Introduction to OSPF

ISP Workshops

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Acknowledgements

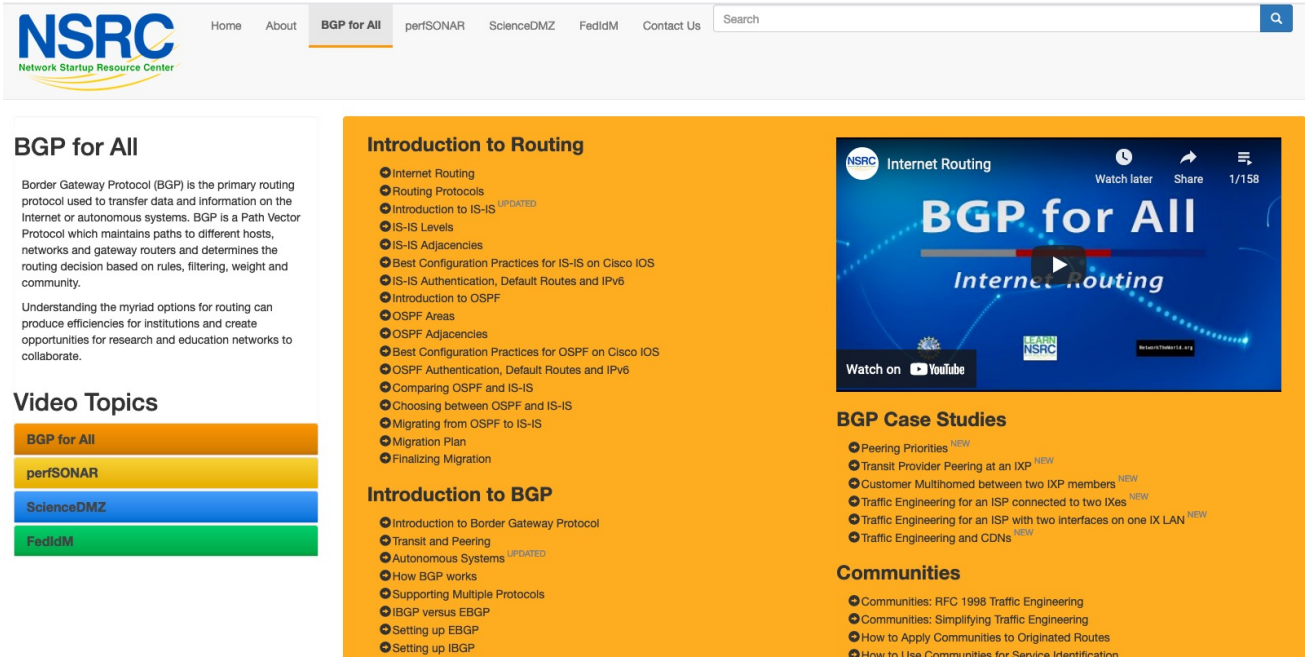
- This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene

- Bug fixes and improvements are welcomed
  - Please email *workshop (at) bgp4all.com*

Philip Smith

BGP Videos

- NSRC has produced a library of Routing presentations (including this one), recorded on video, for the whole community to use
  - https://learn.nsrc.org/bgp



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 ISIS
  - 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

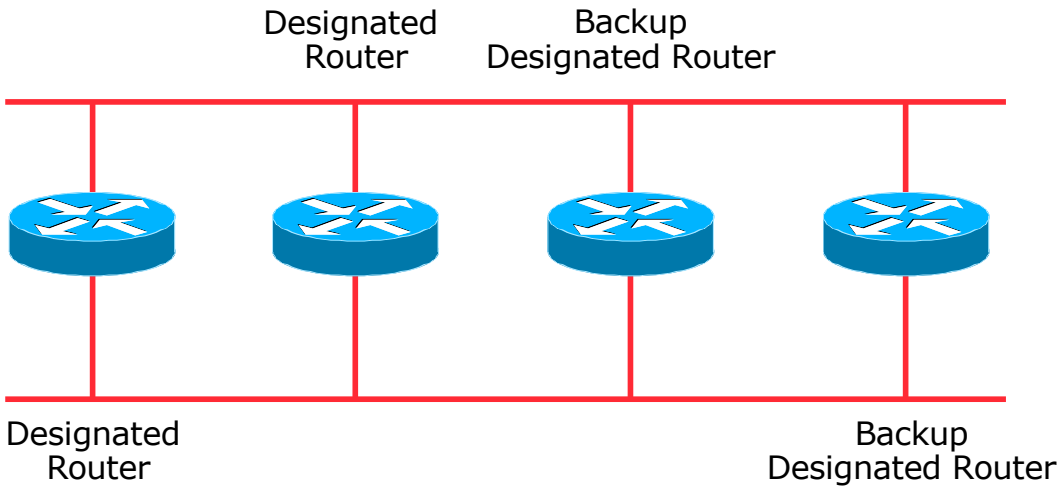
- OSPFv2 is for IPv4
  - For carrying IPv4 prefixes only
- OSPFv3 is for IPv6
  - For carrying IPv6 prefixes only
  - Based on OSPFv2 but is specifically for IPv6
  - Documented in RFC5340
  - Is totally independent of OSPFv2
- Configuration concepts and syntax are very similar
  - (There are subtle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

