x7FFFFFFF.
- OSPF floods each LSA every 30 minutes to maintain proper database synchronization. Each time the LSA is flooded, the sequence number is incremented by one.
- Ultimately, an LSA sequence number will wrap around to 0x80000001. When this occurs, the existing LSA is prematurely aged to maxage (one hour) and flushed.
- When a router encounters two instances of an LSA, it must determine which is more recent. The LSA having the newer (higher) LS sequence number is more recent.



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Configuring Basic OSPF



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Router(config)#

```
router ospf process-id [vrf vpn-name]
```

- Enable one or more OSPF routing processes.

Router(config-router)#

```
network ip-address wildcard-mask area area-id
```

- Define the interfaces that OSPF will run on.

Router(config-if)#

```
ip ospf process-id area area-id [secondaries none]
```

- Optional method to enable OSPF explicitly on an interface.



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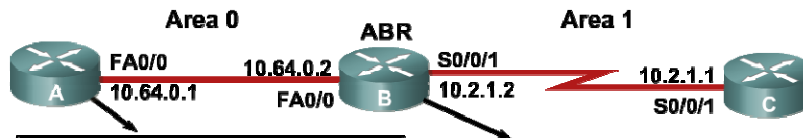
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Configuring OSPF for Multiple Areas



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```
<Output Omitted>
Interface FastEthernet0/0
ip address 10.64.0.1 255.255.255.0

<Output Omitted>
router ospf 1
network 10.0.0.0 0.255.255.255 area 0
```

```
<Output Omitted>
Interface FastEthernet0/0
ip address 10.64.0.2 255.255.255.0

Interface Serial0/0/1
ip address 10.2.1.2 255.255.255.0
ip ospf 10 area 1

<Output Omitted>
router ospf 50
network 10.64.0.2 0.0.0.0 area 0
```



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OSPF Router ID



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- The router is known to OSPF by the OSPF router ID number.
- LSDBs use the OSPF router ID to differentiate one router from the next.
- By default, the router ID is the highest IP address on an active interface at the moment of OSPF process startup.
 - If no interface is up when the OSPF process starts, you will get the following error message:
 - p5r2(config)#router ospf 1
 - 2w1d: %OSPF-4-NORTRID: OSPF process 1 cannot start.
- A loopback interface can override the OSPF router ID. If a loopback interface exists, the router ID is the highest IP address on any active loopback interface.
- The OSPF **router-id** command can be used to override the OSPF router ID.
- Using a loopback interface or a **router-id** command is recommended for stability.



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OSPF router-id Command



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

```
router-id ip-address
```

- This command is configured under the `router ospf [process-id]` command.
- Any unique arbitrary 32-bit value in an IP address format (dotted decimal) can be used.
- If this command is used on an OSPF process that is already active, then the new router ID takes effect after the next reload or after a manual restarting of the OSPF process using:

```
Router#clear ip ospf process
```

```
Router(config)#router ospf 1  
Router(config-router)#router-id 172.16.1.1
```

```
Router#clear ip ospf process
```



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OSPF over NBMA Topology



Modes of Operation

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- RFC 2328-compliant modes are as follows:
 - Nonbroadcast (NBMA)
 - Point-to-multipoint
- Additional modes from Cisco are as follows:

```
Router(config-if)#
```

```
ip ospf network [{broadcast | non-broadcast | point-to-multipoint [non-broadcast] | point-to-point}]
```

This `point-to-point` command defines OSPF network type.



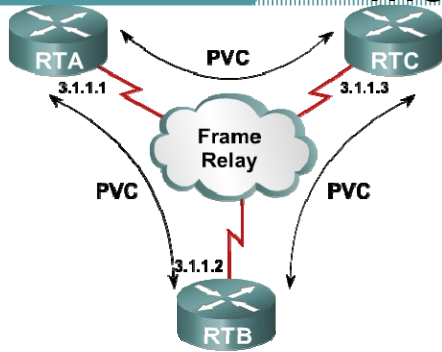
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RFC-compliant Non-broadcast Mode



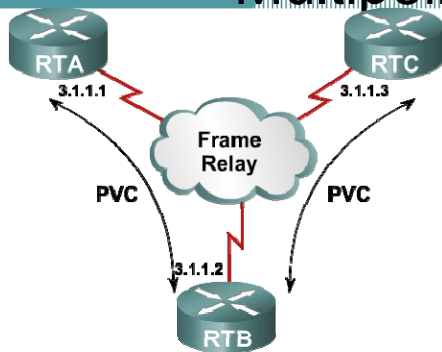
- One IP subnet.
- Neighbors must be manually configured.
- DR and BDR elected.
- DR and BDR need to have full connectivity with all other routers.

