

Deploying OSPF for ISPs



ISP Training Workshops

Agenda

- p OSPF Design in SP Networks
- p Adding Networks in OSPF
- p OSPF in Cisco's IOS

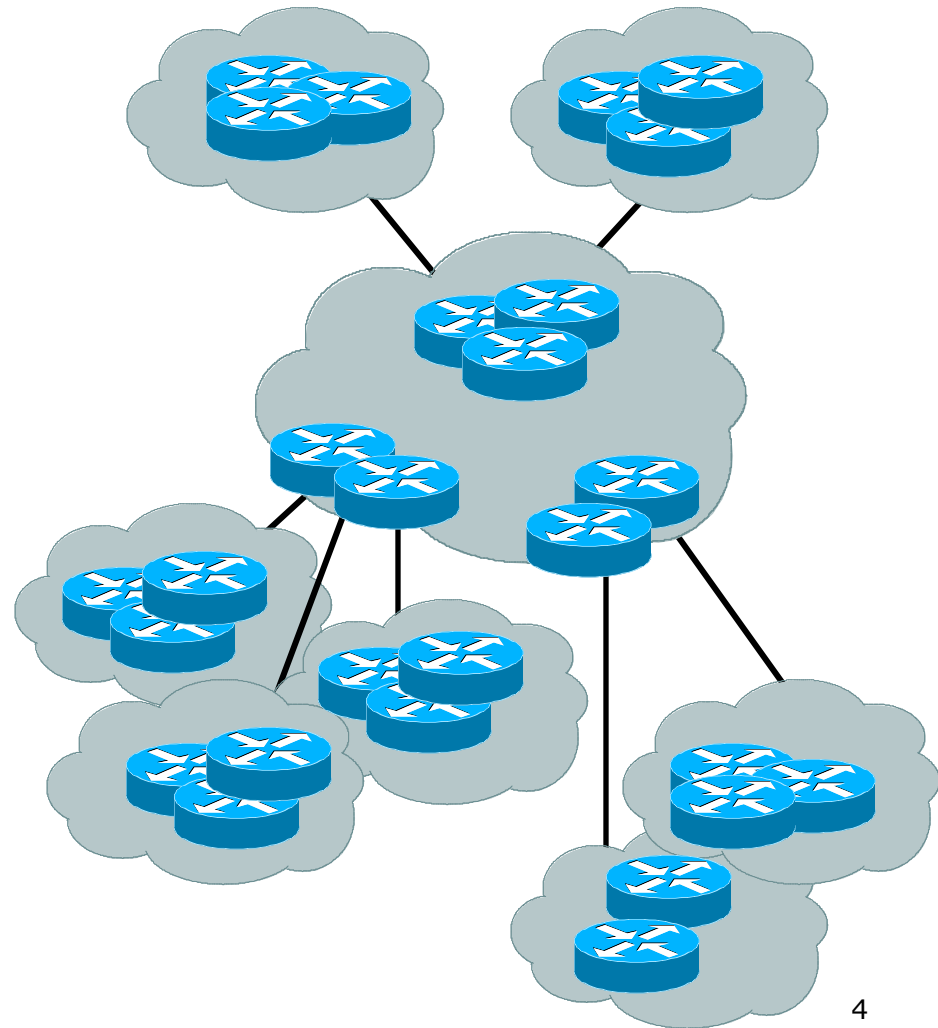
OSPF Design



As applicable to Service Provider
Networks