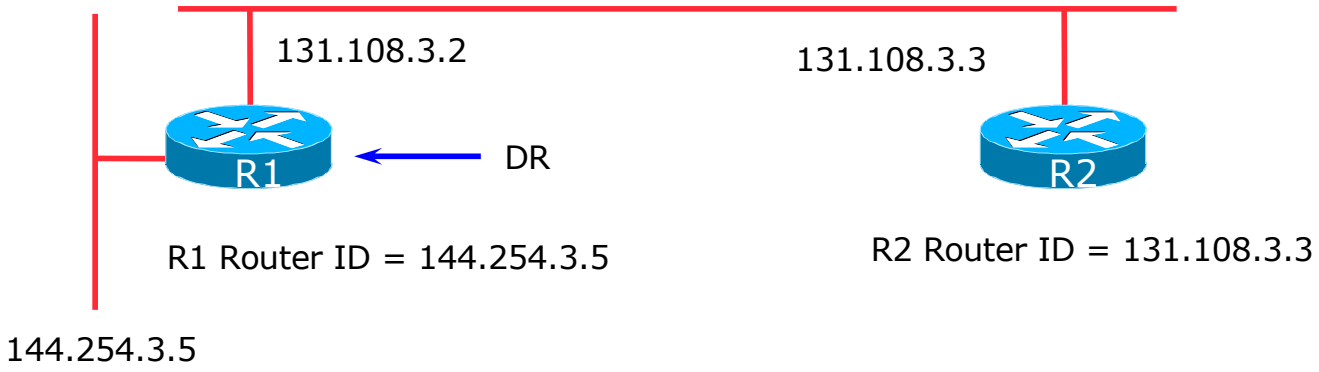
Designated Router

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



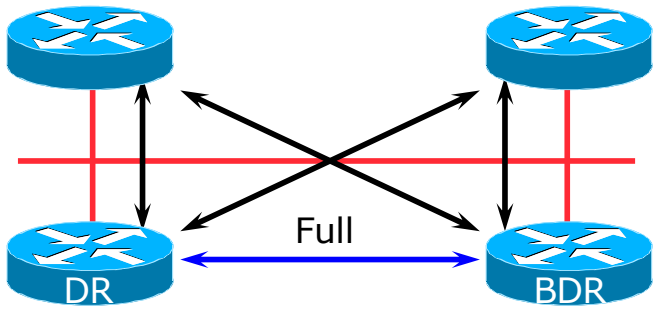
Selecting the Designated Router

- 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



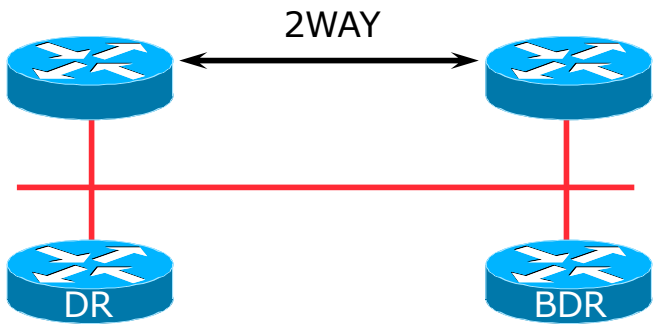
Adjacencies on multi-access networks

- 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 local to the router
  - Allows the possibility of running multiple instances of OSPF on one router
  - The process ID is not passed between routers
  - The process ID must be a number – no option for alphanumeric ID
  - 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

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

  - ISP Best Practice is to disable this behaviour:

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

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

OSPF on Cisco IOS

- Enabling OSPF on an interface does two things:
  1. Enables the Hello protocol for forming neighbour relationships and adjacencies with other routers connected to that interface
  2. 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)

