Link-State Routing Protocols

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Objectives

- **Link-state routing protocol**
- **Single-area OSPF concepts**
- **Single-area OSPF configuration**

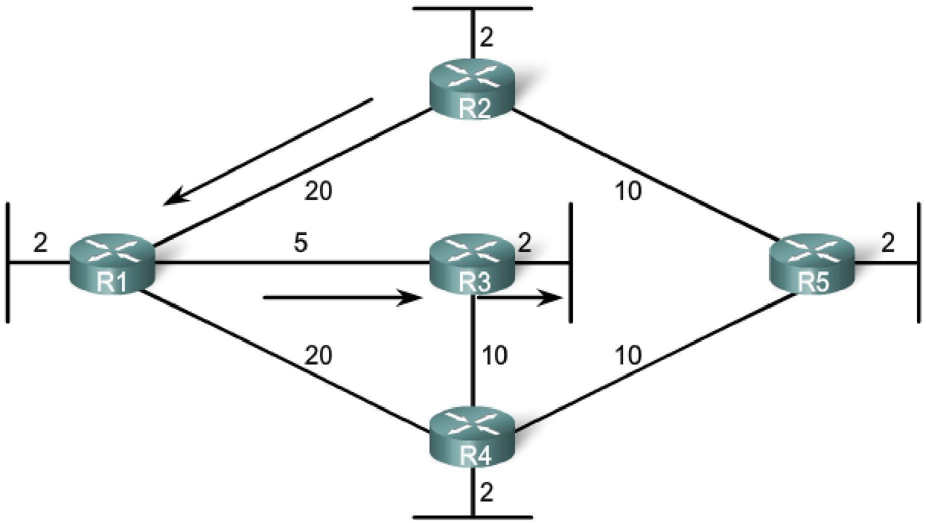
Link-State Protocols

- More complex than Distance vector protocols
- Basic functionality and configuration is not complex at all
- Also known as Shortest Path First protocols
  - Djikstra/SPF algorithm

SPF Algorithm

- **Accumulates costs along each path from source to destination**
- **Each router determines its own cost to each destination**

Dijkstra's Shortest Path First Algorithm



Shortest Path for host on R2 LAN to reach host on R3 LAN:
R2 to R1 (20) + R1 to R3 (5) + R3 to LAN (2) = 27

Comparing Distance Vector and Link-State Routing

Distance Vector	Link State
• View network topology from neighbor's perspective • Adds distance vectors from router to router • Frequent, periodic updates: Slow convergence • Passes copies of routing tables to neighbor routers	• Gets common view of entire network topology • Calculates the shortest path to other routers • Event-triggered updates: Faster convergence • Passes link-state routing updates to other routers

Link-State Routing Process

1. Each router learns about its own links (directly connected networks)
2. Find directly connected neighbors
3. Builds a Link-State Packet (LSP) with the state of each directly connected link
4. Floods the LSP to all neighbors, who stores the received LSPs in a database
5. Each router uses the database to construct a complete map of the network topology
6. Computes the best path to each destination network

Advantages with Link-State Protocols

- **Builds a topological map**
  - **Full knowledge of the network**
- **Fast convergence**
  - **Floods LSPs immediately**
- **Event-driven updates**
  - **LSP sent when there is a change, only contains information regarding the affected link**
- **Hierarchical design**
  - **Areas can be used to separate routing traffic**

