

# **BSc in Telecommunications Engineering**

**TEL3214**

**Computer Communication Networks**

## **Mid-Semester Assignment - Solution**

Eng Diarmuid O'Briain, CEng, CISSP



Department of Electrical and Computer Engineering,  
College of Engineering, Design, Art and Technology,  
Makerere University

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## 1. Routing Lab Assignment

### 1.1 Interlinks between routers (rtr)

- /30 subnets from the network 192.77.203.0/24
- /127 subnets from the prefix 2192:1::/112

### 1.2 Local interface addresses

- /32 host routes from the network 10.0.0.0/8
- /128 host routes from the prefix 2010::/32

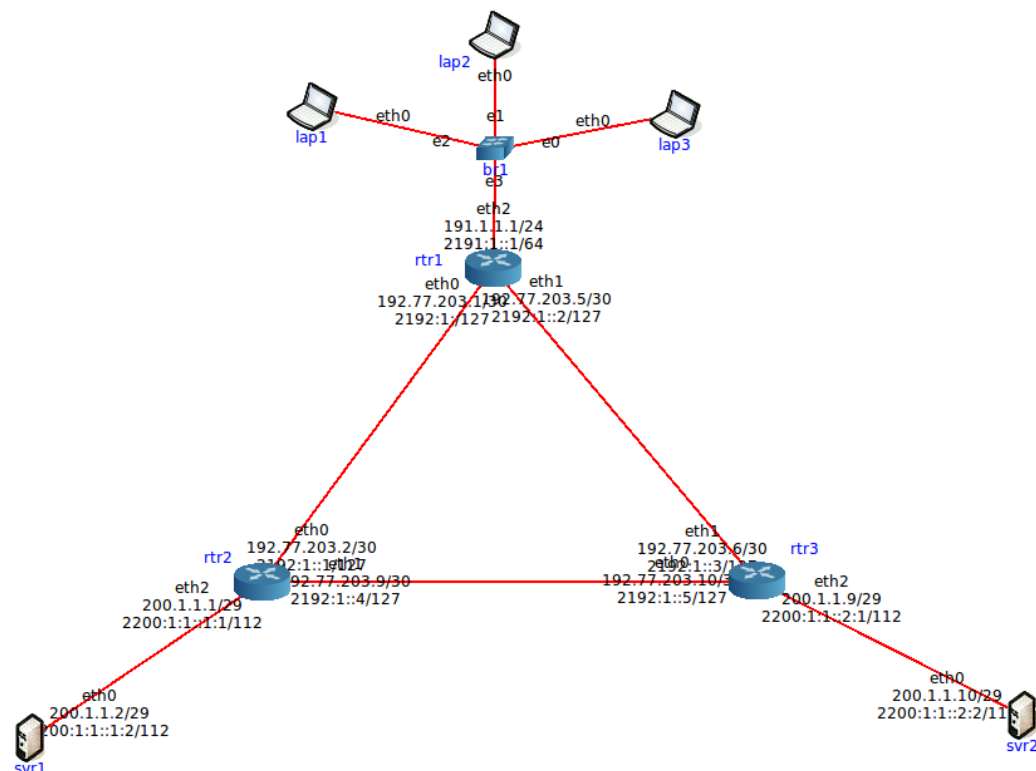
### 1.3 Server networks

- /29 subnets from the network 200.1.1.0/24
- /112 subnets from the prefix 2200:1:1::/64

### 1.4 Laptop network

- /24 subnet from the network 191.1.1.0/16
- /64 subnet from the prefix 2191:1::/60

This exercise was carried out on NTE\_v2.0.1 VM for VirtualBox.



*Illustration 1: Routing Lab*

## 2. IP Address assignment

The table outlines the IP address assignment after the address plan was completed (See Address plan in Section 8 at the end).