```

RTB(config-if)#ip ospf network non-broadcast
-----
RTB(config-router)#network 3.1.1.0 0.0.0.255 area 0
RTB(config-router)#neighbor 3.1.1.1
RTB(config-router)#neighbor 3.1.1.3
    
```



RFC-compliant Point-to-Multipoint Mode



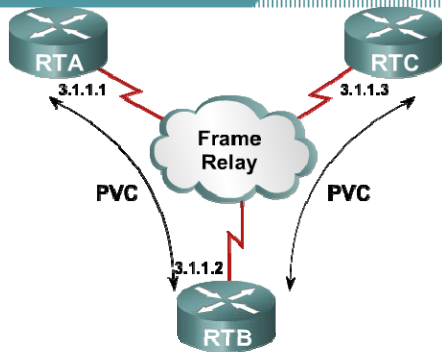
- One IP subnet.
- Uses multicast OSPF hello packet to automatically discover neighbors.
- DR and BDR not required
- Typically used in a

```

RTB(config-if)#ip ospf network point-to-multipoint
-----
RTB(config-router)#network 3.1.1.0 0.0.0.255 area 0
    
```



Cisco's Point-to-Multipoint Non-broadcast mode



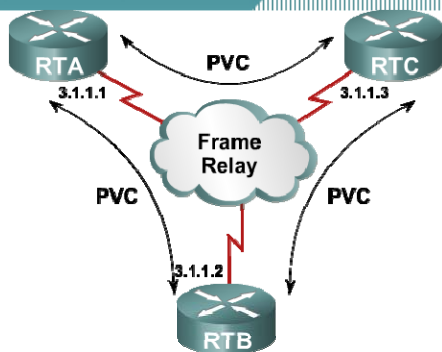
- Cisco extension to RFC-compliant point-to-multipoint mode
- Must statically define neighbors, like nonbroadcast mode
- Like point-to-multipoint mode, DR/BDR not elected

```
RTB(config-if)#ip ospf network point-to-multipoint non-broadcast
-----
```

```
RTB(config-router)#network 3.1.1.0 0.0.0.255 area 0
RTB(config-router)#neighbor 3.1.1.1 cost 10
RTB(config-router)#neighbor 3.1.1.3 cost 20
```

- Used in special cases where neighbors cannot be automatically discovered

Cisco's Broadcast Mode



- Makes a WAN interface appear to be a LAN
- One IP subnet
- Uses multicast hellos to discover neighbors

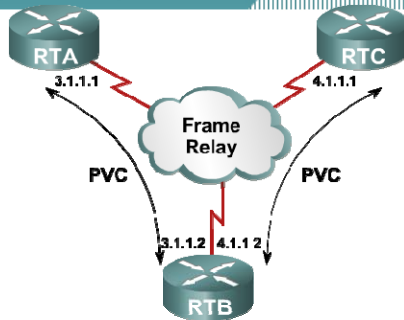
```
RTB(config-if)#ip ospf network broadcast
-----
RTB(config-router)#network 3.1.1.0 0.0.0.255 area 0
```



Cisco's Point-to-Point mode



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- One IP subnet per subinterface pair
- No DR or BDR election
- Used when only two routers need to form an adjacency on a pair of interfaces
- Same properties as any physical point-to-point physical interface

```
RTB(config)#interface serial 0/0.1
RTB(config-subif)#ip address 3.1.1.2 255.255.255.0
RTB(config-subif)#interface serial 0/0.2
RTB(config-subif)#ip address 4.1.1.2 255.255.255.0
-----
RTB(config-router)#network 3.1.1.0 0.0.0.255 area 0
RTB(config-router)#network 4.1.1.0 0.0.0.255 area 0
```



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Using the neighbor Command



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

