# OSPF Exercises

All participants will work within a group as a team. Each group has three routers and four switches to work with.

These exercises are divided into several components:

1. Basic Router Configuration
2. Static Routing
3. Dynamic routing with OSPF
4. First hop redundancy using HSRP

There is a certain dependency between the labs as the exercises progress. Make sure to maintain your configuration unless otherwise instructed. All exercises will use a common IP addressing scheme and network topology.

As you go through the exercises all the examples are given from the point of view of R11, the border router in group 1. Make sure that you take the examples and adapt them to your own router, network topology and addressing scheme.

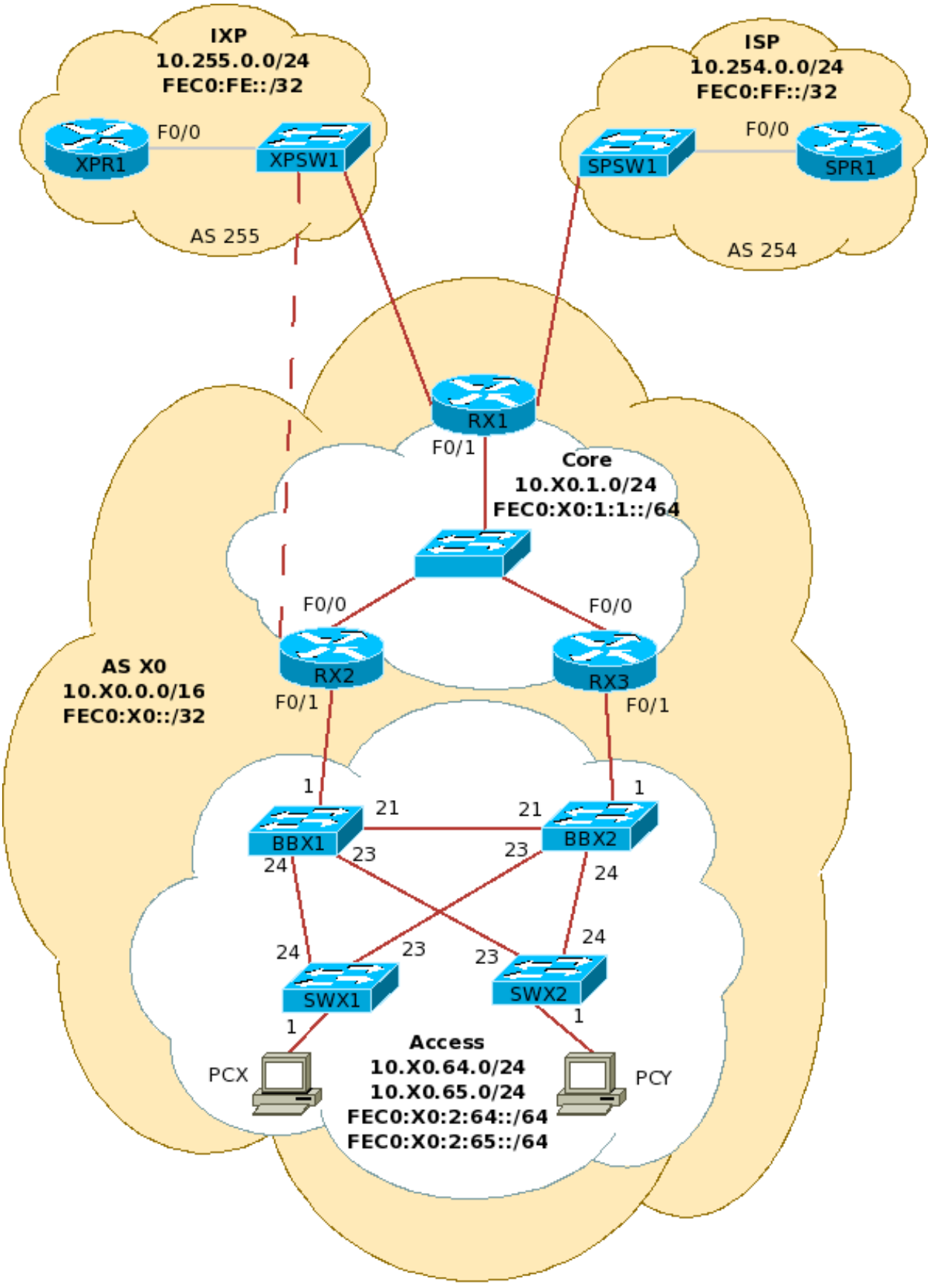
## Address Space Allocation

| | |
|---|---|
| Group 1: 10.10.0.0/16 | ASN: 10 |
| Group 2: 10.20.0.0/16 | ASN: 20 |
| Group 3: 10.30.0.0/16 | ASN: 30 |
| Group 4: 10.40.0.0/16 | ASN: 40 |
| Group 5: 10.50.0.0/16 | ASN: 50 |