Device	Interface	IPv4	IPv6
rtr1	eth0	192.77.203.1/30	2192:1::/127
	eth1	192.77.203.5/30	2192:1::2/127
	eth2	191.1.1.1/24	2191:1::1/64
	lo	10.0.0.1/32	2010::1/128
rtr2	eth0	192.77.203.2/30	2192:1::1/127
	eth1	192.77.203.9/30	2192:1::4/127
	eth2	200.1.1.1/29	2200:1:1::1/112
	lo	10.0.0.2/32	2010::2/128
rtr3	eth0	192.77.203.10/30	2192:1::5/127
	eth1	192.77.203.6/30	2192:1::3/127
	eth2	200.1.1.9/29	2200:1:1::2/112
	lo	10.0.0.3/32	2010::3/128
svr1	eth0	200.1.1.2/29	2200:1:1::1/112
svr2	eth0	200.1.1.10/29	2200:1:1::2/112
lap1	eth0	DHCP: 191.1.1.1/29	SLAAC: 2191:1::200:ff:feaa:6/64
lap2	eth0	DHCP: 191.1.1.3/29	SLAAC: 2191:1::200:ff:feaa:5/64
lap3	eth0	DHCP: 191.1.1.4/29	SLAAC: 2191:1::200:ff:feaa:4/64

*Table 1: IP Address assigned after IP address plan exercise*

## 3. Router Configuration

### 3.1 Router 1 (rtr1)

```
hostname rtr1
!
interface eth0
 ip address 192.77.203.1/30
 ipv6 address 2192:1::/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth1
 ip address 192.77.203.5/30
 ipv6 address 2192:1::2/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth2
 ip address 191.1.1.1/24
 ipv6 address 2191:1::1/64
 ipv6 nd prefix 2191:1::/64 86400 86400
 ipv6 nd reachable-time 5000
 ipv6 ospf6 network broadcast
 no ipv6 nd suppress-ra
!
interface lo
 ip address 10.0.0.1/32
 ipv6 address 2010::1/128
!
router ospf
 ospf router-id 10.0.0.1
 network 191.1.1.0/24 area 0.0.0.0
 network 192.77.203.0/30 area 0.0.0.0
 network 192.77.203.4/30 area 0.0.0.0
!
router ospf6
 router-id 10.0.0.1
 interface eth0 area 0.0.0.0
 interface eth1 area 0.0.0.0
 interface eth2 area 0.0.0.0
!
ip forwarding
ipv6 forwarding
!
```

#### 3.1.1 DHCP Server

```
root@rtr1:/tmp/pycore.36785/rtr1.conf# cat etc.dhcp/dhcpd.conf
subnet 191.1.1.0 netmask 255.255.255.0 {
    pool {
        range 191.1.1.2 191.1.1.254;
        default-lease-time 600;
        option routers 191.1.1.1;
        option domain-name-servers 8.8.8.8;
    }
}
```

### 3.2 Router 2 (rtr2)

```
hostname rtr2
!
interface eth0
 ip address 192.77.203.2/30
 ipv6 address 2192:1::1/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth1
 ip address 192.77.203.9/30
 ipv6 address 2192:1::4/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth2
 ip address 200.1.1.1/29
 ipv6 address 2200:1:1::1:1/112
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface lo
 ip address 10.0.0.2/32
 ipv6 address 2010::2/128
!
router ospf
 ospf router-id 10.0.0.2
 network 192.77.203.0/30 area 0.0.0.0
 network 192.77.203.8/30 area 0.0.0.0
 network 200.1.1.0/29 area 0.0.0.0
!
router ospf6
 router-id 10.0.0.2
 interface eth0 area 0.0.0.0
 interface eth1 area 0.0.0.0
 interface eth2 area 0.0.0.0
!
ip forwarding
ipv6 forwarding
!
```



### 3.3 Router 3 (rtr3)

```
hostname rtr3
!
interface eth0
 ip address 192.77.203.10/30
 ipv6 address 2192:1::5/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth1
 ip address 192.77.203.6/30
 ipv6 address 2192:1::3/127
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface eth2
 ip address 200.1.1.9/29
 ipv6 address 2200:1:1::2:1/112
 ipv6 nd suppress-ra
 ipv6 ospf6 network broadcast
!
interface lo
 ip address 10.0.0.3/32
 ipv6 address 2010::3/128
!
router ospf
 ospf router-id 10.0.0.3
 network 192.77.203.4/30 area 0.0.0.0
 network 192.77.203.8/30 area 0.0.0.0
 network 200.1.1.8/29 area 0.0.0.0
!
router ospf6
 router-id 10.0.0.3
 interface eth0 area 0.0.0.0
 interface eth1 area 0.0.0.0
 interface eth2 area 0.0.0.0
!
ip forwarding
ipv6 forwarding
!
```

