



Deploying OSPF for ISPs

ISP/IXP Workshops

Agenda

- OSPF Design in SP Networks
- Adding Networks in OSPF
- OSPF in IOS

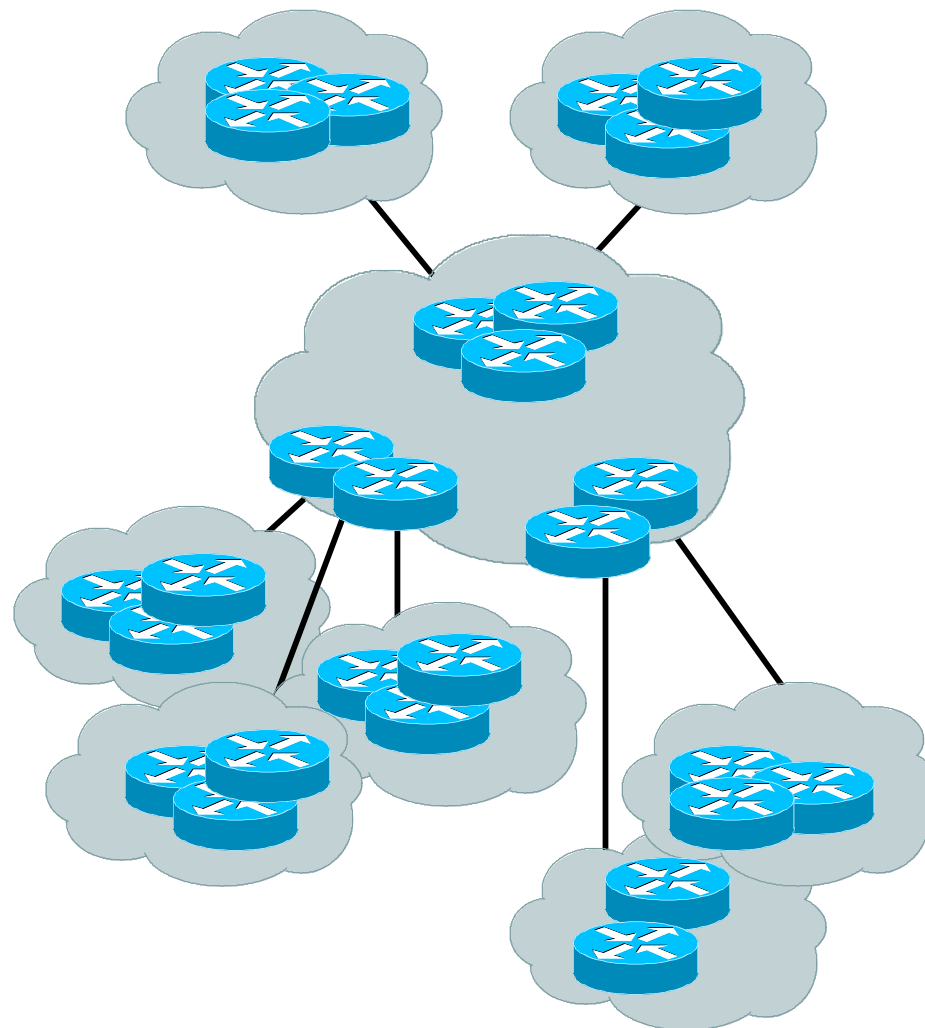


OSPF Design

As applicable to Service Provider Networks

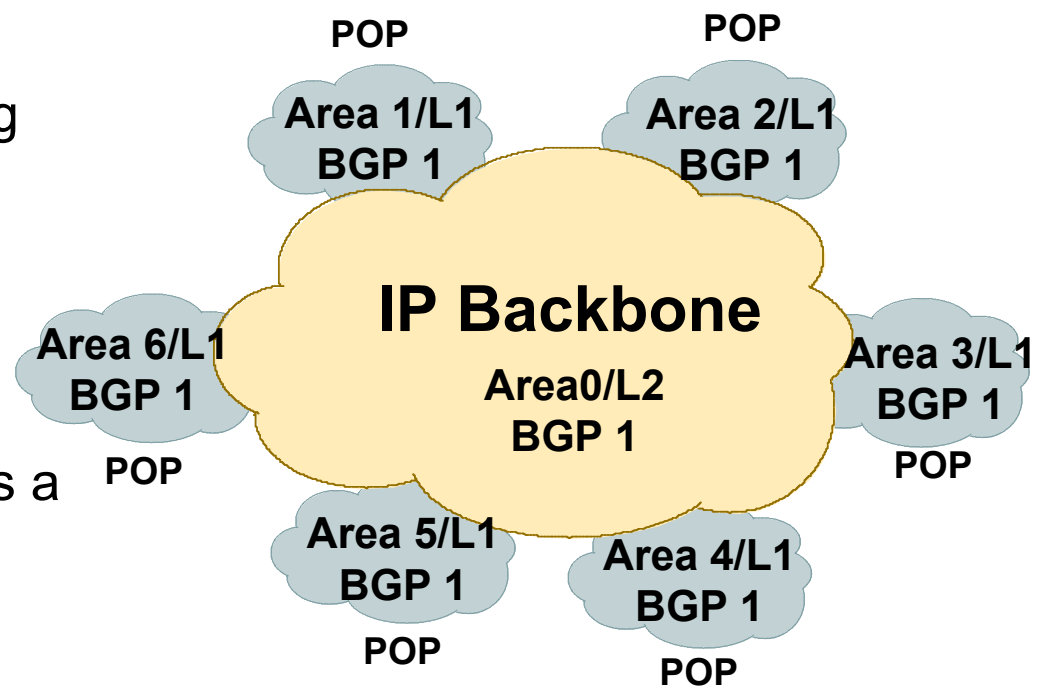
Service Providers

- 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



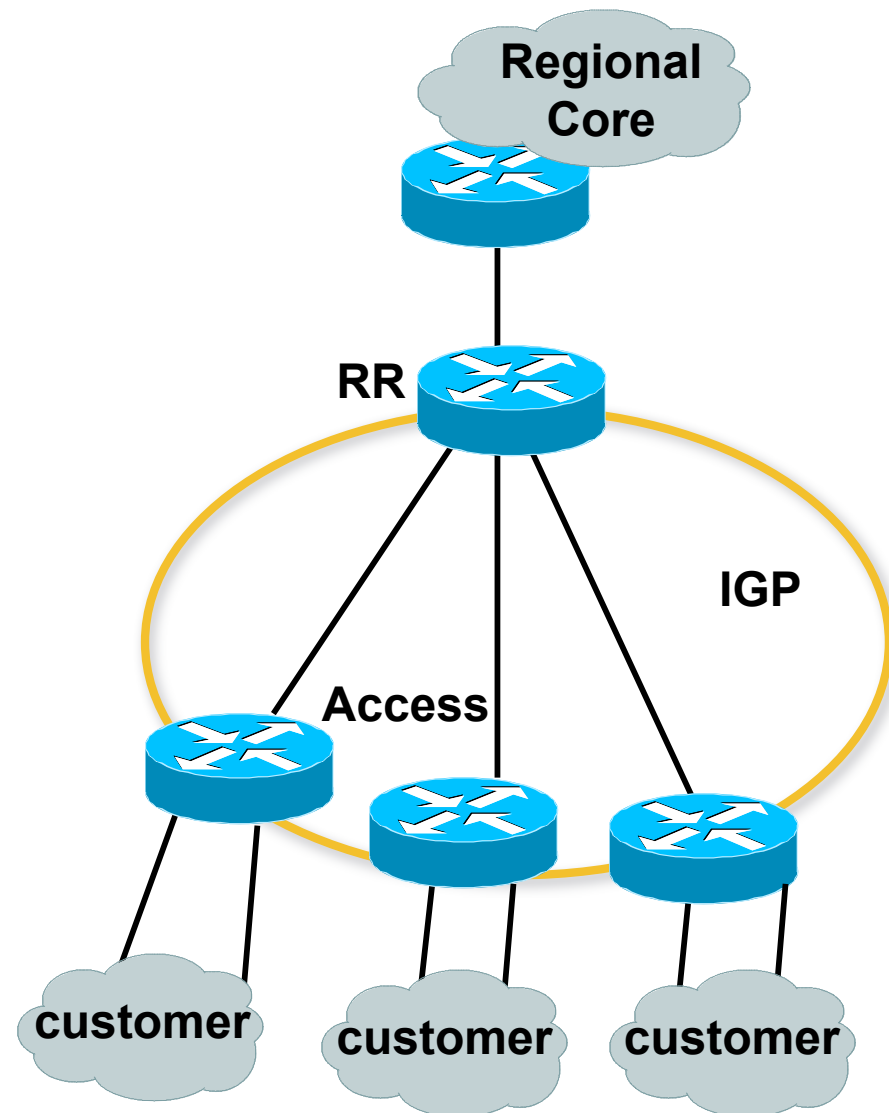
SP Architecture

- Major routing information is ~290K prefixes via BGP
- Largest known IGP routing table is ~9–10K
- Total of 300K
- 10K/300K ~ 3% 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

- 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
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OSPF Design: Addressing

- Minimising the number of prefixes in OSPF:

Address loopbacks out of a contiguous address block

But do not summarise these across area boundaries: iBGP will not work

Use contiguous address blocks per area for infrastructure point-to-point links

Use `area range` command on ABR to summarise

- 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

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

OSPF Design: Areas

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

OSPF Design: Areas

- Area 0 **must** be contiguous

Do NOT use virtual links to join two Area 0 islands

- Traffic between two non-zero areas 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

- Think Redundancy

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

- 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

- Where to place OSPF Areas?

