

## Module 5 – Advanced OSPF

**Objective:** To implement different types of OSPF areas and use advanced OSPF Features in the lab network.

**Prerequisite:** Module 1 and OSPF presentation

Topology:

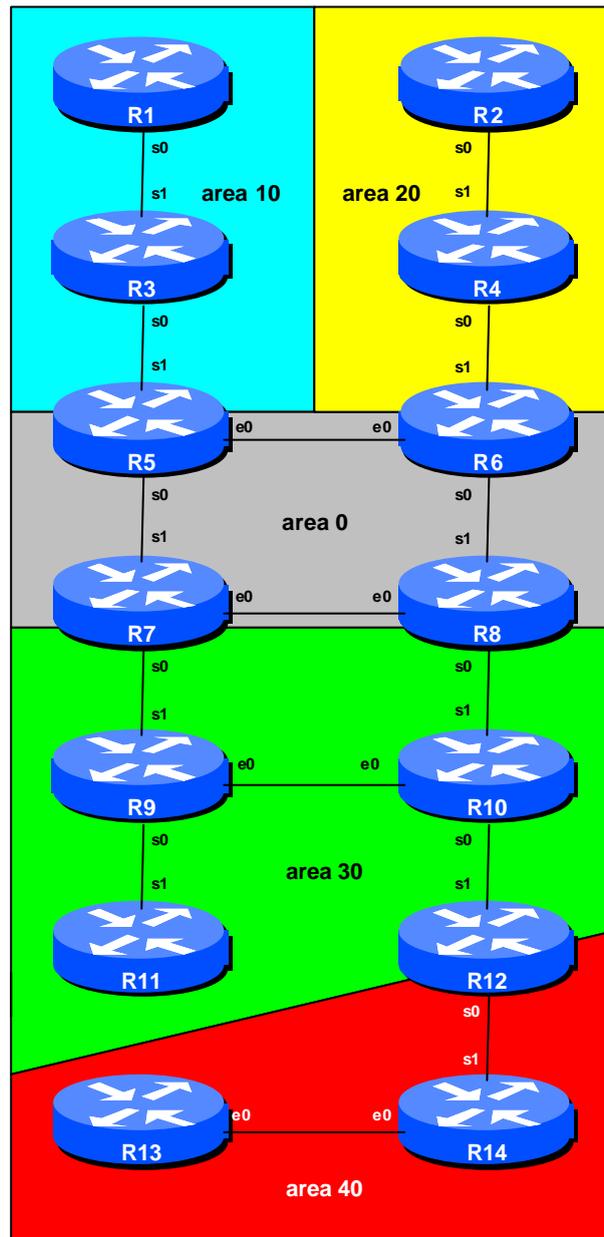


Figure 1 – OSPF Areas

## Lab Notes

This module provides an introduction to more advanced OSPF topics. These cover OSPF areas types, including area 0, regular areas, not so stubby areas and virtual links. The module forms the basis for the Route Reflector Module which follows. It is strongly recommended that the OSPF presentation is reviewed prior to starting this module. Prerequisites for this Module are Module 1, and the OSPF presentation. As before, ask the workshop instructors or refer to the CD Documentation if there is any doubt.

Before starting, decide which routers in the network will represent the core network, and which will represent other portions of the backbone. The example given in Figure 1 allows the student to configure the best combination for the study of OSPF areas.

### Functional assignments of routers in Figure 1:

- Routers 5 to 8 represent the “core network” and the core interfaces are all in OSPF area 0. In a typical ISP backbone, these routers would carry all the internal link routes known in the ISPs network.
- Routers 1 and 3 are completely in OSPF area 10. This area is a **not so stubby area (NSSA)**. This means that by default only **summary LSAs** (link state advertisements) are announced from area 0 to the NSSA. However, external routes connected to the NSSA can be redistributed into OSPF. Router 5 is the boundary between area 0 and area 10, so requires configuration for both areas.
- Routers 2 and 4 are completely in OSPF area 20. This area is also an **NSSA**. Router 6 is the boundary between area 0 and area 20, so requires configuration for both areas.
- Routers 9, 10 and 11 are wholly in OSPF area 30. Area 30 is a regular OSPF area – the routers will exchange a full OSPF routing table with area 0. Routers 7 and 8 are the border routers between area 0 and area 30 – they both will require configuration for both areas.
- Router 12 has interfaces in OSPF area 30, and one interface in OSPF area 40.
- Finally Routers 13 and 14 are in OSPF area 40. Area 40 has no direct connection to area 0 (the OSPF standard requires that all areas must connect to area 0), so a **virtual link** from Router 12 will be used to connect it to area 0. Furthermore, area 40 will be configured as an **NSSA**.