## 4. Servers and Laptops

### 4.1 Server 1 (svr1)

```
root@svr1:/tmp/pycore.36756/svr1.conf# ip addr list dev eth0
194: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP group default qlen 1000
    link/ether 00:00:00:aa:00:08 brd ff:ff:ff:ff:ff:ff
    inet 200.1.1.2/29 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2200:1:1::1:2/112 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:feaa:8/64 scope link
        valid_lft forever preferred_lft forever
```

```
root@svr1:/tmp/pycore.36756/svr1.conf# ip route
default via 200.1.1.1 dev eth0
200.1.1.0/29 dev eth0 proto kernel scope link src 200.1.1.2
```

```
root@svr1:/tmp/pycore.36756/svr1.conf# ip -6 route
2200:1:1::1:0/112 dev eth0 proto kernel metric 256
fe80::/64 dev eth0 proto kernel metric 256
default via 2200:1:1::1:1 dev eth0 metric 1024
```

### 4.2 Server 2 (svr2)

```
root@svr2:/tmp/pycore.36756/svr2.conf# ip addr list dev eth0
199: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP group default qlen 1000
    link/ether 00:00:00:aa:00:0a brd ff:ff:ff:ff:ff:ff
    inet 200.1.1.10/29 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2200:1:1::2:2/112 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:feaa:a/64 scope link
        valid_lft forever preferred_lft forever
```

```
root@svr2:/tmp/pycore.36756/svr2.conf# ip route
default via 200.1.1.9 dev eth0
200.1.1.8/29 dev eth0 proto kernel scope link src 200.1.1.10
```

```
root@svr2:/tmp/pycore.36756/svr2.conf# ip -6 route
2200:1:1::2:0/112 dev eth0 proto kernel metric 256
fe80::/64 dev eth0 proto kernel metric 256
default via 2200:1:1::2:1 dev eth0 metric 1024
```

### 4.3 Laptop 1 (lap1)

```
root@lap1:/tmp/pycore.36756/lap1.conf# dhclient eth0
Internet Systems Consortium DHCP Client 4.3.1
Copyright 2004-2014 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/
```

```
Listening on LPF/eth0/00:00:00:aa:00:06
Sending on   LPF/eth0/00:00:00:aa:00:06
Sending on   Socket/fallback
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPACK from 191.1.1.1
bound to 191.1.1.2 -- renewal in 293 seconds.
```

```
root@lap1:/tmp/pycore.36756/lap1.conf# ip addr list dev eth0
189: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP group default qlen 1000
    link/ether 00:00:00:aa:00:06 brd ff:ff:ff:ff:ff:ff
    inet 191.1.1.2/24 brd 191.1.1.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2191:1::200:ff:feaa:6/64 scope global mngtmpaddr dynamic
        valid_lft 85993sec preferred_lft 85993sec
    inet6 fe80::200:ff:feaa:6/64 scope link
        valid_lft forever preferred_lft forever
```

```
root@lap1:/tmp/pycore.36756/lap1.conf# ip route
default via 191.1.1.1 dev eth0
191.1.1.0/24 dev eth0  proto kernel  scope link  src 191.1.1.2
```

```
root@lap1:/tmp/pycore.36756/lap1.conf# ip -6 route
2191:1::/64 dev eth0  proto kernel  metric 256  expires 86062sec
fe80::/64 dev eth0  proto kernel  metric 256
default via fe80::200:ff:feaa:7 dev eth0  proto ra  metric 1024  expires
1462sec hoplimit 64
```

