

Campus Network Design Workshop

Introduction to OSPF

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OSPF

- Open Shortest Path First
- Open:
 - Meaning an Open Standard
 - Developed by IETF (OSPF Working Group) for IP – RFC1247
 - Current standard is OSPFv2 (RFC2328)
- Shortest Path First:
 - Edsger Dijkstra's algorithm for producing shortest path tree through a graph
 - Dijkstra, E. W. (1959). "A note on two problems in connexion with graphs". Numerische Mathematik 1: 269–271



OSPF

- Known as a Link State Routing Protocol
 - The other link state routing protocol is IS-IS
 - Each node in the network computes the map of connectivity through the network
- The other type of Routing Protocol is Distance Vector
 - Like EIGRP or RIP
 - Each node shares its view of the routing table with other nodes



OSPF

- Routers with OSPF enabled on them look for neighbouring routers also running OSPF
 - Using the “Hello” protocol
 - The “Hello” packet includes the subnet mask, list of known neighbours, and details such as “hello interval” and “router dead interval”
 - Hello interval – how often the router will send Hellos
 - Router dead interval – how long to wait before deciding router has disappeared
 - The values of “hello interval”, “router dead interval” and subnet mask must match on both neighbours
 - When a neighbouring router responds with matching details, a neighbour relationship is formed



OSPF Neighbour Relationships

- A relationship is formed between selected neighbouring routers for the purpose of exchanging routing information
 - This is called an **ADJACENCY**
- Not every pair of neighbouring routers become adjacent
 - On multi-access networks (e.g. ethernet), only selected routers form adjacencies

OSPF Adjacencies

- Once an adjacency is formed, neighbours share their link state information
 - Information goes in a **Link State Packet** (LSP)
 - LSPs sent to a neighbour are known as **Link State Announcements** (LSA)
- New information received from neighbours is used to compute a new view of the network
- On a link failure
 - New LSPs are flooded
 - The routers recompute the routing table



OSPF across a network

- All routers across the network form **neighbour relationships** with their directly attached neighbours
- Each router computes the routing table
- Once each router has the **same view** of the network, the network has **converged**
- The IGP design for a network is crucially important to ensure scalability and rapid convergence
- **Generally: the fewer the prefixes, the faster the convergence**

OSPF Areas

- OSPF has the concept of areas
 - All networks must have an area 0, the “default” area
 - Areas are used to scale OSPF for large networks
 - There are many types of areas, to suit many different types of infrastructure and topologies
 - Most small to medium networks (up to ~300 routers) can happily use a single area



OSPF

- OSPFv2 is for IPv4
 - For carrying IPv4 prefixes only
- OSPFv3 is for IPv6
 - For carrying IPv6 prefixes only
 - Based on OSPFv2 but is specifically for IPv6
 - Documented in RFC5340
 - Is totally independent of OSPFv2
- Configuration concepts and syntax are very similar
 - (There are subtle differences/improvements)