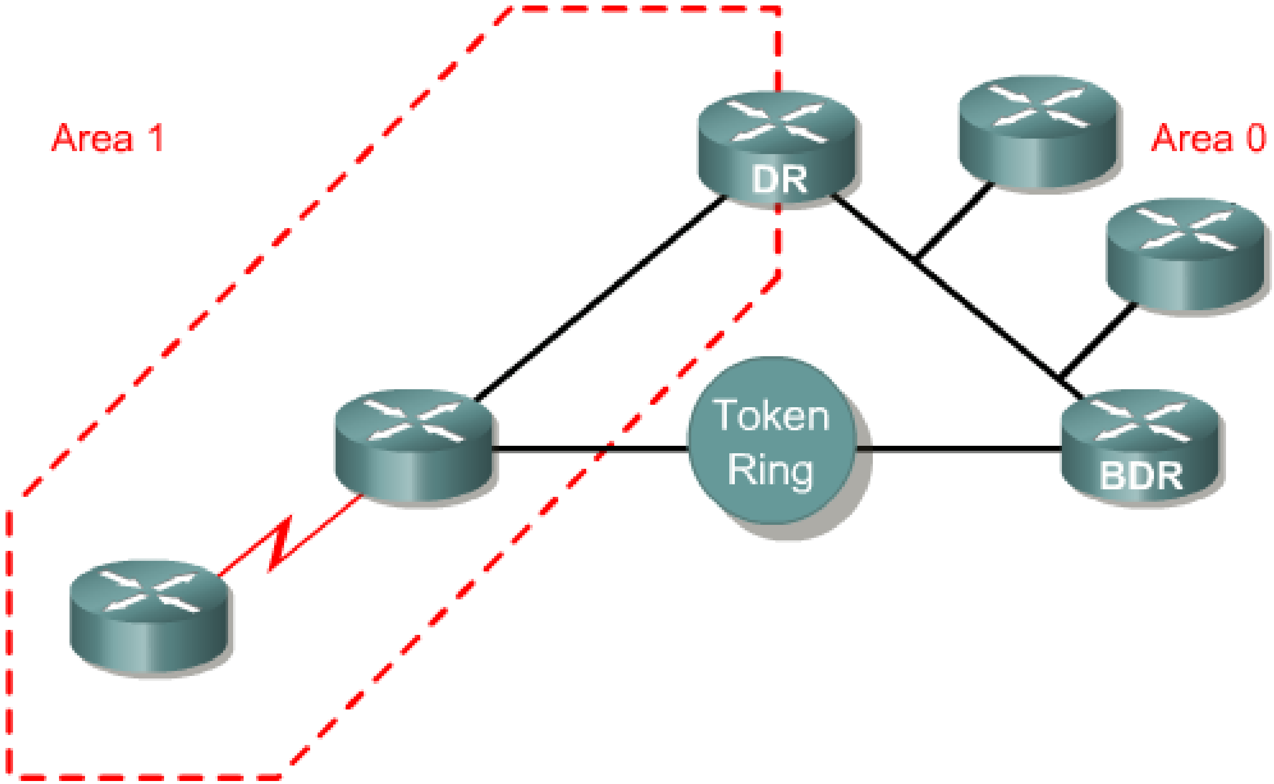
Disadvantages with Link-State Protocol

- Significant demands on memory and processing resources
- Requires very strict network design
- Requires a knowledgable network administrator
- Initial flooding can impede network performance

Open Shortest Path First (OSPF)

- **Link-state protocol that was developed as a replacement for RIP**
- **Classless protocol**
- **Scalable**
  - **Areas**
- **Fast convergence**

OSPF Terminology



Area: A collection of networks and routers that has the same area identification. Each router within an area has the same link-state information. A router within an area is called an internal router.

More OSPF Terminology

Link: An interface on a router.

Link-State: The status of a link between two routers. Also a router interface and its relationship to its neighboring routers.

Link-state database (or topological database): A list of information about all other routers in the internetwork. It shows the internetwork topology.

Adjacencies database: A listing of all the neighbors to which a router has established bidirectional communication.

Routing table: The routing table (also known as forwarding database) generated when an algorithm is run on the link-state database. Each router's routing table is unique.

Cost: The value assigned to a link. Rather than hops, link-state protocols assign a cost to a link, which is based on the bandwidth of the link (transmission speed).