```
neighbor ip-address [priority number] [poll-interval
number] [cost number] [database-filter all]
```

- Used to statically define neighbor relationships in an NBMA network



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OSPF over NBMA Topology Summary



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OSPF Mode	NBMA Preferred Topology	Subnet Address	Hello Timer	Adjacency	RFC or Cisco
Broadcast	Full or Partial Mesh	Same	10 sec	Automatic DR/BDR Elected	Cisco
Nonbroadcast (NBMA)	Full or Partial Mesh	Same	30 sec	Manual Configuration DR/BDR Elected	RFC
Point-to-Multipoint	Partial-Mesh or Star	Same	30 sec	Automatic No DR/BDR	RFC
Point-to-Multipoint Nonbroadcast	Partial-Mesh or Star	Same	30 sec	Manual Configuration No DR/BDR	Cisco
Point-to-Point	Partial-Mesh or Star, Using Subinterface	Different for Each Subinterface	10 sec	Automatic No DR/BDR	Cisco



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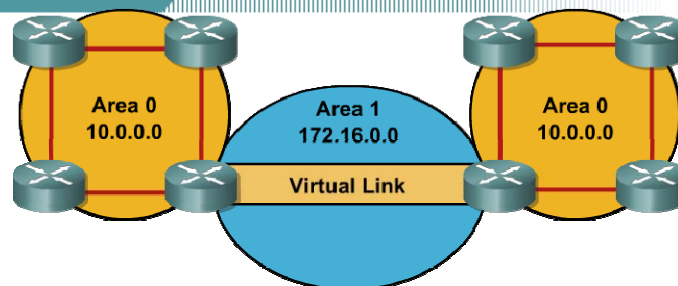
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Virtual Links



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- Virtual links are used to connect a discontinuous area to area 0.
- A logical connection is built between router A and router B.
- Virtual links are recommended for



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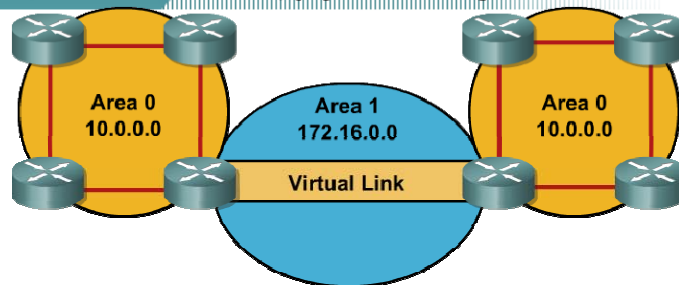
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Special Treatment for LSAs over Virtual Links



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- LSAs usually age out after 30 minutes
- LSAs learned across virtual links have the DoNotAge (DNA) option set



Required to prevent excessive flooding over virtual links

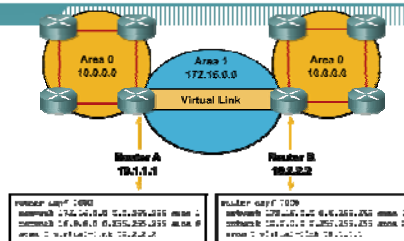
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Configuring and Verifying a Virtual Link



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```
RouterA#sh ip ospf virtual-links
Virtual Link OSPF_VL0 to router 10.2.2.2 is up
Run as demand circuit
DoNotAge LSA allowed.
Transit area 1, via interface Serial0/0/1, Cost of using 781
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
Hello due in 00:00:07
Adjacency State FULL (Hello suppressed)
Index 1/2, retransmission queue length 0, number of
retransmission 1
First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
Last retransmission scan length is 1, maximum is 1
Last retransmission scan time is 0 msec, maximum is 0 msec
```



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LSA Types



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LSA Type	Description
1	Router LSAs
2	Network LSAs
3 or 4	Summary LSAs
5	Autonomous System External LSAs
6	Multicast OSPF LSAs
7	Defined for Not-So-Stubby Areas
8	External Attributes LSA for Border Gateway Protocol (BGP)
9, 10, 11	Opaque LSAs



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OSPF LSDB Overload Protection



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Router(config-router)#

```
max-lsa maximum-number [threshold-percentage] [warning-only] [ignore-time minutes] [ignore-count count-number] [reset-time minutes]
```

- Excessive LSAs generated by other routers can drain local router resources.
- This feature can limit the processing of non-self-generated LSAs for a defined OSPF process.