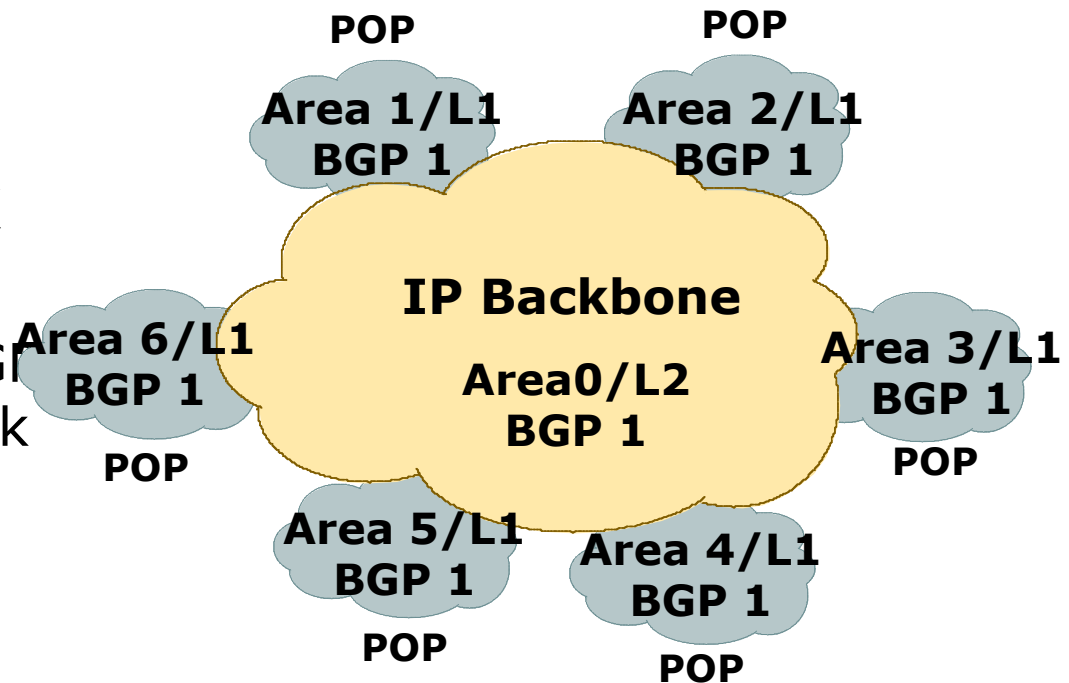
Service Providers

- ⌘ SP networks are divided into PoPs
- ⌘ PoPs are linked by the backbone
- ⌘ Transit routing information is carried via iBGP
- ⌘ IGP is only used to carry the next hop for BGP
- ⌘ Optimal path to the next hop is critical