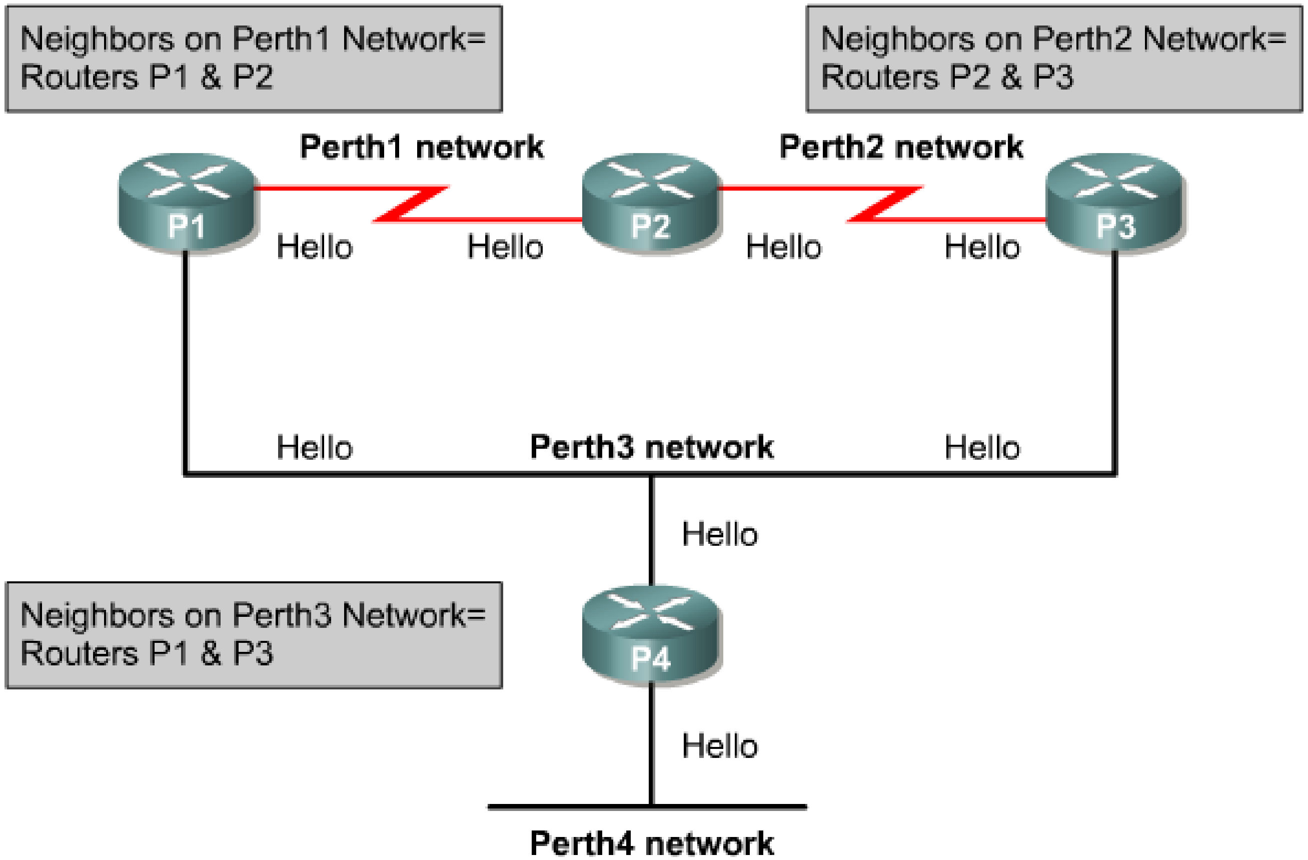
Designated router (DR) and backup designated router (BDR): A router that is elected by all other routers on the same LAN to represent all the routers. Each network has a DR and BDR.