Follow the physical topology!

Remember the earlier design advice

- Configure area at a time!

Start at the outermost edge of the network

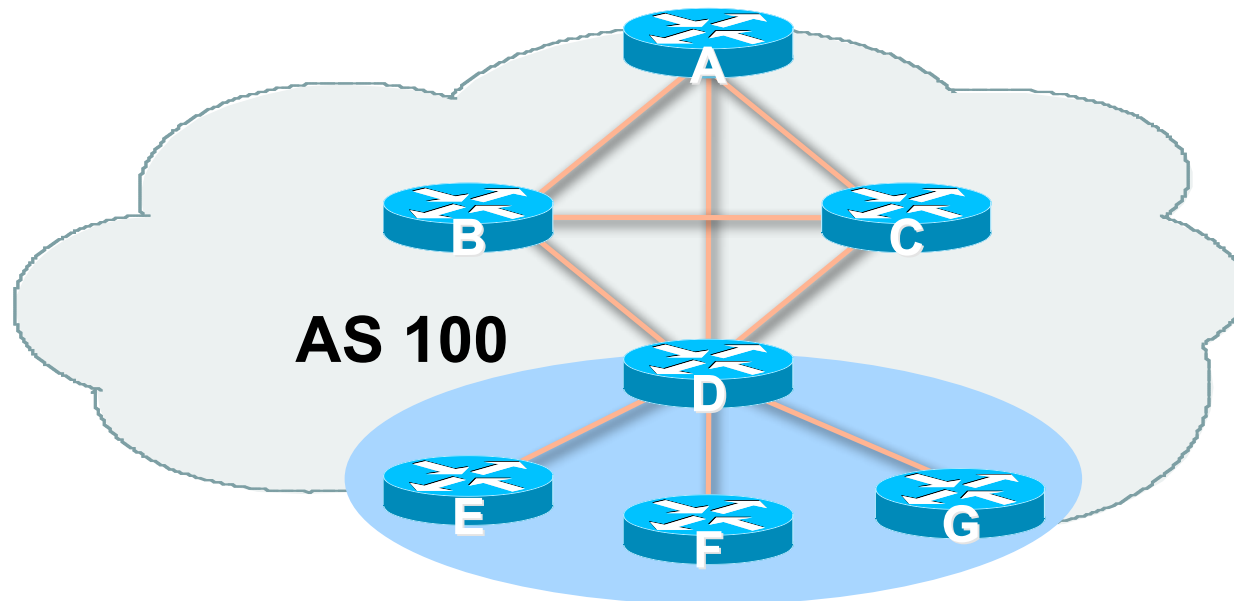
Log into routers at either end of a link and change the link from Area 0 to the chosen Area

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

- Starting OSPF in IOS

```
router ospf 100
```

Where “100” 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

Most ISPs configure the process ID to be the same as their BGP Autonomous System Number

OSPF: Adding Networks

Option One

- Redistribution:

```
redistribute connected subnets
```

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
```

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

Type-2 LSAs flood through entire network

These LSAs are not all useful for determining paths through backbone; simply take up space

OSPF: Adding Networks

Option Two

- 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 192.168.1.0 255.255.255.0
  ip address 172.16.1.0 255.255.255.224 secondary
  ip ospf 100 area 0
!
router ospf 100
  passive-interface default
  no passive interface POS 4/0
```

OSPF: Adding Networks

Option Three

- Specific network statements

Every active interface with a configured IP address needs an OSPF network statement

Interfaces that will have no OSPF neighbours needs passive-interface to disable OSPF Hello's

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

- 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

- Don't ever use Option 1
- Use Option 2 if supported; otherwise:
- 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
- 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 (IOS \geq 12.4)

- 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 (IOS < 12.4)

- 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 (IOS \geq 12.4)

- 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 (IOS < 12.4)