Each group will then further partition their space:

| | | |
|---|---|---|
| 10.X0.1.0/24 | FEC0:X0:1:1::/64 | - Core Network |
| 10.X0.64.0/24 | FEC0:X0:2:64::/64 | - Data Subnet (VLAN 64) |
| 10.X0.65.0/24 | FEC0:X0:2:65::/64 | - VOIP Subnet (VLAN 65) |
| 10.X0.254.0/24 | FEC0:X0:0:FE::/64 | - Router Loopback Subnet |
| 10.X0.255.0/24 | FEC0:X0:0:FF::/64 | - Switch MGMT Subnet (VLAN 255) |

With X being your group number (1,2,3,4,5)


IXP
10.255.0.0/24
FEC0:FE::/32
F0/0
XPR1
XPSW1
AS 255
ISP
10.254.0.0/24
FEC0:FF::/32
F0/0
SPSW1
SPR1
AS 254
RX1
F0/1
Core
10.X0.1.0/24
FEC0:X0:1:1::/64
F0/0
F0/0
RX2
RX3
F0/1
F0/1
AS X0
10.X0.0.0/16
FEC0:X0::/32
1
21
21
1
BBX1
BBX2
24
23
23
24
24
23
23
24
SWX1
SWX2
1
1
PCX
PCY
Access
10.X0.64.0/24
10.X0.65.0/24
FEC0:X0:2:64::/64
FEC0:X0:2:65::/64

# Basic Router Configuration

## 1. Name the router.

```
Router> enable
Router# config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# hostname R11
R11(config)#
```

## 2. Deactivate domain name resolution.

```
R11 (config)# no ip domain-lookup
```

## 3. Make sure the router understands CIDR

```
R11 (config)# ip subnet-zero
R11 (config)# ip classless
```

## 4. Activate IPv6 routing.

```
R11 (config)# ipv6 unicast-routing
```

## 5. Save the configuration and checkpoint.

```
R11(config)#^Z
R11# write memory
Building configuration...
[OK]
```

## 6. Configure your interfaces.

```
R11(config)# interface FastEthernet0/1
R11(config-if)# ip address 10.10.1.1 255.255.255.0
R11(config-if)# description Link to Core
R11(config-if)# ipv6 enable
R11(config-if)# ipv6 address FEC0:10:1:1::1/64
R11(config-if)# no ip redirects
R11(config-if)# no ip directed-broadcast
R11(config-if)# no ip proxy-arp
R11(config-if)# no shutdown
R11(config)#^Z
```

From the point of view of R12 & R13 where you will use VLANs:

```
R12(config)# interface FastEthernet0/1
R12(config)# no ip address
R12(config)# no shutdown
R12(config)# interface FastEthernet0/1.64
R12(config-subif)# encapsulation dot1Q 64
R12(config-subif)# ip address 10.10.64.2 255.255.255.0
R12(config-subif)# description Link VLAN 64
R12(config-subif)# ipv6 enable
R12(config-subif)# ipv6 address FEC0:10:2:64::2/64
R12(config-subif)# no ip redirects
R12(config-subif)# no ip directed-broadcast
R12(config-subif)# no ip proxy-arp
R12(config-subif)# no shutdown
R12(config-subif)#^Z
R12#

R13(config)# interface FastEthernet0/1
R13(config)# no ip address
R13(config)# no shutdown
R13(config)# interface FastEthernet0/1.64
R13(config-subif)# encapsulation dot1Q 64
R13(config-subif)# ip address 10.10.64.3 255.255.255.0
R13(config-subif)# description Link VLAN 64
R13(config-subif)# ipv6 enable
R13(config-subif)# ipv6 address FEC0:10:2:64::3/64
R13(config-subif)# no ip redirects
R13(config-subif)# no ip directed-broadcast
R13(config-subif)# no ip proxy-arp
R13(config-subif)# no shutdown
R13(config-subif)#^Z
```

Do the same for VLANs 65 and 255.