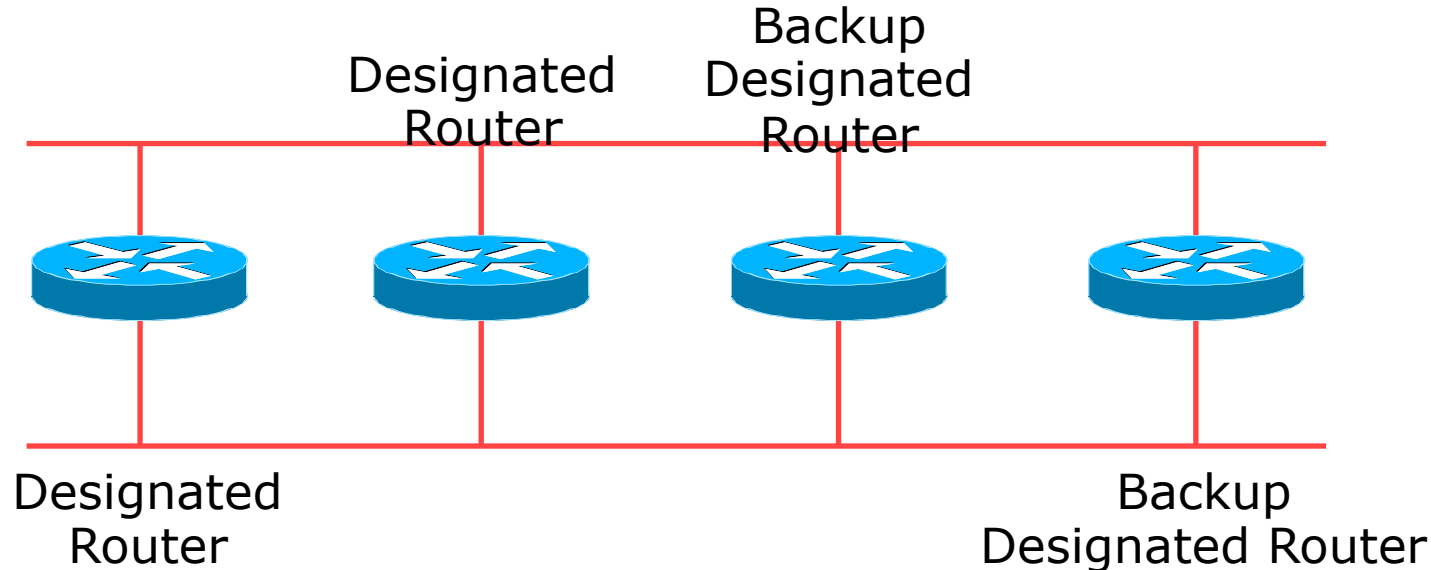
Links in OSPF

- Two types of links in OSPF:
 - Point-to-point link
 - Only one other router on the link, forming a point-to-point adjacency
 - Multi-access network (e.g. ethernet)
 - Potential for many other routers on the network, with several other adjacencies
- OSPF in multi-access networks has optimisations to aid scaling
 - Two routers are elected to originate the LSAs for the whole multi-access network
 - Called “**Designated Router**” and “**Backup Designated Router**”
 - Other routers on the multi-access network form adjacencies with the DR and BDR



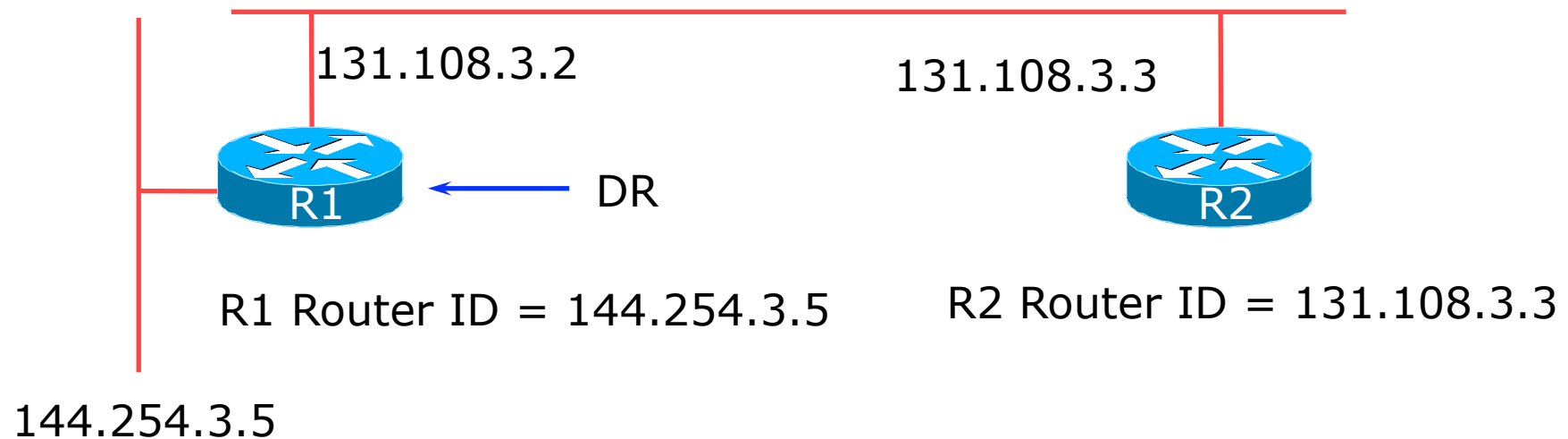
Designated Router

- There is ONE designated router per multi-access network
 - Generates network link advertisements
 - Assists in database synchronization
 - Scales OSPF for multi-access (ethernet) networks