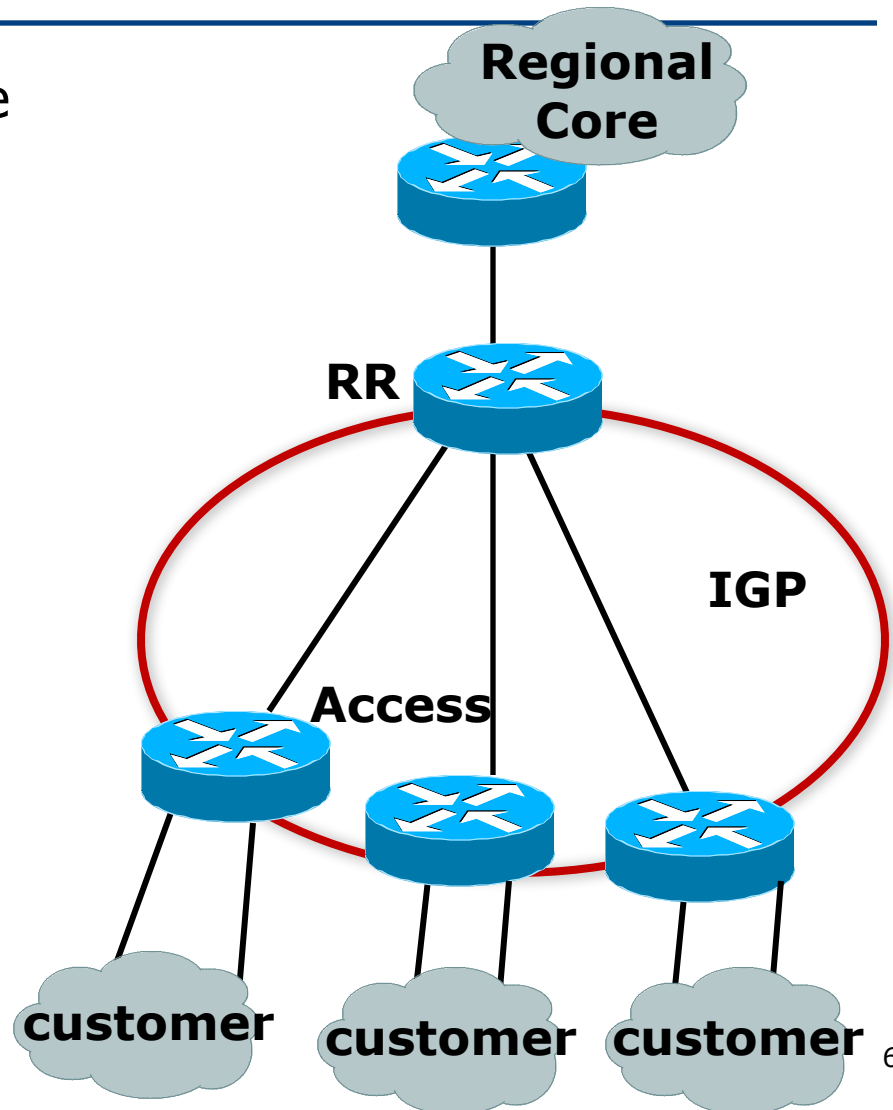
SP Architecture

- Major routing information is ~430K prefixes via BGP
- Largest known IGP routing table is ~9–10K
- Total of 440K
- 10K/440K is 2½% of IGP routes in an ISP network
- A very small factor but has a huge impact on network convergence!



SP Architecture

- ⌞ You can reduce the IGP size from 10K to approx the number of routers in your network
- ⌞ This will bring really fast convergence
- ⌞ Optimise where you must and summarise where you can
- ⌞ Stops unnecessary flapping



OSPF Design: Addressing

- p OSPF Design and Addressing go together
 - Objective is to keep the Link State Database lean
 - Create an address hierarchy to match the topology
 - Use separate Address Blocks for loopbacks, network infrastructure, customer interfaces & customers



Customer Address Space	PtP Links	Infrastructure	Loopbacks
------------------------	-----------	----------------	-----------

OSPF Design: Addressing

- p Minimising the number of prefixes in OSPF:
 - **Number loopbacks out of a contiguous address block**
 - p But do not summarise these across area boundaries: iBGP peer addresses need to be in the IGP
 - Use contiguous address blocks per area for infrastructure point-to-point links
 - p Use `area range` command on ABR to summarise
- p With these guidelines:
 - Number of prefixes in area 0 will then be very close to the number of routers in the network
 - It is critically important that the number of prefixes and LSAs in area 0 is kept to the absolute minimum

OSPF Design: Areas

- p Examine physical topology
 - Is it meshed or hub-and-spoke?
- p Use areas and summarisation
 - This reduces overhead and LSA counts
 - (but watch next-hop for iBGP when summarising)
- p Don't bother with the various stub areas
 - No benefits for ISPs, causes problems for iBGP
- p Push the creation of a backbone
 - Reduces mesh and promotes hierarchy

OSPF Design: Areas

- p One SPF per area, flooding done per area
 - Watch out for overloading ABRs
- p Avoid externals in OSPF
 - **DO NOT REDISTRIBUTE** into OSPF
 - External LSAs flood through entire network
- p Different types of areas do different flooding
 - Normal areas
 - Stub areas
 - Totally stubby (stub no-summary)
 - Not so stubby areas (NSSA)