## 4.4 Laptop 2 (lap2)

```

root@lap2:/tmp/pycore.36756/lap2.conf# dhclient -v eth0
Internet Systems Consortium DHCP Client 4.3.1
Copyright 2004-2014 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on LPF/eth0/00:00:00:aa:00:05
Sending on   LPF/eth0/00:00:00:aa:00:05
Sending on   Socket/fallback
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPNAK from 191.1.1.1
DHCPDISCOVER on eth0 to 255.255.255.255 port 67 interval 6
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPOFFER from 191.1.1.1
DHCPACK from 191.1.1.1
bound to 191.1.1.3 -- renewal in 285 seconds.

root@lap2:/tmp/pycore.36756/lap2.conf# ip addr list dev eth0
187: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP group default qlen 1000
    link/ether 00:00:00:aa:00:05 brd ff:ff:ff:ff:ff:ff
    inet 191.1.1.3/24 brd 191.1.1.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2191:1::200:ff:feaa:5/64 scope global mngtmpaddr dynamic
        valid_lft 85935sec preferred_lft 85935sec
    inet6 fe80::200:ff:feaa:5/64 scope link
        valid_lft forever preferred_lft forever

root@lap2:/tmp/pycore.36756/lap2.conf# ip route
default via 191.1.1.1 dev eth0
191.1.1.0/24 dev eth0 proto kernel scope link src 191.1.1.3

root@lap2:/tmp/pycore.36756/lap2.conf# ip -6 route
2191:1::/64 dev eth0 proto kernel metric 256 expires 85918sec
fe80::/64 dev eth0 proto kernel metric 256
default via fe80::200:ff:feaa:7 dev eth0 proto ra metric 1024 expires
1318sec hoplimit 64

```

## 4.5 Laptop 3 (lap3)

```
root@lap3:/tmp/pycore.36756/lap3.conf# dhclient -v eth0
Internet Systems Consortium DHCP Client 4.3.1
Copyright 2004-2014 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on LPF/eth0/00:00:00:aa:00:04
Sending on   LPF/eth0/00:00:00:aa:00:04
Sending on   Socket/fallback
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPNAK from 191.1.1.1
DHCPDISCOVER on eth0 to 255.255.255.255 port 67 interval 5
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPOFFER from 191.1.1.1
DHCPACK from 191.1.1.1
bound to 191.1.1.4 -- renewal in 282 seconds.

root@lap3:/tmp/pycore.36756/lap3.conf# ip addr list dev eth0
185: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP group default qlen 1000
    link/ether 00:00:00:aa:00:04 brd ff:ff:ff:ff:ff:ff
    inet 191.1.1.4/24 brd 191.1.1.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2191:1::200:ff:feaa:4/64 scope global mngtmpaddr dynamic
        valid_lft 85856sec preferred_lft 85856sec
    inet6 fe80::200:ff:feaa:4/64 scope link
        valid_lft forever preferred_lft forever

root@lap3:/tmp/pycore.36756/lap3.conf# ip route
default via 191.1.1.1 dev eth0
191.1.1.0/24 dev eth0  proto kernel  scope link  src 191.1.1.4

root@lap3:/tmp/pycore.36756/lap3.conf# ip -6 route
2191:1::/64 dev eth0  proto kernel  metric 256  expires 85839sec
fe80::/64 dev eth0  proto kernel  metric 256
default via fe80::200:ff:feaa:7 dev eth0  proto ra    metric 1024  expires
1239sec hoplimit 64
```

## 5. Review networking

### 5.1 Router 1 (rtr1)

```
rtr1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	RXmtL	RqstL	DBsmL
10.0.0.2	1	2-Way/DROther	33.361s	192.77.203.2	eth0:192.77.203.1	0	0	0
10.0.0.3	1	2-Way/DROther	33.389s	192.77.203.6	eth1:192.77.203.5	0	0	0

```
rtr1# show ipv6 ospf6 neighbor
```

Neighbor ID	Pri	DeadTime	State/IfState	Duration	I/F[State]
10.0.0.2	1	00:00:37	Full/DR	00:13:03	eth0[BDR]
10.0.0.3	1	00:00:37	Full/DR	00:13:03	eth1[BDR]