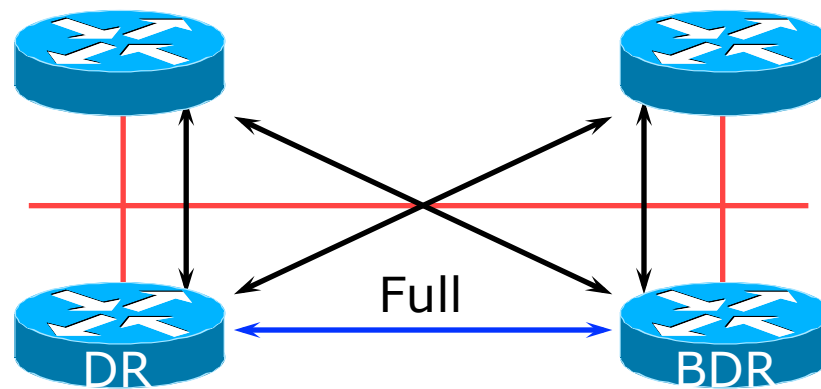
Selecting the Designated Router

- Configured priority (per interface)
 - Configure high priority on the routers to be the DR/BDR
- Else priority determined by highest router ID
 - Router ID is 32 bit integer
 - Set manually, otherwise derived from the loopback interface IPv4 address, otherwise the highest IPv4 address on the router



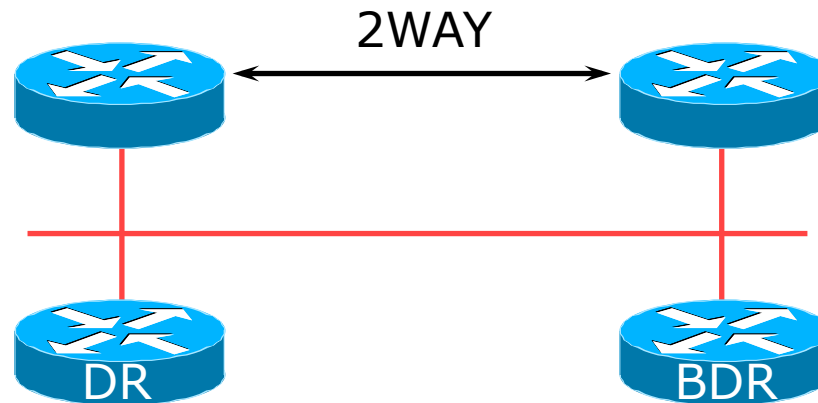
Adjacencies on multi-access networks

- DR and BDR form **FULL** adjacencies:
 - With each other
 - With all other routers on the multi-access network
 - Databases are synchronised
 - LSAs propagate along adjacencies



Adjacencies on multi-access networks

- Neighbour relationships between routers which are not DR or BDR are called **2WAY**
 - They see each other in HELLO packets but do not exchange topology information
 - The neighbours then are **not adjacent**



Adjacencies: Examples

- To find adjacency state, use:

```
show ip[v6] ospf neighbor
```

- Point-to-Point link

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.15.236	0	FULL/ -	00:00:35	10.10.15.16	Serial1/0

- FULL: other router to DR/BDR

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.15.225	1	FULL/BDR	00:00:35	10.10.15.2	FastEth0/0
10.10.15.226	1	FULL/DR	00:00:35	10.10.15.3	FastEth0/0

- 2WAY: other router to other router

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.15.227	1	2WAY/DROTHER	00:00:35	10.10.15.4	FastEth0/0



OSPF on Cisco IOS

- Starting OSPFv2 (IPv4) in Cisco's IOS

```
router ospf 42
```

- Where “42” is the process ID

- Starting OSPFv3 (IPv6) in Cisco's IOS

```
ipv6 router ospf 42
```

- Where “42” is the process ID

- OSPF process ID is unique to the router
 - Gives possibility of running multiple instances of OSPF on one router
 - Process ID is not passed between routers in an AS
 - Some ISPs configure the process ID to be the same as their BGP Autonomous System Number