OSPF Packet Types

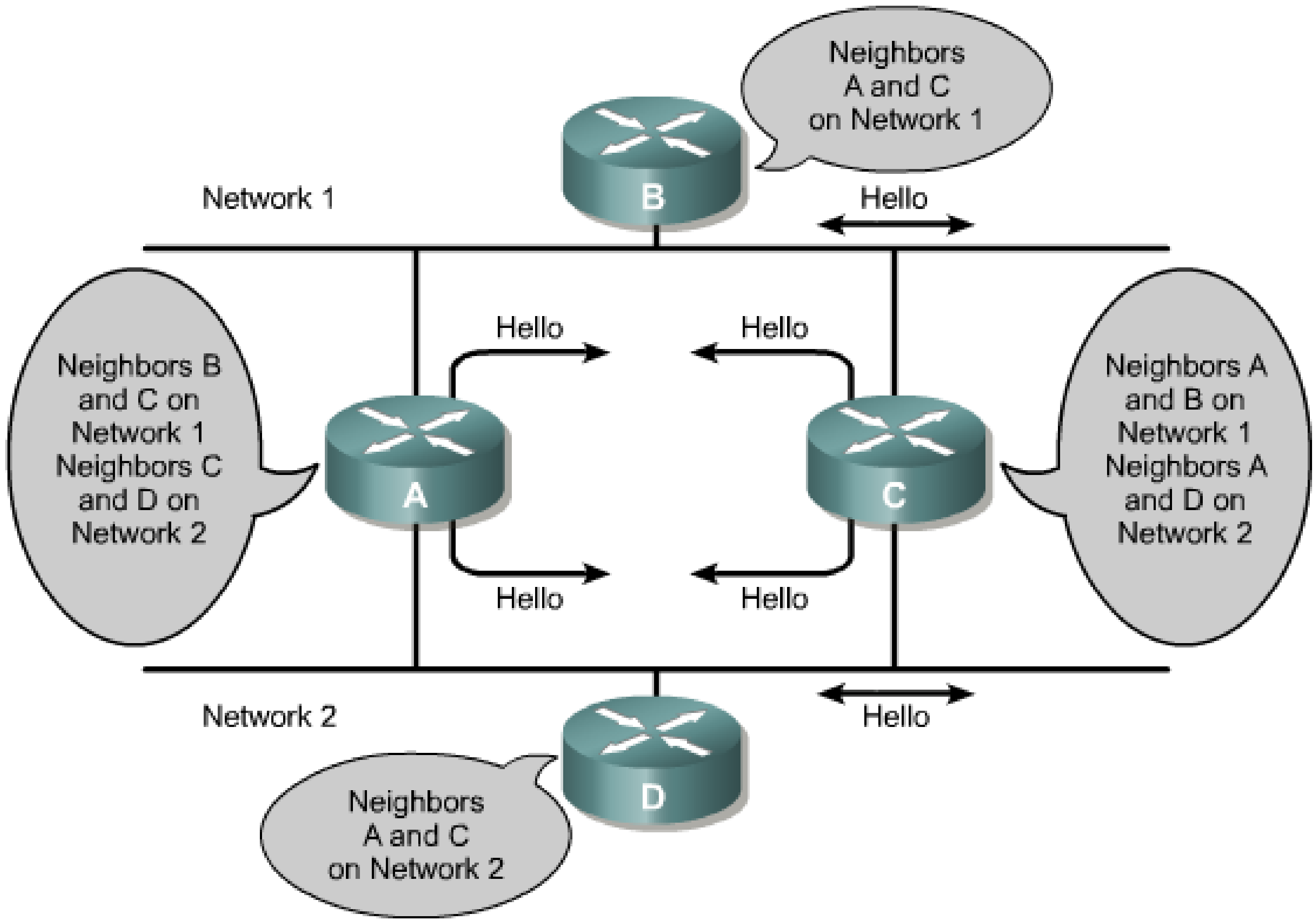
- **Hello packets**
- **Database Description (DBD)**
- **Link-State Request (LSR)**
- **Link-State Update (LSU)**
- **Link-State Acknowledgement (LSA)**