OSPF Design: Areas

- p Area 0 **must** be contiguous
 - Do NOT use virtual links to join two Area 0 islands
- p Traffic between two non-zero areas always goes via Area 0
 - **There is no benefit in joining two non-zero areas together**
 - Avoid designs which have two non-zero areas touching each other
 - (Typical design is an area per PoP, with core routers being ABR to the backbone area 0)

OSPF Design: Summary

p Think Redundancy

- Dual Links out of each area – using metrics (cost) for traffic engineering

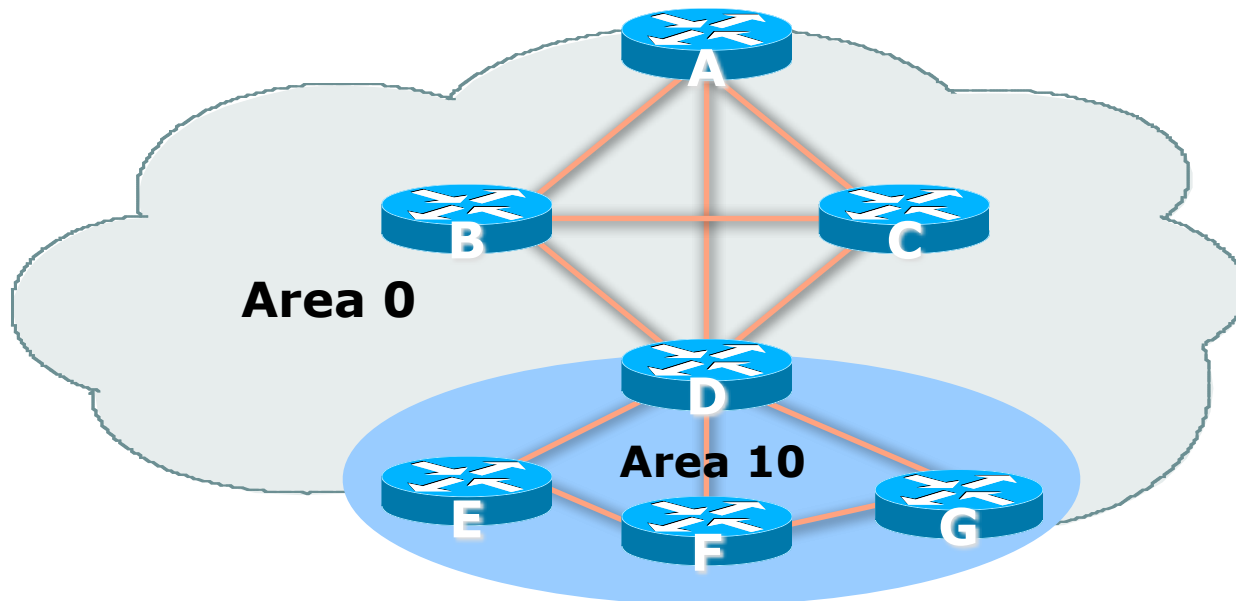
p Too much redundancy...

- Dual links to backbone in stub areas must be the same cost – other wise sub-optimal routing will result
- Too Much Redundancy in the backbone area without good summarisation will effect convergence in the Area 0

OSPF Areas: Migration

- p Where to place OSPF Areas?
 - **Follow the physical topology!**
 - Remember the earlier design advice
- p Configure area at a time!
 - Start at the outermost edge of the network
 - Log into routers at either end of a link and change the link from Area 0 to the chosen Area
 - Wait for OSPF to re-establish adjacencies
 - And then move onto the next link, etc
 - Important to ensure that there is never an Area 0 island anywhere in the migrating network

OSPF Areas: Migration



- Migrate small parts of the network, one area at a time
 - Remember to introduce summarisation where feasible
- With careful planning, the migration can be done with minimal network downtime