## 7. Do some ping tests.

```
R11# ping 10.10.1.2
R11# ping 10.10.1.3
R11# ping FEC0:10:1:1::2
R11# ping FEC0:10:1:1::3
```

and then verify the output of the following commands

**IPv4**:

| | |
|---|---|
| `show arp` | : Shows ARP cache |
| `show interface <int> <number>` | : Shows interface state and configuration |
| `show ip interface` | : Shows interface IP state and config |

**IPv6**:

| | |
|---|---|
| `show ipv6 neighbors` | : Shows IPv6 neighbors |
| `show ipv6 interface <int> <number>` | : Shows interface state and configuration |
| `show ipv6 interface` | : Shows interface state and configuration |

### 8. Create loopback interface.

```
R11(config)#interface loopback 0
R11(config-if)#ip address 10.10.254.1 255.255.255.255
R11(config-if)#ipv6 address FEC0:10:0:FE::1/128
R11(config-if)#^Z
R11#
```

### 9. Verify and save the configuration.

```
R11# show running-config
R11# write memory
Building configuration...
[OK]
```

## Static Routing

### 1. Try pinging the addresses within your AS.

```
R11# ping 10.10.1.2
R11# ping 10.10.1.3
R11# ping 10.10.254.2
R11# ping 10.10.254.3
R11# ping 10.10.64.2
R11# ping 10.10.64.3
R11# ping 10.10.65.2
R11# ping 10.10.65.3
R11# ping 10.10.255.2
R11# ping 10.10.255.3
R11# ping ipv6 FEC0:10:1:1::2
R11# ping ipv6 FEC0:10:1:1::3
R11# ping ipv6 FEC0:10:0:FE::2
R11# ping ipv6 FEC0:10:0:FE::3
R11# ping ipv6 FEC0:10:2:64::2
R11# ping ipv6 FEC0:10:2:64::3
R11# ping ipv6 FEC0:10:2:65::2
R11# ping ipv6 FEC0:10:2:65::3
R11# ping ipv6 FEC0:10:0:FF::2
R11# ping ipv6 FEC0:10:0:FF::3
```

What is happening? Why can't we ping some of the addresses?

### 2. Create static routes.

```
R11(config)# ip route 10.10.254.2 255.255.255.255 10.10.1.2
R11(config)# ip route 10.10.254.3 255.255.255.255 10.10.1.3
R11(config)# ip route 10.10.64.0 255.255.255.0 10.10.1.2
R11(config)# ip route 10.10.64.0 255.255.255.0 10.10.1.3
```

```
R11(config)# ip route 10.10.65.0 255.255.255.0 10.10.1.2
R11(config)# ip route 10.10.65.0 255.255.255.0 10.10.1.3
R11(config)# ipv6 route FEC0:10:0:FE::2/128 FEC0:10:1:1::2
R11(config)# ipv6 route FEC0:10:0:FE::3/128 FEC0:10:1:1::3
R11(config)# ipv6 route FEC0:10:2:64::/64 FEC0:10:1:1::2
R11(config)# ipv6 route FEC0:10:2:64::/64 FEC0:10:1:1::3
R11(config)# ipv6 route FEC0:10:2:65::/64 FEC0:10:1:1::2
R11(config)# ipv6 route FEC0:10:2:65::/64 FEC0:10:1:1::3
R11(config)# ipv6 route FEC0:10:0:FF::/64 FEC0:10:1:1::2
R11(config)# ipv6 route FEC0:10:0:FF::/64 FEC0:10:1:1::3
R11(config)#^Z
R11#
```

Repeat the ping tests now. What happens when a new network is added?

3. **Save the configuration and checkpoint.**

```
R11# write memory
Building configuration...
[OK]
R11#
R11# show running-config
R11# show startup-config
```

## Dynamic Routing with OSPF

1. **Configure a new OSPF routing process.**

**IPv4**:

```
R11(config)#router ospf 100
R11(config)#ospf log-adjacency-changes
R11(config)#^Z
```

**IPv6**:

```
R11(config)#ipv6 router ospf 100
R11(config)#ospf log-adjacency-changes
R11(config)#^Z
```

2. **Add the networks.**

**IPv4:**

```
R11(config)#interface loopback 0
R11(config-if)#ip ospf 100 area 0
R11(config)#^Z
```

**IPv6**:

```
R11(config)#interface loopback 0
R11(config-if)#ipv6 ospf 100 area 0
R11(config)#^Z
```

You need to add each and every network which needs to be announced.

3. **STOP -- Checkpoint.**

**IPv4**:

```
show ip ospf neighbor                    : show adjacencies
```

**IPv6**:

```
show ipv6 ospf neighbor
```

a. How many adjacencies do you see listed? Are they all necessary?
b. Tell OSPF which interfaces do not need to establish adjacencies

**IPv4:**

```
R11(config)#router ospf 100
R11(config-router)#passive-interface FastEthernet0/0
R11(config)#^Z
```

**IPv6**:

```
R11(config)#ipv6 router ospf 100
R11(config-router)#passive-interface FastEthernet0/0
R11(config)#^Z
```

4. **STOP -- Checkpoint.**

**IPv4**:

```
show ip route              : show routes in routing table
show ip ospf               : shows general OSPF information
show ip ospf interface     : shows the status of OSPF in an interface
```

**IPv6**:

```
show ipv6 route
show ipv6 ospf
show ipv6 ospf interface
```

Which routes are preferred?