Adding interfaces to OSPF

- OSPF interface configuration:
 - When OSPF is configured for a subnet or on an interface, the router will automatically attempt to find neighbours on that subnet or interface
 - ISP Best Practice is to disable this behaviour:

```
router ospf 42  
  passive-interface default
```

- And then explicitly enable the interface to allow OSPF to search for neighbours as required:

```
router ospf 42  
  no passive-interface POS 4/0
```



OSPF on Cisco IOS

- Enabling OSPF on an interface does **two** things:
 - Enables the Hello protocol for forming neighbour relationships and adjacencies with other routers connected to that interface
 - Announces the interface subnet(s) into OSPF
- Care needed
 - Must avoid enabling the Hello protocol on untrusted networks
 - (e.g. those outside your Autonomous System)



OSPF on Cisco IOS

- Forming neighbour relationships
 - OSPF needs to be activated on the interface the neighbour relationship is desired on:

```
interface POS 4/0
  ip address 192.168.1.1 255.255.255.252
  ip ospf 42 area 0
!
router ospf 42
  passive-interface default
  no passive-interface POS 4/0
!
```



OSPF interface costs

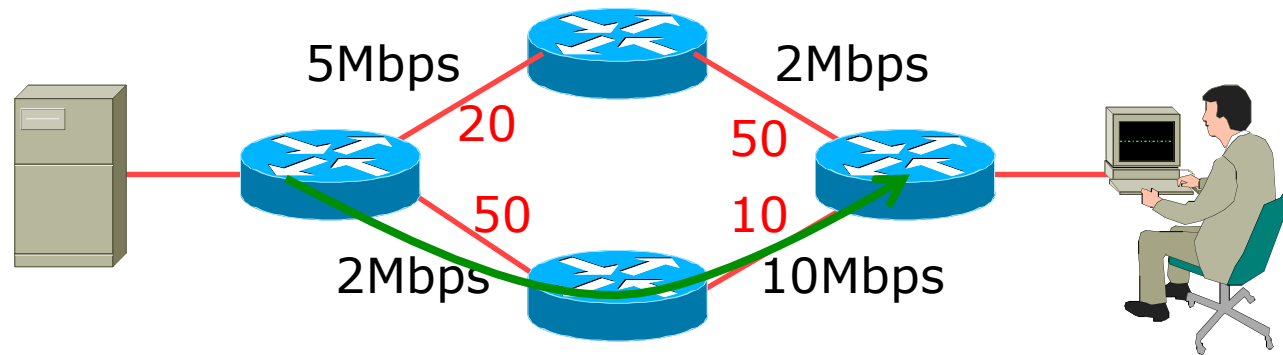
- Cisco IOS sets the interface cost automatically
 - Formula used: $\text{cost} = 10^8 / \text{interface bandwidth}$
 - Which is fine for interfaces up to 100Mbps
- Many operators develop their own interface cost strategy

```
ip ospf cost 100
```

- Sets interface cost to 100
- Care needed as the sum of costs determines the best path through the network
- OSPF chooses lowest cost path through a network
- OSPF will load balance over paths with equal cost to the same destination