OSPF for Service Providers



Configuring OSPF & Adding
Networks

OSPF: Configuration

p Starting OSPF in Cisco's IOS

```
router ospf 100
```

- Where "100" is the process ID

p 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
- Many ISPs configure the process ID to be the same as their BGP Autonomous System Number

OSPF: Establishing Adjacencies

- p Cisco IOS OSPFv2 automatically tries to establish adjacencies on all defined interfaces (or subnets)
- p Best practice is to disable this
 - Potential security risk: sending OSPF Hellos outside of the autonomous system, and risking forming adjacencies with external networks
 - Example: Only POS4/0 interface will attempt to form an OSPF adjacency

```
router ospf 100
  passive-interface default
  no passive-interface POS4/0
```

OSPF: Adding Networks

Option One

p Redistribution:

- Applies to all connected interfaces on the router but sends networks as external type-2s – which are not summarised

```
router ospf 100
```

```
redistribute connected subnets
```

p **Do NOT do this!** Because:

- Type-2 LSAs flood through entire network
- These LSAs are not all useful for determining paths through backbone; they simply take up valuable space

OSPF: Adding Networks

Option Two

- p Per link configuration – from IOS 12.4 onwards
 - OSPF is configured on each interface (same as ISIS)
 - Useful for multiple subnets per interface

```
interface POS 4/0
  ip address 192.168.1.1 255.255.255.0
  ip address 172.16.1.1 255.255.255.224 secondary
  ip ospf 100 area 0
!
router ospf 100
  passive-interface default
  no passive-interface POS 4/0
```

OSPF: Adding Networks

Option Three

- p Specific network statements
 - Every active interface with a configured IP address needs an OSPF network statement
 - Interfaces that will have no OSPF neighbours need passive-interface to disable OSPF Hello's
 - p That is: all interfaces connecting to devices outside the ISP backbone (i.e. customers, peers, etc)

```
router ospf 100
  network 192.168.1.0 0.0.0.3 area 51
  network 192.168.1.4 0.0.0.3 area 51
  passive-interface Serial 1/0
```

OSPF: Adding Networks

Option Four

- p Network statements – wildcard mask
 - Every active interface with configured IP address covered by wildcard mask used in OSPF network statement
 - Interfaces covered by wildcard mask but having no OSPF neighbours need passive-interface (or use passive-interface default and then activate the interfaces which will have OSPF neighbours)

```
router ospf 100
  network 192.168.1.0 0.0.0.255 area 51
  passive-interface default
  no passive interface POS 4/0
```

OSPF: Adding Networks

Recommendations

- p Don't ever use Option 1
- p Use Option 2 if supported; otherwise:
- p Option 3 is fine for core/infrastructure routers
 - Doesn't scale too well when router has a large number of interfaces but only a few with OSPF neighbours
 - → solution is to use Option 3 with "no passive" on interfaces with OSPF neighbours
- p Option 4 is preferred for aggregation routers
 - Or use iBGP next-hop-self
 - Or even ip unnumbered on external point-to-point links

OSPF: Adding Networks

Example One (Cisco IOS ≥ 12.4)

- p Aggregation router with large number of leased line customers and just two links to the core network:

```
interface loopback 0
  ip address 192.168.255.1 255.255.255.255
  ip ospf 100 area 0
interface POS 0/0
  ip address 192.168.10.1 255.255.255.252
  ip ospf 100 area 0
interface POS 1/0
  ip address 192.168.10.5 255.255.255.252
  ip ospf 100 area 0
interface serial 2/0:0 ...
  ip unnumbered loopback 0
! Customers connect here ^^^^^^
router ospf 100
  passive-interface default
  no passive interface POS 0/0
  no passive interface POS 1/0
```

OSPF: Adding Networks

Example One (Cisco IOS < 12.4)