Link-State Routing Features

- **Hello protocol**
  - **Used to discover and maintain neighbor adjacencies**

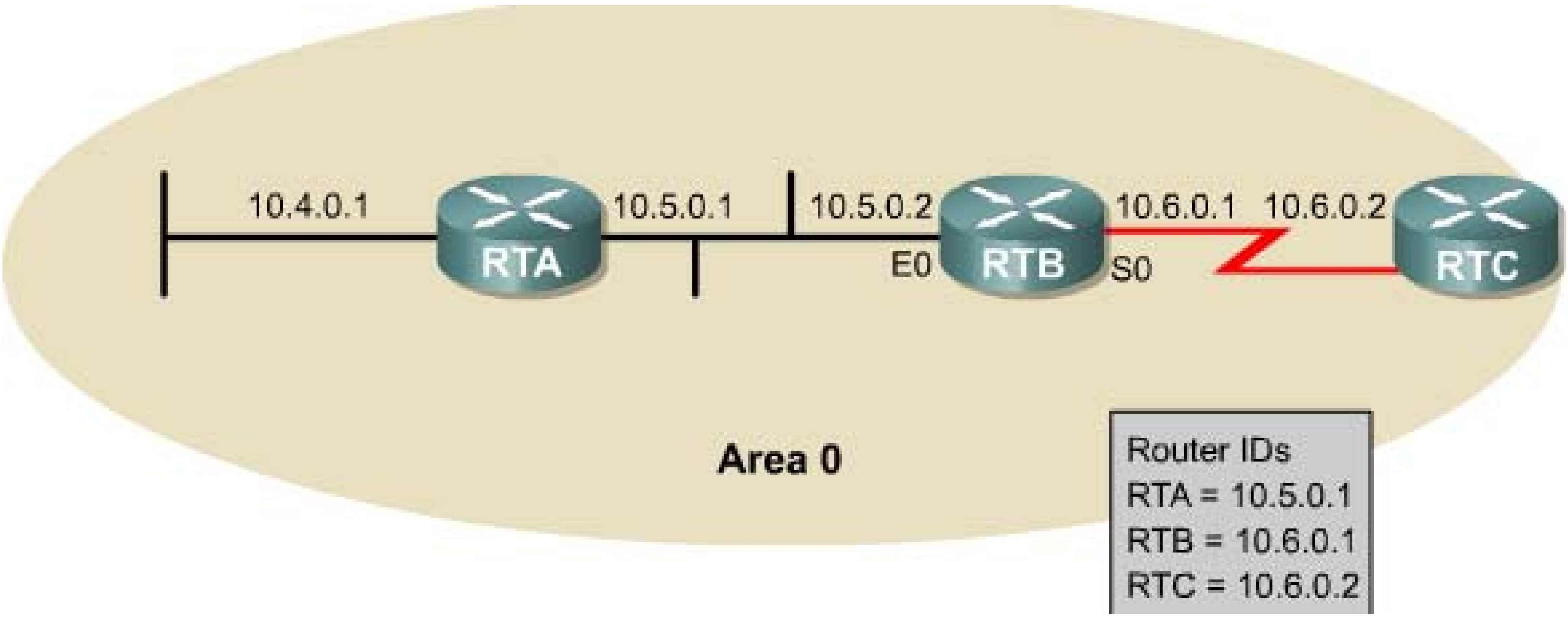


How Routing Information Is Maintained



Steps in the Operation of OSPF

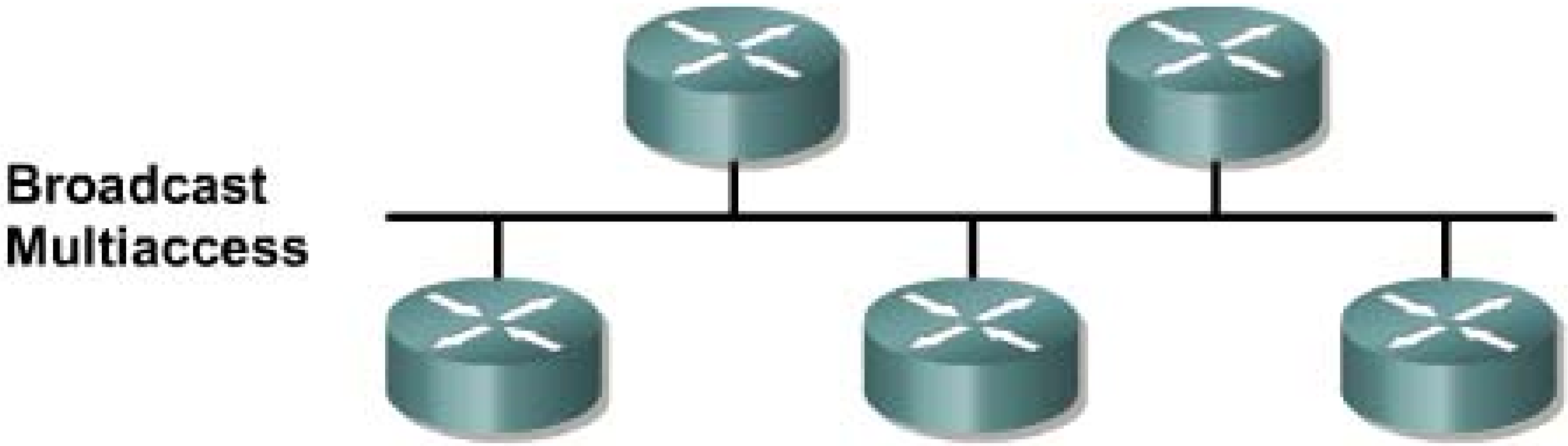
Discover neighbors



- **Hello-packet to form adjacencies**
  - **Router ID (highest IP address)**
  - **Hello (10 s) and Dead (40 s) intervals**