OSPF Metric Calculation

- Best path/lowest cost = 60

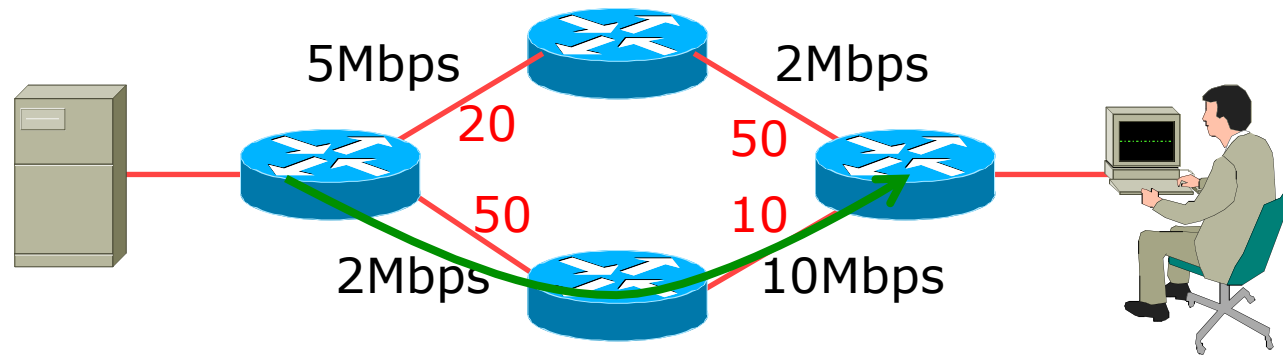


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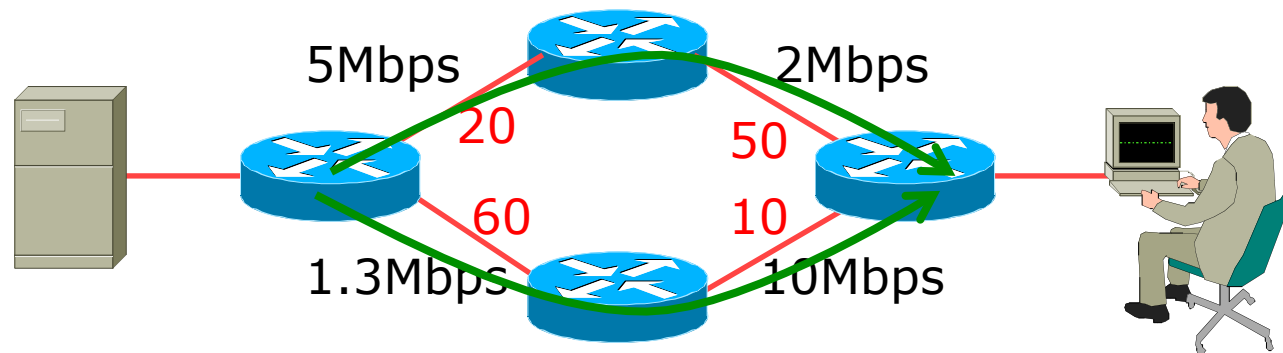


OSPF Metric Calculation

- Best path/lowest cost = 60



- Equal cost paths = 70



OSPF Neighbour Authentication

- Neighbour authentication is highly recommended
 - Prevents unauthorised routers from forming neighbour relationships and potentially compromising the network
- OSPFv2 – Authentication is built-in
 - There are two types:
 - Plain text password
 - MD5 hash
- OSPFv3 – uses standard IP security header
 - There are two types:
 - MD5 hash
 - SHA1



OSPFv2 – Neighbour Authentication

- Configuring authentication for area 0
 - Interfaces still need the authentication key, e.g. POS4/0

```
router ospf 42
  area 0 authentication message-digest
  !
interface POS 4/0
  ip ospf message-digest-key <key-no> md5 <passwd>
  !
```

- Configuring authentication per interface:

```
interface POS 4/0
  ip ospf authentication message-digest
  ip ospf message-digest-key <key-no> md5 <passwd>
  !
```



OSPFv3 – Neighbour Authentication

- Configuring authentication for all interfaces in area 0
 - The key is included in the command turning on authentication for area 0:

```
ipv6 router ospf 42
  area 0 authentication ipsec spi 256 md5 <passwd>
!
```

- Configuring authentication per interface:

```
interface POS 4/0
  ipv6 ospf authentication ipsec spi 256 md5 <passwd>
!
```



Other OSPF Features

- Originating a default route into OSPF:

```
router ospf 42  
  default-information originate
```

- Which will originate a default route into OSPF if a default route exists in the RIB

- OSPF on point-to-point ethernet:

- DR and BDR election is not needed on a point to point link – so it is disabled, which is more efficient

```
interface fastethernet0/2  
  ip ospf network point-to-point
```

- There are equivalent commands for OSPFv3



Conclusion

- OSPF is a Link State Routing Protocol
- Quick and simple to get started
 - But has a myriad of options and features to cover almost all types of network topology
 - ISPs keep their OSPF design **SIMPLE**
 - ~300 routers in a single area is entirely feasible

Questions?

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