- p Aggregation router with large number of leased line customers and just two links to the core network:

```
interface loopback 0
  ip address 192.168.255.1 255.255.255.255
interface POS 0/0
  ip address 192.168.10.1 255.255.255.252
interface POS 1/0
  ip address 192.168.10.5 255.255.255.252
interface serial 2/0:0 ...
  ip unnumbered loopback 0
! Customers connect here ^^^^^^
router ospf 100
  network 192.168.255.1 0.0.0.0 area 51
  network 192.168.10.0 0.0.0.3 area 51
  network 192.168.10.4 0.0.0.3 area 51
  passive-interface default
  no passive interface POS 0/0
  no passive interface POS 1/0
```


OSPF: Adding Networks

Example Two (Cisco IOS ≥ 12.4)

- p Core router with only links to other core routers:

```
interface loopback 0
  ip address 192.168.255.1 255.255.255.255
  ip ospf 100 area 0
interface POS 0/0
  ip address 192.168.10.129 255.255.255.252
  ip ospf 100 area 0
interface POS 1/0
  ip address 192.168.10.133 255.255.255.252
  ip ospf 100 area 0
interface POS 2/0
  ip address 192.168.10.137 255.255.255.252
  ip ospf 100 area 0
interface POS 2/1
  ip address 192.168.10.141 255.255.255.252
  ip ospf 100 area 0
router ospf 100
  passive interface loopback 0
```

OSPF: Adding Networks

Example Two (Cisco IOS < 12.4)

- p Core router with only links to other core routers:

```
interface loopback 0
  ip address 192.168.255.1 255.255.255.255
interface POS 0/0
  ip address 192.168.10.129 255.255.255.252
interface POS 1/0
  ip address 192.168.10.133 255.255.255.252
interface POS 2/0
  ip address 192.168.10.137 255.255.255.252
interface POS 2/1
  ip address 192.168.10.141 255.255.255.252
router ospf 100
  network 192.168.255.1 0.0.0.0 area 0
  network 192.168.10.128 0.0.0.3 area 0
  network 192.168.10.132 0.0.0.3 area 0
  network 192.168.10.136 0.0.0.3 area 0
  network 192.168.10.140 0.0.0.3 area 0
  passive interface loopback 0
```

OSPF: Adding Networks

Summary

- p Key Theme when selecting a technique:
Keep the Link State Database Lean
 - Increases Stability
 - Reduces the amount of information in the Link State Advertisements (LSAs)
 - Speeds Convergence Time