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NSSA Configuration



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```
RouterA(config-router)#
```

```
area area-id nssa [no-redistribution] [default-information-originate [metric metric-value] [metric-type type-value]] [no-summary]
```

- Use this command instead of the **area stub** command to define the area as NSSA.
- **no-summary** creates an NSSA totally stubby area; this is a Cisco proprietary feature.



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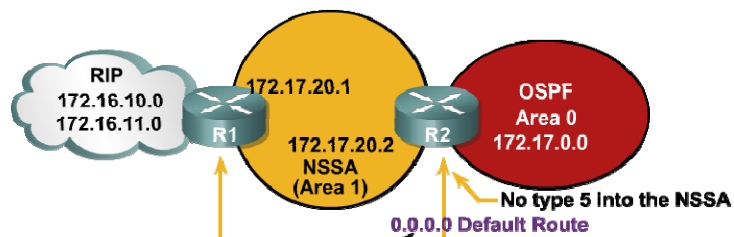
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Example: NSSA Configuration



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```
R1:  
router ospf 10  
redistribute rip subnets  
default-metric 100  
network 172.17.0.0 255.255.255.0 area 1  
area 1 nssa
```

```
R2:  
router ospf 10  
summary-address 172.16.0.0 255.255.0.0  
network 172.17.0.0 255.255.255.0 area 0  
network 172.17.0.0 255.255.255.0 area 1  
area 1 nssa default-information-originate
```



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OSPF Authentication Types



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- OSPF supports 2 types of authentication:
 - Simple password authentication (plain text)
 - MD5 authentication
- Router generates and checks each packet and authenticates the source of each update packet it receives
- Configure a “key” (password)
 - Note: all participating neighbors must have the same key configured



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Configuring Simple Password Authentication



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Router(config-if)#

```
ip ospf authentication-key password
```

- Assign a password to be used with neighboring routers.

Router(config-if)#

```
ip ospf authentication [message-digest | null]
```

- Specifies the authentication type for an interface (since IOS 12.0).

Router(config-router)#

```
area area-id authentication [message-digest]
```

- Specifies the authentication type for an area (was in IOS before 12.0).



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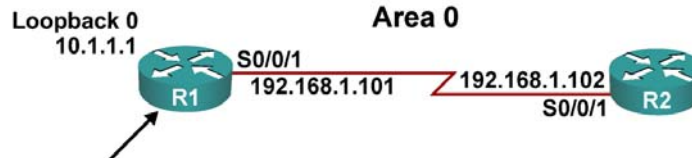
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Example Simple Password Authentication Configuration



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```
<output omitted>
interface Loopback0
 ip address 10.1.1.1 255.255.255.0

<output omitted>
interface Serial0/0/1
 ip address 192.168.1.101 255.255.255.224
 ip ospf authentication
 ip ospf authentication-key plainpas

<output omitted>
router ospf 10
 log-adjacency-changes
 network 10.1.1.1 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
```



R2 Configuration for Simple Password Authentication



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```
<output omitted>
interface Loopback0
 ip address 10.2.2.2 255.255.255.0

<output omitted>
interface Serial0/0/1
 ip address 192.168.1.102 255.255.255.224
 ip ospf authentication
 ip ospf authentication-key plainpas

<output omitted>
router ospf 10
 log-adjacency-changes
 network 10.2.2.2 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
```



Configuring OSPF MD5 Authentication



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Router(config-if)#

```
ip ospf message-digest-key key-id md5 key
```

- Assign a key ID and key to be used with neighboring routers.

Router(config-if)#

```
ip ospf authentication [message-digest | null]
```

- Specifies the authentication type for an interface (since IOS 12.0).

Router(config-router)#

```
area area-id authentication [message-digest]
```

- Specifies the authentication type for an area (was in IOS before 12.0).



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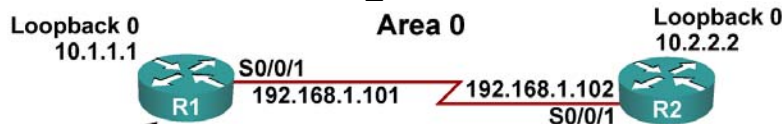
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Example MD5 Authentication Configuration



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```
<output omitted>
interface Loopback0
 ip address 10.1.1.1 255.255.255.0

<output omitted>
interface Serial0/0/1
 ip address 192.168.1.101 255.255.255.224
 ip ospf authentication message-digest
 ip ospf message-digest-key 1 md5 secretpass

<output omitted>
router ospf 10
 log-adjacency-changes
 network 10.1.1.1 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
```

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R2 Configuration for MD5 Authentication



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```
<output omitted>
interface Loopback0
 ip address 10.2.2.2 255.255.255.0

<output omitted>
interface Serial0/0/1
 ip address 192.168.1.102 255.255.255.224
 ip ospf authentication message-digest
 ip ospf message-digest-key 1 md5 secretpass

<output omitted>
router ospf 10
 log-adjacency-changes
 network 10.2.2.2 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
```



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