OSPFv2 on Cisco IOS

- Forming neighbour relationships
  - OSPFv2 needs to be activated on the interface the neighbour relationship is desired on:

```
interface Gigabit 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 Gigabit 4/0
!
```

OSPFv3 on Cisco IOS

- Forming neighbour relationships
  - OSPFv3 needs to be activated on the interface the neighbour relationship is desired on:

```
interface Gigabit 4/0
 ipv6 address 2001:DB8:10:FE::4/64
 ipv6 ospf 42 area 0
!
ipv6 router ospf 42
 passive-interface default
 no passive-interface Gigabit 4/0
!
```

OSPF interface costs

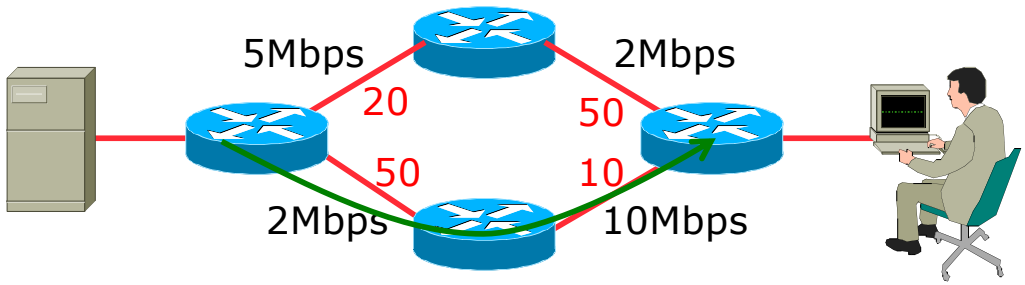
- Cisco IOS sets the interface cost automatically
  - Formula used: cost = 10^8/interface bandwidth
    - Which is fine for interfaces up to 100Mbps
- Many operators develop their own interface cost strategy

```
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

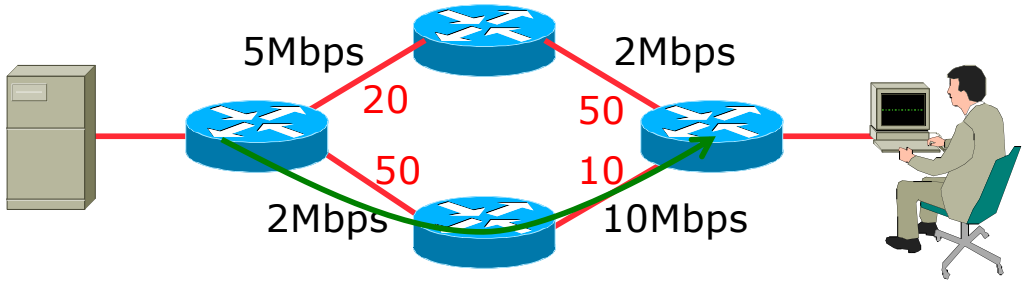
OSPF Metric Calculation

- Best path/lowest cost = 60

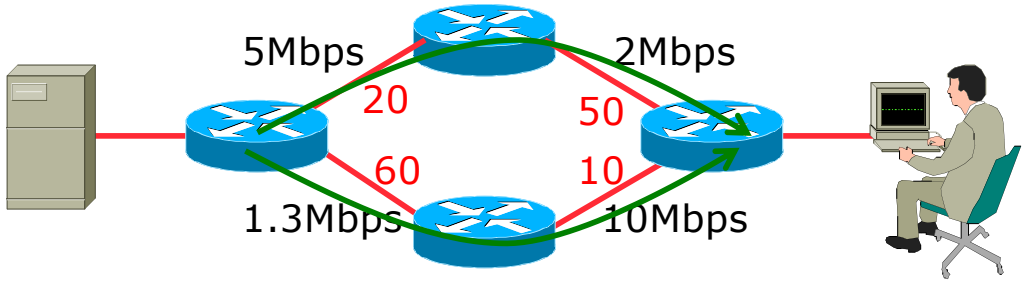


OSPF Metric Calculation

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

- Configuring authentication per interface:

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

Originating a Default Route

- Originating a default route into OSPF:

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

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

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

  - Which will always originate a default route into OSPF even if no default is in the RIB
- There are equivalent commands for OSPFv3

OSPF on Point-to-Point Ethernet

- 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 gigabit 2/0
 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
  - >400 routers in a single area is entirely feasible

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