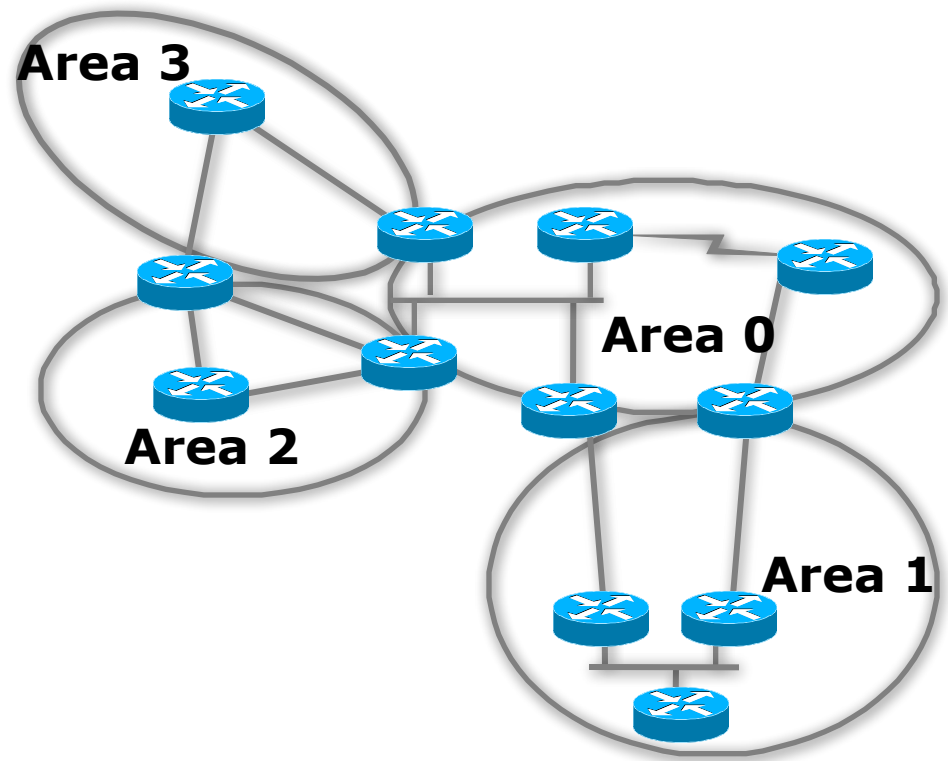
OSPF in Cisco IOS



Useful features for ISPs

Areas

- p An area is stored as a 32-bit field:
 - Defined in IPv4 address format (i.e. Area 0.0.0.0)
 - Can also be defined using single decimal value (i.e. Area 0)
- p 0.0.0.0 reserved for the backbone area



Logging Adjacency Changes

- p The router will generate a log message whenever an OSPF neighbour changes state
- p Syntax:
 - `[no] [ospf] log-adjacency-changes`
 - (OSPF keyword is optional, depending on IOS version)
- p Example of a typical log message:
 - `%OSPF-5-ADJCHG: Process 1, Nbr 223.127.255.223 on Ethernet0 from LOADING to FULL, Loading Done`

Number of State Changes

- p The number of state transitions is available via SNMP (ospfNbrEvents) and the CLI:
 - `show ip ospf neighbor [type number] [neighbor-id] [detail]`
 - Detail—(Optional) Displays all neighbours given in detail (list all neighbours). When specified, neighbour state transition counters are displayed per interface or neighbour ID

State Changes (Continued)

- p To reset OSPF-related statistics, use the `clear ip ospf counters` command
 - This will reset neighbour state transition counters per interface or neighbour id
 - `clear ip ospf counters [neighbor [<type number>] [neighbor-id]]`

Router ID

- ⌘ If the loopback interface exists and has an IP address, that is used as the router ID in routing protocols – **stability!**
- ⌘ If the loopback interface does not exist, or has no IP address, the router ID is the highest IP address configured – **danger!**
- ⌘ OSPF sub command to manually set the Router ID:
 - `router-id <ip address>`

Cost & Reference Bandwidth

- ⌘ Bandwidth used in Metric calculation
 - $\text{Cost} = 10^8 / \text{bandwidth}$
 - Not useful for interface bandwidths > 100 Mbps
- ⌘ Syntax:
 - `ospf auto-cost reference-bandwidth <reference-bw>`
- ⌘ Default reference bandwidth still 100 Mbps for backward compatibility
- ⌘ Most ISPs simply choose to develop their own cost strategy and apply to each interface type

Cost: Example Strategy

100GE	100Gbps	cost = 1
40GE/OC768	40Gbps	cost = 2
10GE/OC192	10Gbps	cost = 5
OC48	2.5Gbps	cost = 10
GigEthernet	1Gbps	cost = 20
OC12	622Mbps	cost = 50
OC3	155Mbps	cost = 100
FastEthernet	100Mbps	cost = 200
Ethernet	10Mbps	cost = 500
E1	2Mbps	cost = 1000

Default routes

- p Originating a default route into OSPF
 - **default-information originate metric <n>**
 - Will originate a default route into OSPF if there is a matching default route in the Routing Table (RIB)
 - The optional **always** keyword will always originate a default route, even if there is no existing entry in the RIB