```
rtr1# show ip route
```

Codes: K - kernel route, C - connected, S - static, R - RIP,  
 O - OSPF, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* 10.0.0.1/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O 191.1.1.0/24 [110/10] is directly connected, eth2, 00:00:54
C>* 191.1.1.0/24 is directly connected, eth2
O 192.77.203.0/30 [110/10] is directly connected, eth0, 00:00:54
C>* 192.77.203.0/30 is directly connected, eth0
O 192.77.203.4/30 [110/10] is directly connected, eth1, 00:00:09
C>* 192.77.203.4/30 is directly connected, eth1
O>* 192.77.203.8/30 [110/20] via 192.77.203.2, eth0, 00:00:04
    * via 192.77.203.6, eth1, 00:00:04
O>* 200.1.1.0/29 [110/20] via 192.77.203.2, eth0, 00:00:09
O>* 200.1.1.8/29 [110/20] via 192.77.203.6, eth1, 00:00:04
```

```
rtr1# show ipv6 route
```

Codes: K - kernel route, C - connected, S - static, R - RIPng,  
 O - OSPFv6, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* ::1/128 is directly connected, lo
C>* 2010::1/128 is directly connected, lo
O 2191:1::/64 [110/10] is directly connected, eth2, 00:00:31
C>* 2191:1::/64 is directly connected, eth2
O 2192:1::/127 [110/10] is directly connected, eth0, 00:00:31
C>* 2192:1::/127 is directly connected, eth0
O 2192:1::2/127 [110/10] is directly connected, eth1, 00:00:31
C>* 2192:1::2/127 is directly connected, eth1
O>* 2192:1::4/127 [110/20] via fe80::200:ff:feaa:2, eth1, 00:00:21
O>* 2200:1:1::1:0/112 [110/20] via fe80::200:ff:feaa:1, eth0, 00:00:26
O>* 2200:1:1::2:0/112 [110/20] via fe80::200:ff:feaa:2, eth1, 00:00:21
C * fe80::/64 is directly connected, eth2
C * fe80::/64 is directly connected, eth1
C>* fe80::/64 is directly connected, eth0
```

## 5.2 Router 2 (rtr2)

```
rtr2# show ip ospf neighbor
```

Neighbor	ID	Pri	State	Dead Time	Address	Interface	RXmtL	RqstL	DBsml
10.0.0.1		1	Full/Backup	30.405s	192.77.203.1	eth0:192.77.203.2	0	0	0
10.0.0.3		1	Full/DR	30.493s	192.77.203.10	eth1:192.77.203.9	0	0	0

```
rtr2# show ipv6 ospf neighbor
```

Neighbor	ID	Pri	DeadTime	State/IfState	Duration	I/F[State]
10.0.0.1		1	00:00:33	Full/BDR	00:01:27	eth0[DR]
10.0.0.3		1	00:00:33	Full/DR	00:01:27	eth1[BDR]

```
rtr2# show ip route
```

Codes: K - kernel route, C - connected, S - static, R - RIP,  
 O - OSPF, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* 10.0.0.2/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O>* 191.1.1.0/24 [110/20] via 192.77.203.1, eth0, 00:01:48
O 192.77.203.0/30 [110/10] is directly connected, eth0, 00:02:33
C>* 192.77.203.0/30 is directly connected, eth0
O>* 192.77.203.4/30 [110/20] via 192.77.203.1, eth0, 00:01:48
* via 192.77.203.10, eth1, 00:01:48
O 192.77.203.8/30 [110/10] is directly connected, eth1, 00:02:33
C>* 192.77.203.8/30 is directly connected, eth1
O 200.1.1.0/29 [110/10] is directly connected, eth2, 00:02:33
C>* 200.1.1.0/29 is directly connected, eth2
O>* 200.1.1.8/29 [110/20] via 192.77.203.10, eth1, 00:01:48
```

```
rtr2# show ipv6 route
```

Codes: K - kernel route, C - connected, S - static, R - RIPng,  
 O - OSPFv6, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* ::1/128 is directly connected, lo
C>* 2010::2/128 is directly connected, lo
O>* 2191:1::/64 [110/20] via fe80::200:ff:feaa:0, eth0, 00:02:04
O 2192:1::/127 [110/10] is directly connected, eth0, 00:02:09
C>* 2192:1::/127 is directly connected, eth0
O>* 2192:1::2/127 [110/20] via fe80::200:ff:feaa:d, eth1, 00:02:04
O 2192:1::4/127 [110/10] is directly connected, eth1, 00:02:04
C>* 2192:1::4/127 is directly connected, eth1
O 2200:1:1::1:0/112 [110/10] is directly connected, eth2, 00:02:09
C>* 2200:1:1::1:0/112 is directly connected, eth2
O>* 2200:1:1::2:0/112 [110/20] via fe80::200:ff:feaa:d, eth1, 00:02:04
C * fe80::/64 is directly connected, eth1
C * fe80::/64 is directly connected, eth2
C>* fe80::/64 is directly connected, eth0
```

### 5.3 Router 3 (rtr3)