- 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

- 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

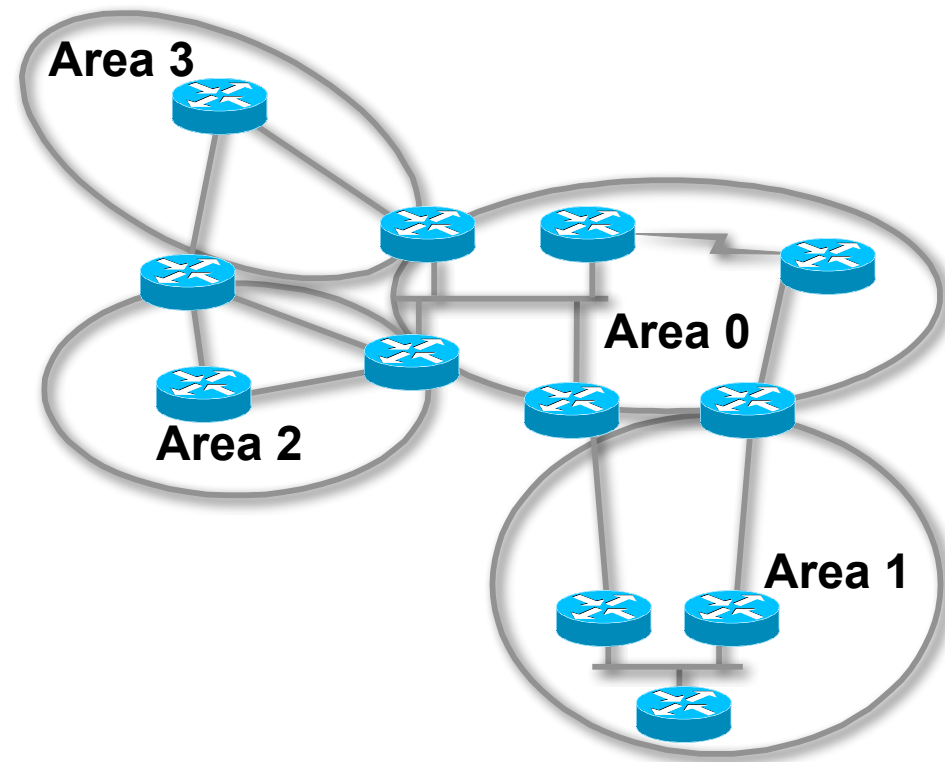


OSPF in IOS

Useful features for ISPs

Areas

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



Logging Adjacency Changes

- The router will generate a log message whenever an OSPF neighbour changes state

- Syntax:

[no] [ospf] log-adjacency-changes

(OSPF keyword is optional, depending on IOS version)

- 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

- 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)

- 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

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

40GE	40Gbps	cost = 1
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 = 500
Ethernet	10Mbps	cost = 1000
E1	2Mbps	cost = 5000

Clear/Restart

- OSPF **clear** commands

If no process ID is given, all OSPF processes on the router are assumed

- **clear ip ospf [pid] redistribution**

This command clears redistribution based on OSPF routing process ID

- **clear ip ospf [pid] counters**

This command clears counters based on OSPF routing process ID

- **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

- Use authentication; too many people overlook this basic feature

- When using authentication, use the MD5 feature

```
area <area-id> authentication message-digest  
(whole area)
```

```
ip ospf message-digest-key 1 md5 <key>
```

- 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 wire,

- 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)

- 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

- LSA Pacing

`timers lsa-group-pacing 300` (default 240)

This is a great feature; allows grouping and pacing of LSA updates at configured interval; reduces overall network and router impact

Tuning OSPF (2)

- 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 (3)

- 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 (4)

- 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

(Introduced by CSCdp82156 in 12.0S, 12.2 and 12.2S)

- ISIS equivalent:

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

Tuning OSPF (5)

- LSA filtering/interface blocking

Per interface:

```
ip ospf database-filter all out (no options)
```

Per neighbor:

```
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

- Improper use can result in routing loops and black-holes that can be very difficult to troubleshoot



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OSPF Command Summary

OSPF Router Commands

```
ROUTER OSPF <pid#x>
```

```
NETWORK <n.n.n.n> <mask> AREA <area-id>
```

```
AREA <area-id> STUB {no-summary}
```

```
AREA <area-id> AUTHENTICATION
```

```
AREA <area-id> DEFAULT_COST <cost>
```

```
AREA <area-id> VIRTUAL-LINK <router-id>...
```

```
AREA <area-id> RANGE <address mask>
```

Interface Subcommands

IP OSPF COST <cost>

IP OSPF PRIORITY <8-bit-number>

IP OSPF HELLO-INTERVAL <number-of-seconds>

IP OSPF DEAD-INTERVAL <number-of-seconds>

IP OSPF AUTHENTICATION-KEY <8-bytes-of-password>