Clear/Restart

- p **OSPF clear** commands
 - If no process ID is given, all OSPF processes on the router are assumed
- p **clear ip ospf [pid] redistribution**
 - This command clears redistribution based on OSPF routing process ID
- p **clear ip ospf [pid] counters**
 - This command clears counters based on OSPF routing process ID
- p **clear ip ospf [pid] process**
 - This command will restart the specified OSPF process. It attempts to keep the old router-id, except in cases where a new router-id was configured or an old user configured router-id was removed. Since this command can potentially cause a network churn, a user confirmation is required before performing any action

Use OSPF Authentication

- p Use authentication
 - Too many operators overlook this basic requirement
- p When using authentication, use the MD5 feature
 - Under the global OSPF configuration, specify:
`area <area-id> authentication message-digest`
 - Under the interface configuration, specify:
`ip ospf message-digest-key 1 md5 <key>`
- p Authentication can be selectively disabled per interface with:
`ip ospf authentication null`

Point to Point Ethernet Links

- ⌘ For any broadcast media (like Ethernet), OSPF will attempt to elect a designated and backup designated router when it forms an adjacency
 - If the interface is running as a point-to-point WAN link, with only 2 routers on the wire, configuring OSPF to operate in "point-to-point mode" scales the protocol by reducing the link failure detection times
 - Point-to-point mode improves convergence times on Ethernet networks because it:
 - ⌘ Prevents the election of a DR/BDR on the link,
 - ⌘ Simplifies the SPF computations and reduces the router's memory footprint due to a smaller topology database.

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

Tuning OSPF (1)

p DR/BDR Selection

- `ip ospf priority 100` (default 1)
- This feature should be in use in your OSPF network
- Forcibly set your DR and BDR per segment so that they are known
- Choose your most powerful, or most idle routers, so that OSPF converges as fast as possible under maximum network load conditions
- Try to keep the DR/BDR limited to one segment each

Tuning OSPF (2)

p OSPF startup

- **max-metric router-lsa on-startup wait-for-bgp**
- Avoids blackholing traffic on router restart
- Causes OSPF to announce its prefixes with highest possible metric until iBGP is up and running
- When iBGP is running, OSPF metrics return to normal, make the path valid

p ISIS equivalent:

- **set-overload-bit on-startup wait-for-bgp**

Tuning OSPF (3)

p Hello/Dead Timers

- `ip ospf hello-interval 3` (default 10)
- `ip ospf dead-interval 15` (default is 4x hello)
- This allows for faster network awareness of a failure, and can result in faster reconvergence, but requires more router CPU and generates more overhead

p LSA Pacing

- `timers lsa-group-pacing 300` (default 240)
- Allows grouping and pacing of LSA updates at configured interval
- Reduces overall network and router impact

Tuning OSPF (4)

p OSPF Internal Timers

- `timers spf 2 8` (default is 5 and 10)
- Allows you to adjust SPF characteristics
- The first number sets wait time from topology change to SPF run
- The second is hold-down between SPF runs
- BE CAREFUL WITH THIS COMMAND; if you're not sure when to use it, it means you don't need it; default is sufficient 95% of the time

Tuning OSPF (5)

- p LSA filtering/interface blocking
 - Per interface:
 - p `ip ospf database-filter all out` (no options)
 - Per neighbor:
 - p `neighbor 1.1.1.1 database-filter all out` (no options)
 - OSPFs router will flood an LSA out all interfaces except the receiving one; LSA filtering can be useful in cases where such flooding unnecessary (i.e., NBMA networks), where the DR/BDR can handle flooding chores
 - `area <area-id> filter-list <acl>`
 - Filters out specific Type 3 LSAs at ABRs
- p Improper use can result in routing loops and black-holes that can be very difficult to troubleshoot

Summary

- ⌘ OSPF has a bewildering number of features and options
- ⌘ Observe ISP best practices
- ⌘ Keep design and configuration simple
- ⌘ Investigate tuning options and suitability for your own network
 - Don't just turn them on!

Deploying OSPF for ISPs



ISP Training Workshops