5. **Remove the old static route entries.**

```
R11(config)# no ip route 10.10.254.2 255.255.255.255 10.10.1.2
…
R11(config)#^Z
R11#
```

6. **STOP -- Checkpoint.**

**IPv4:**

`show ip route` : show routes in routing table

**IPv6**:

`show ipv6 route`

How many routes do you have for each access network? Which route is preferred?

7. **Load balance the traffic for the different networks by using OSPF link costs.**

   a. Check each interface's cost

```
R12#show ip ospf interface fastEthernet 0/1.64
```

   b. If you did the Layer 2 exercises and used MSTP to load balance traffic for the different VLANs, make sure that you assign OSPF link costs accordingly to avoid unnecessary hops

```
R12#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R12(config)#interface fastEthernet 0/1.255
R12(config-subif)#ip ospf cost 5
R12(config-subif)#ipv6 ospf cost 5
R12(config-subif)#^Z
```

## First Hop Redundancy

We will be using HSRP for this exercise. All the examples are presented from the point of view of R12 & R13.

### 1. Configure HSRP for the interfaces

```
R12(config)# interface FastEthernet0/1.64
R12(config-if)# standby 1 name 10.10.64.0/24
R12(config-if)# standby 1 ip 10.10.64.1

R13(config)# interface FastEthernet0/1.64
R13(config-if)# standby 1 name 10.10.64.0/24
R13(config-if)# standby 1 ip 10.10.64.1
```

### 2. STOP – Checkpoint. Verify the active router

```
show standby FastEthernet0/1.64          : Shows HSRP status
```

a. Which is the active router?
b. Which is the standby router?
c. What is the address for the virtual IP?
d. What is the virtual MAC (Ethernet) address?
e. Ping from the workstations out towards the border
f. Traceroute from the workstations towards the border

### 3. Change the interface's HSRP priority for one of the routers serving subnet 10.X0.64.0/24

a. If you did the Layer 2 exercises and used MSTP to load balance traffic for the different VLANs, make sure that you assign the HSRP priorities accordingly to achieve symmetric routing

```
R12(config)# interface FastEthernet0/1.64
R12(config-if)# standby 1 priority 110
```

### 4. STOP – Checkpoint. Verify the active router

```
show standby FastEthernet0/1.64          : Shows HSRP status
```

a. Which is the active router?
b. Which is the standby router?
c. What is the address for the virtual IP?
d. What is the virtual MAC (Ethernet) address?
e. Ping from the workstations out towards the border
f. Traceroute from the workstations towards the border

## 5. Modify other HSRP parameters

```
R12(config)# interface FastEthernet0/1.64
R12(config-if)# standby 1 preempt delay minimum 0
R12(config-if)# standby 1 timers 3 10
R12(config-if)# standby 1 authentication md5 key-string PASS

R13(config)# interface FastEthernet0/1.64
R13(config-if)# standby 1 preempt delay minimum 0
R13(config-if)# standby 1 timers 3 10
R13(config-if)# standby 1 authentication md5 key-string PASS
```

## 6. Track the status of the uplink interface

```
R12(config)# interface FastEthernet0/1.64
R12(config-if)# standby 1 track FastEthernet0/0 20

R13(config)# interface FastEthernet0/1.64
R13(config-if)# standby 1 track FastEthernet0/0 20
```

## 7. STOP – Checkpoint

`show standby FastEthernet0/1.64` : Shows HSRP status

a. Ping from the workstations out towards the border
b. Traceroute from the workstations towards the border

Shut down the interface FastEthernet0/0 for the active router and answer the following questions

c. Which is the active router?
d. Which is the standby router?
e. What happened to your ping?

## 8. Save the configuration and checkpoint.

```
R11# write memory
Building configuration...
[OK]
R11#
R11# show running-config
R11# show startup-config
```

## Notes:

- Old OSPF syntax for adding IPv4 networks (before IOS 12.3):

```
R11(config)#router ospf 100
R11(config-router)#network 10.10.1.0 0.0.0.255 area 0
R11(config-router)#network 10.10.254.1 0.0.0.0 area 0
R11(config-router)#network 10.10.255.1 0.0.0.0 area 0
R11(config)#^Z
R11#
```