```
rtr3# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	RXmtL	RqstL	DBsmL
10.0.0.1	1	Full/Backup	39.089s	192.77.203.5	eth1:192.77.203.6	0	0	0
10.0.0.2	1	Full/Backup	39.140s	192.77.203.9	eth0:192.77.203.10	0	0	0

```
rtr3# show ipv6 ospf neighbor
```

Neighbor ID	Pri	DeadTime	State/IfState	Duration I/F[State]
10.0.0.1	1	00:00:37	Full/BDR	00:03:22 eth1[DR]
10.0.0.2	1	00:00:37	Full/BDR	00:03:17 eth0[DR]

```
rtr3# show ip route
```

Codes: K - kernel route, C - connected, S - static, R - RIP,  
 O - OSPF, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* 10.0.0.3/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O>* 191.1.1.0/24 [110/20] via 192.77.203.5, eth1, 00:03:37
O>* 192.77.203.0/30 [110/20] via 192.77.203.5, eth1, 00:03:32
  * via 192.77.203.9, eth0, 00:03:32
O 192.77.203.4/30 [110/10] is directly connected, eth1, 00:04:22
C>* 192.77.203.4/30 is directly connected, eth1
O 192.77.203.8/30 [110/10] is directly connected, eth0, 00:04:22
C>* 192.77.203.8/30 is directly connected, eth0
O>* 200.1.1.0/29 [110/20] via 192.77.203.9, eth0, 00:03:32
O 200.1.1.8/29 [110/10] is directly connected, eth2, 00:04:22
C>* 200.1.1.8/29 is directly connected, eth2
```

```
rtr3# show ipv6 route
```

Codes: K - kernel route, C - connected, S - static, R - RIPng,  
 O - OSPFv6, I - IS-IS, B - BGP, A - Babel,  
 > - selected route, \* - FIB route

```
C>* ::1/128 is directly connected, lo
C>* 2010::3/128 is directly connected, lo
O>* 2191:1::/64 [110/20] via fe80::200:ff:feaa:3, eth1, 00:03:50
O>* 2192:1::/127 [110/20] via fe80::200:ff:feaa:c, eth0, 00:03:50
O 2192:1::2/127 [110/10] is directly connected, eth1, 00:03:55
C>* 2192:1::2/127 is directly connected, eth1
O 2192:1::4/127 [110/10] is directly connected, eth0, 00:03:50
C>* 2192:1::4/127 is directly connected, eth0
O>* 2200:1:1::1:0/112 [110/20] via fe80::200:ff:feaa:c, eth0, 00:03:50
O 2200:1:1::2:0/112 [110/10] is directly connected, eth2, 00:03:50
C>* 2200:1:1::2:0/112 is directly connected, eth2
C * fe80::/64 is directly connected, eth0
C * fe80::/64 is directly connected, eth2
C>* fe80::/64 is directly connected, eth1
```



## 6. Test network

### 6.1 Laptop 2 (lap2)

```
root@lap2:/tmp/pycore.36785/lap2.conf# dhclient -v eth0
Internet Systems Consortium DHCP Client 4.3.1
Copyright 2004-2014 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on LPF/eth0/00:00:00:aa:00:05
Sending on   LPF/eth0/00:00:00:aa:00:05
Sending on   Socket/fallback
DHCPREQUEST on eth0 to 255.255.255.255 port 67
DHCPACK from 191.1.1.1
RTNETLINK answers: File exists
bound to 191.1.1.2 -- renewal in 250 seconds.
```

#### 6.1.1 Server 1 (svr1)