Steps in the Operation of OSPF

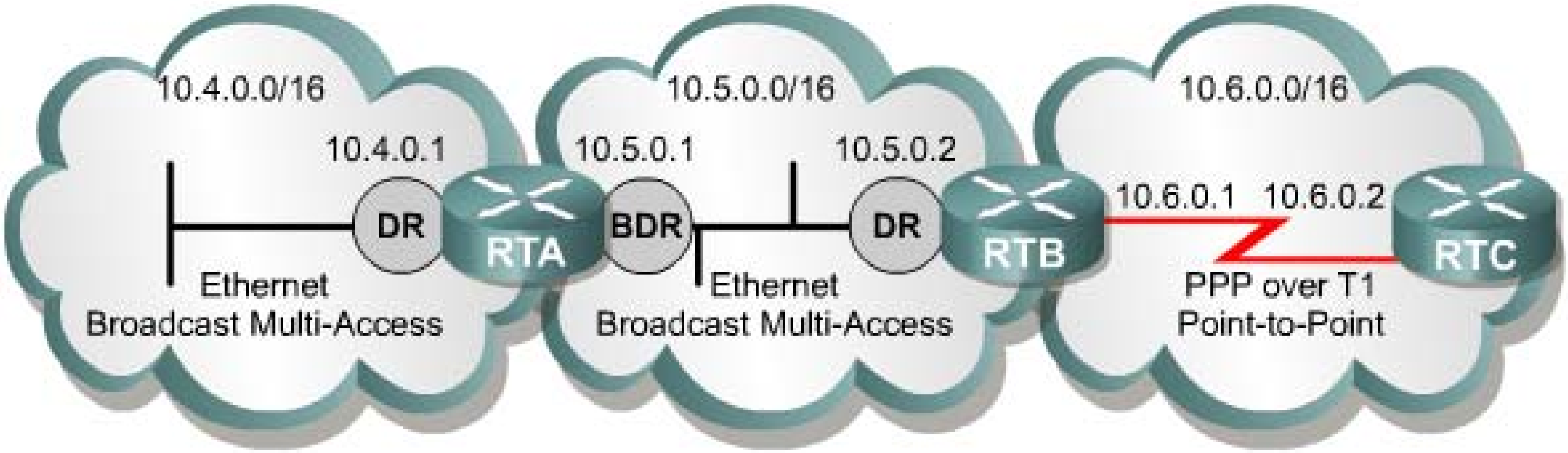
Elect DR and BDR on Multi Access Network



DR and BDR

- DR = highest Router ID
- BDR = second highest Router ID
- Multicast from DR: 224.0.0.5
- Multicast to DR: 224.0.0.6