## Lab Exercise

1. **Reset the configuration of each router** so that it is as it was at the end of Step 11 of Module 1. Basically IP addresses need to be assigned to interfaces, inactive interfaces as per the diagram should be disabled (either shutdown the interface, or remove its configuration), and the new ethernet connection between Router 7 and Router 8 should be activated.

**Important:** There should be no OSPF or BGP running in the lab network. Also ensure that there are no access-lists or route-maps remaining on the routers. Unused configuration should be deleted. OSPF and BGP configuration can be deleted by entering the commands:

```
no router bgp <ASN>
no router ospf <PID>
```

**Checkpoint #1:** Call the lab assistant and show the router configuration and connectivity.

- 2. OSPF Configuration for routers in Area 0 only.** Configure OSPF for your router using PID 100. Remember all the tips and techniques which you have learned in previous modules. Recall the use of the *network* statement, and the *redistribute connected* statement. You only want to configure OSPF with other routers in Area 0. Do **not** configure OSPF with routers in other areas yet.

**Example for Router 5:**

```
router ospf 100
network 210.210.8.0 0.0.0.3 area 0      !link to Router6
network 210.210.10.0 0.0.0.3 area 0   !link to Router7
network 210.210.11.224 0.0.0.0 area 0 !loopback interface
passive-interface loopback 0
```

- 3. OSPF configuration for routers with interfaces in Area 30 only.** Configure OSPF for your router using PID 100. Remember the tips and techniques which you have learned in previous modules. Recall the use of the *network* statement, and the *passive-interface* statement. You only want to configure OSPF with other routers which have interfaces in Area 30. Do **not** configure OSPF with routers in other areas yet.

**Example for Router 9:**

```
router ospf 100
network 220.220.8.0 0.0.0.3 area 30   !link to Router10
network 220.220.9.0 0.0.0.3 area 30   !link to Router7
network 220.220.10.0 0.0.0.3 area 30  !link to Router11
network 220.220.11.224 0.0.0.0 area 30 !loopback interface
passive-interface loopback 0
```

- 4. OSPF configuration for routers with interfaces in Area 10 only.** Configure OSPF for your router using PID 100. Remember the tips and techniques which you have learned in previous modules. Recall the use of the *network* statement, and the *passive-interface* statement. Remember that Area 10 is a **not so stubby area**. Review the OSPF documentation to see what extra configuration commands you require.

**Example for Router 3:**

```
router ospf 100
network 200.200.5.0 0.0.0.3 area 10    !link to Router1
```

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```
network 200.200.19.224 0.0.0.0 area 10      !loopback interface
network 210.210.9.0 0.0.0.3 area 10       !link to Router5
passive-interface loopback 0
area 10 nssa
```

Notice the introduction of the *area 10 nssa* command. This tells the router that Area 10 is an OSPF **NSSA**.

- 5. OSPF Configuration for routers with interfaces in Area 20 only.** Use the configuration hints in step 4 above to configure OSPF for the routers in Area 20. Area 20 is also an **NSSA**.
- 6. OSPF Configuration for routers with interfaces in Area 40 only.** Configure OSPF for your router using PID 100. Remember the tips and techniques which you have learned in previous modules. Recall the use of the *network* statement, and the *passive-interface* statement. Remember that Area 40 is an **NSSA**. Again review the OSPF documentation to see what extra configuration commands you require.

#### **Example for Router 14:**