Steps in the Operation of OSPF

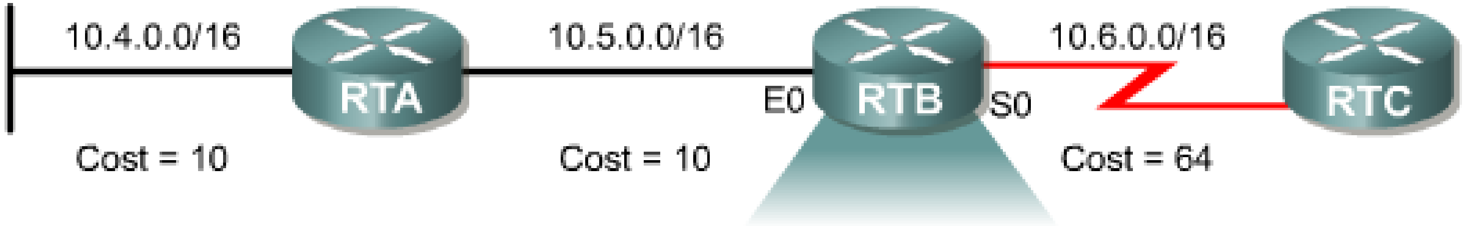


Steps in the Operation of OSPF

No DR and BDR is elected

Steps in the Operation of OSPF

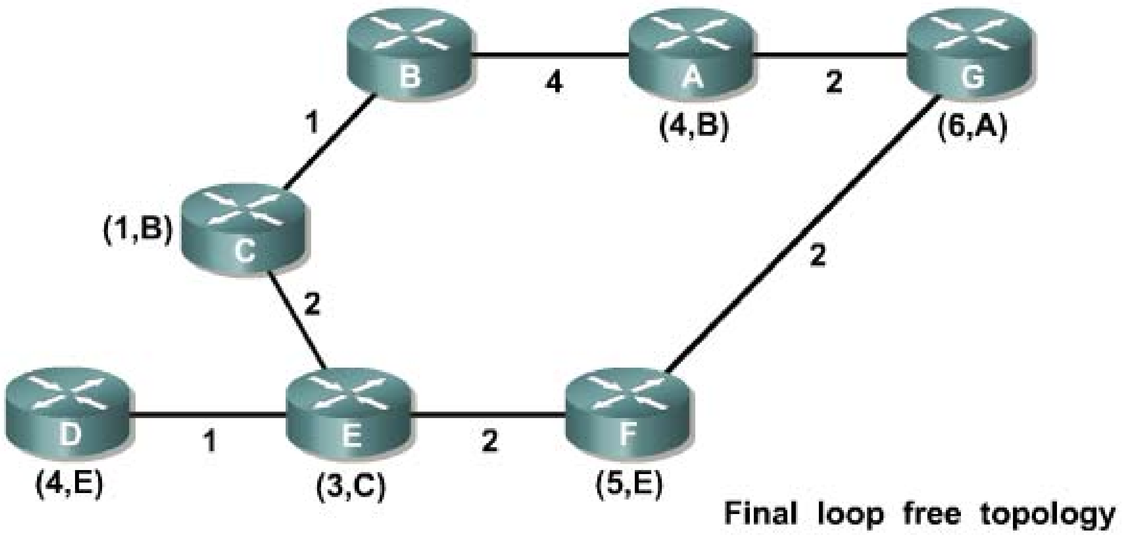
Selecting the Best Route



Net	Cost	Out Interface
10.4.0.0	20	E0

- **Link State Advertisment (LSA)**
  - **Active links (network address) and metric (cost)**
- **LSA inserted in the link-state (topology) database**

Shortest Path Algorithm



A	B	C	D	E	F	G
B/4	A/4	B/1	C/4	C/2	E/2	A/2
G/2	C/1	D/4	E/1	D/1	G/2	F/2
		E/2		F/2		

- **SPF Algorithm to calculate the lowest-cost path**
- **Best path inserted in the routing table**

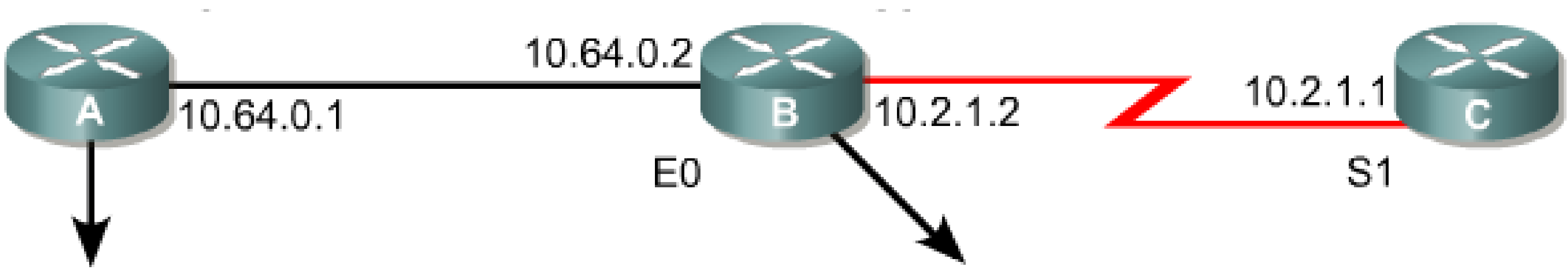
OSPF Metric

- **The reference bandwidth is used as the cost value**

Cisco OSPF Cost Values

Interface Type	10^8/ bps = Cost
Fast Ethernet and faster	10^8/100,000,000 bps = 1
Ethernet	10^8/10,000,000 bps = 10
E1	10^8/2,048,000 bps = 48
T1	10^8/1,544,000 bps = 64
128 kbps	10^8/128,000 bps = 781
64 kbps	10^8/64,000 bps = 1562
56 kbps	10^8/56,000 bps = 1785