```
router ospf 100
network 222.222.32.0 0.0.0.3 area 40      !link to Router12
network 222.222.16.0 0.0.0.3 area 40     !link to Router13
network 222.222.35.224 0.0.0.0 area 40   !loopback interface
passive-interface loopback 0
area 40 nssa
```

Notice the introduction of the *area 40 nssa* command. This tells the router Area 40 is an OSPF **nssa**.

**Checkpoint #2:** Call the lab instructors and show the function of your router. You should have neighbour relationships with all the routers in your area (called *intra-area*). You should also demonstrate the output from “*show ip route*” so that you can see which routes you are hearing from which routers.

- 7. Putting it all together!** We have now configured OSPF in the routers which are wholly in a particular area. We now need to join the areas together to rebuild our OSPF network. The following steps should be carried out by the appropriate router teams to achieve this.
- 8. Connecting Area 0 to the Areas 10, 20 and 30.** The teams running Routers 5 to 8, the core of our lab network, now need to set up configuration so that the three other physically connected areas have an OSPF relationship with Area 0.

For example, the team operating Router 5 need to configure an OSPF network statement for the interface which connects to Router 3 in Area 10 so that the routers can try to establish a neighbour relationship. An example configuration might be:

```
router ospf 100
 network 210.210.9.0 0.0.0.3 area 10
 area 10 nssa
```

This tells the router that the OSPF neighbour it finds will be in OSPF area 10, which is a not so stubby area.

Routers 6, 7, and 8 should enter similar and appropriate configuration for their non-area 0 neighbours. Don't forget that Area 20 is also an NSSA (so requires the **nssa** command) and that Area 30 is a normal area (so does **not** require the nssa command).

- 9. Connecting Area 30 to Area 40.** While OSPF requires that all areas must connect directly to Area 0, there is nothing preventing the configuration of a router so that two other areas have a “peering” with each other. The only problem is that one area will only see the other area's LSAs. All OSPF areas except for the “special” area 0 are defined as **non-transit** OSPF areas – they will not pass LSAs from one area to another area.

Router 12 should now apply configuration which will set up a neighbour relationship with Router 14 in Area 40. Don't forget that Area 40 is an **NSSA**. An example configuration for Router 12 might be:

```
router ospf 100
 network 222.222.32.0 0.0.0.3 area 40
 area 40 nssa
```

- 10. All router teams should check their routing table.** Those teams in Area 40 will only see the LSAs originated from Area 30. They will not see any other LSAs. Likewise, Areas 0, 10 and 20 will not see any LSAs which have originated from Area 40.

**Q. Why is this?**

**A.** Review the OSPF documentation. Area 40 needs to be directly connected to Area 0. Area 0 is the only area which can pass LSAs from one area to another.

**Checkpoint #3:** Call the lab instructors and show the function of your router. The inter-area OSPF “peerings” will now be up. If you have an area border router, demonstrate the neighbour relationships using “*sh ip ospf neigh*”. If you are not in an area border, you should now have a more complete routing table.

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**11. Connecting Area 40 to the rest of the lab.** The final step is to configure virtual links so that Area 40 can have connectivity beyond Area 30.

Notice that Area 30 is “blocking” direct access from Area 40 to Area 0. So we need to configure Area 30 to provide a “tunnel” or virtual path so that Area 40 can connect directly to Area 0. To do this, extra configuration needs to be added to Router 7, Router 8 (optional) and Router 12. Only one virtual link is required, but then if Router 7 was turned off, Area 40 would become disconnected beyond Area 30 again. So a second virtual link should be constructed to Router 8.

The virtual link is constructed across the area in question (in this case Area 30), to the router-id (the loopback interface) of the router which forms the border between Area 30 and the Area which you want to reach.

An example configuration for Router 8 might be:

```
router ospf 100
  area 30 virtual-link 222.222.11.224      ! link to Router 12
```

And for Router 12, it might be:

```
router ospf 100
  area 30 virtual-link 210.210.35.224     ! link to Router 7
  area 30 virtual-link 220.220.7.224      ! link to Router 8
```

#### **Checkpoint #4:**

*i] Call the lab instructors and show the routing table. Those routers outside Area 40 will now hear the LSAs from Area 40, and have connectivity to the routers in Area 40. Those routers in Area 40 should find that they have connectivity beyond Area 30 now.*

*ii] The teams operating Router7, 8 and 12 should use the “show ip ospf virtual-links” command to check the status of the virtual link between their routers.*

**12. Limiting routes in NSSAs.** All that a not so stubby area does in OSPF is limit the number of LSAs going into a region of a network, and allow external routes to be injected into that region of the network. However, there are extra features which can be applied to NSSAs to improve the benefits for the local network.

Cisco IOS allows 3 options to be set as part of the NSSA command subset. These are **no-redistribution**, **default-information-originate**, and **no-summary**. Those routers with an interface

connecting to an NSSA (Routers 5, 6 and 12) should now apply these configuration commands. For example, Router 5 might have:

```
router ospf 100
 network 210.210.9.0 0.0.0.3 area 10
 area 10 nssa no-redistribution default-information-originate no-summary
```

**Q.** What do these extra commands do?

**Q.** What is their effect?

These commands have effectively given the NSSA the look and feel of a totally stubby area, but allowed the redistribution of connected networks, such as the loopback interface and serial links, into the OSPF process. Without them, summary LSAs and external routes for the entire network are sent to the NSSA.

***Checkpoint #5:*** Call the lab instructors and show the routing table. Those routers in NSSAs should see a significantly reduced routing table, and a default route. Everyone in the lab workshop should now be able to ping all the loopback interfaces of each router in the lab. Routers in the core of the network should see the summary networks coming from the NSSAs.

**13. Intra Area Authentication.** OSPF supports router authentication within areas. This is quite important inside ISP networks to prevent the introduction of improperly configured or unintended equipment.

Each area will turn on authentication within that area. Routers which are **ABRs** will naturally have to enter configuration to cover all areas the router has interfaces in. The password that should be used for all areas in this example is *cisco*. MD5 encryption should be used rather than the standard simple encryption – to do this, use the *message-digest* and *message-digest-key* commands.

An example configuration for Router6 might be:

```
router ospf 100
 area 0 authentication message-digest
 area 20 authentication message-digest
 !
 interface ethernet 0/0
 ip ospf message-digest-key 1 md5 cisco
 interface serial 0/0
 ip ospf message-digest-key 1 md5 cisco
 interface serial 0/1
 ip ospf message-digest-key 1 md5 cisco
 !
```

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Notice now that the OSPF adjacencies do not come up unless the neighbouring router has also entered the same configuration and key. Notice also how the OSPF adjacencies were reset as the configuration was entered – security is being introduced, so the adjacencies are reset.

**Note:** the *message-digest-key* allows up to 255 keys to be set per interface. It is generally not recommended to set more than one per interface, as the router will try and communicate with its neighbours using all keys. If a key needs to be upgraded, common practice then is to set a second key, allowing a graceful changeover without compromising the functioning of the network. Once all the routers on the network are using the new key, the old one should be removed.

**14. Authentication on virtual links – Routers 7, 8 and 12 only.** The previous step of enabling authentication on the OSPF adjacencies has the effect of tearing down the virtual link between area 0 and area 40 across area 30. The final step is to enable authentication for this link.

OSPF virtual links are not associated with any particular router interface. Therefore, the *virtual-link* configuration command has an option which allows authentication to be configured. An example for Router 7 might be:

```
router ospf 100
  area 30 authentication message-digest
  area 30 virtual-link 222.222.11.224 message-digest-key 1 md5 cisco
```

**Hint:** Don't forget that a virtual link connects area 0 to an area which has no direct connection to area 0. Router 12 expects the other end of its virtual links to Router7 and Router8 to terminate in area 0.

**15. Final check.** Use the various “*show ip ospf*” commands to see the OSPF status of the lab network now. Routers with virtual links configured can use the command “*show ip ospf virtual*” to display the status of the virtual links. Notice how in the not so stubby areas you see only the default route injected by the area border router(s). Observe the effect of summarisation, and check the routing and the routing table.

**Checkpoint #6:** *Call the lab instructors and show the routing table and information asked for in the previous step.*

## **CONFIGURATION NOTES**

Documentation is critical! You should record the configuration at each *Checkpoint*, as well as the configuration at the end of the module.