Basic OSPF Configuration




```
<Output Omitted>
interface Ethernet0
ip address 10.64.0.1 255.255.255.0
!
<Output Omitted>
router ospf 1
network 10.64.0.0 0.0.0.255 area 0
```

```
<Output Omitted>
interface Ethernet0
ip address 10.64.0.2 255.255.255.0
!
interface Serial0
ip address 10.2.1.2 255.255.255.0
<Output Omitted>
router ospf 1
network 10.2.1.2 0.0.0.0 area 0
network 10.64.0.2 0.0.0.0 area 0
```

Basic OSPF Configuration

Network area Command	Description
address	Can be the network address, subnet, or the address of the interface. Instructs router to know which links to advertise, which links to listen to advertisements on, and what networks to advertise.
wildcard-mask	An inverse mask used to determine how to read the address. The mask has wildcard bits where 0 is a match and 1 is "do not care"; for example, 0.0.255.255 indicates a match in the first two bytes. (the equivalent REGULAR subnet mask would be a 16 bit mask of 255.255.0.0) If specifying the interface address, use mask 0.0.0.0.
area-id	Specifies the area to be associated with the address. Can be a number or can be similar to an IP address A.B.C.D. For a backbone area, the ID must equal 0.

Configuring OSPF Loopback Address and Router Priority

```
! Create the loopback 0 interface
Sydney3(config)#interface loopback 0
Sydney3(config-if)#ip address 192.168.31.33
255.255.255.255
Sydney3(config-if)#exit
! Remove loopback 0 interface
Sydney3(config)#no interface loopback 0
Sydney3(config)#
01:47:27: %LINK-5-CHANGED: Interface Loopback0, changed
state to administratively down
```

A loopback is a software only interface. To remove a loopback interface enter **`no interface loopback`**.

Setting OSPF Priority

```
Sydney1(config)#interface fastethernet 0/0
Sydney1(config-if)#ip ospf priority 50
Sydney1(config-if)#end
Sydney1#
00:21:57: %SYS-5-CONFIG_I: Configured from console
by console
```

- **Default priority = 1**

Modifying OSPF Cost Metric

Medium	Cost
56 kbps serial link	1785
T1 (1.544 Mbps serial link)	64
E1 (2.048 Mbps serial link)	48
4 Mbps Token Ring	25
Ethernet	10
16 Mbps Token Ring	6
100 Mbps Fast Ethernet, FDDI	1

```
Sydney2(config-if)#ip ospf cost ?
  <1-65535>   Cost
Sydney2(config-if)#ip ospf cost 1
```

Configuring OSPF Authentication

Cisco

```
Sydney1(config-if)#ip ospf message-digest-key 1 md5 7
asecret
Sydney1(config-if)#exit
Sydney1(config)#router ospf 1
Sydney1(config-router)#area 0 authentication message-
digest
Sydney1(config-router)#end
Sydney1#
```

Interface and Router configuration is required.

Configuring OSPF Timers

Cisco

```
Sydney1(config-if)#ip ospf hello-interval 5
Sydney1(config-if)#ip ospf dead-interval 20
```

OSPF timers are configured on the interface.

Redistributing an OSPF Default Route

- **Configure a default route on the router located between an OSPF routing domain and a non-OSPF router**
- **Redistribute it through the other routers in the area via the routing updates**

```
R1(config)#interface loopback 1
R1(config-if)#ip add 172.30.1.1 255.255.255.252
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback 1
R1(config)#router ospf 1
R1(config-router)#default-information originate
```

Common OSPF Configuration Issues

No Neighbor	OSPF Routes Not Shown
Do interfaces have same OSPF timers?	Do interfaces have correct IP address and subnet mask?
Do connected interfaces have same network type?	Do network statements have correct wildcard masks?
Are authentication keys and passwords the same on interfaces?	Do network statements put links into correct area?
Do the router neighbors have duplicate IP addresses?	
Is the router interface up?	

Verifying OSPF Configuration

- **`show ip protocol`**
- **`show ip route`**
- **`show ip ospf interface`**
- **`shop ip ospf`**
- **`show ip ospf neighbor detail`**
- **`show ip ospf database`**

The debug and `clear` Commands for OSPF Verification

Command	Description
`clear ip route *`	Clear all routes in routing table
`clear ip route a.b.c.d`	Clear route to a.b.c.d in routing table
`debug ip ospf events`	Report all OSPF events
`debug ip ospf adj`	Report OSPF adjacency events