```
root@lap2:/tmp/pycore.36785/lap2.conf# fping 200.1.1.2
200.1.1.2 is alive
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# fping6 2200:1:1::1:2
2200:1:1::1:2 is alive
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# traceroute 200.1.1.2
traceroute to 200.1.1.2 (200.1.1.2), 30 hops max, 60 byte packets
 1  191.1.1.1 (191.1.1.1)  0.036 ms  0.007 ms  0.005 ms
 2  192.77.203.2 (192.77.203.2)  0.016 ms  0.010 ms  0.008 ms
 3  200.1.1.2 (200.1.1.2)  0.019 ms  0.012 ms  0.012 ms
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# traceroute6 2200:1:1::1:2
traceroute to 2200:1:1::1:2 (2200:1:1::1:2), 30 hops max, 80 byte packets
 1  2191:1::1 (2191:1::1)  0.051 ms  0.010 ms  0.007 ms
 2  2192:1::1 (2192:1::1)  0.026 ms  0.013 ms  0.012 ms
 3  2200:1:1::1:2 (2200:1:1::1:2)  0.020 ms  0.012 ms  0.012 ms
```

### 6.1.2 Server 2 (svr2)

```
root@lap2:/tmp/pycore.36785/lap2.conf# fping 200.1.1.10  
200.1.1.10 is alive
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# fping6 2200:1:1::2:2  
2200:1:1::2:2 is alive
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# traceroute 200.1.1.10  
traceroute to 200.1.1.10 (200.1.1.10), 30 hops max, 60 byte packets  
 1  191.1.1.1 (191.1.1.1)  0.030 ms  0.008 ms  0.006 ms  
 2  192.77.203.6 (192.77.203.6)  0.017 ms  0.009 ms  0.009 ms  
 3  200.1.1.10 (200.1.1.10)  0.017 ms  0.011 ms  0.011 ms
```

```
root@lap2:/tmp/pycore.36785/lap2.conf# traceroute6 2200:1:1::2:2  
traceroute to 2200:1:1::2:2 (2200:1:1::2:2), 30 hops max, 80 byte packets  
 1  2191:1::1 (2191:1::1)  0.082 ms  0.020 ms  0.015 ms  
 2  2192:1::3 (2192:1::3)  0.039 ms  0.014 ms  0.024 ms  
 3  2200:1:1::2:2 (2200:1:1::2:2)  0.036 ms  0.015 ms  0.019 ms
```

## 7. Assignment Model answer

```
nte@NTE-i386:~$ blkid | grep -oP 'UUID="\K[^\"]+' | sha256sum | awk '{print $1}'
e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855
```

```
--
```

```
rtr1# show ip route
```

```
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route
```

```
C>* 10.0.0.1/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O 191.1.1.0/24 [110/10] is directly connected, eth2, 00:14:51
C>* 191.1.1.0/24 is directly connected, eth2
O 192.77.203.0/30 [110/10] is directly connected, eth0, 00:14:51
C>* 192.77.203.0/30 is directly connected, eth0
O 192.77.203.4/30 [110/10] is directly connected, eth1, 00:14:06
C>* 192.77.203.4/30 is directly connected, eth1
O>* 192.77.203.8/30 [110/20] via 192.77.203.2, eth0, 00:14:01
   *                               via 192.77.203.6, eth1, 00:14:01
O>* 200.1.1.0/29 [110/20] via 192.77.203.2, eth0, 00:14:06
O>* 200.1.1.8/29 [110/20] via 192.77.203.6, eth1, 00:14:01
```

```
--
```

```
rtr1# show ipv6 route
```

```
Codes: K - kernel route, C - connected, S - static, R - RIPng,
       O - OSPFv6, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route
```

```
C>* ::1/128 is directly connected, lo
C>* 2010::1/128 is directly connected, lo
O 2191:1::/64 [110/10] is directly connected, eth2, 00:01:17
C>* 2191:1::/64 is directly connected, eth2
O 2192:1::/127 [110/10] is directly connected, eth0, 00:01:17
C>* 2192:1::/127 is directly connected, eth0
O 2192:1::2/127 [110/10] is directly connected, eth1, 00:01:17
C>* 2192:1::2/127 is directly connected, eth1
O>* 2192:1::4/127 [110/20] via fe80::200:ff:feaa:2, eth1, 00:01:07
O>* 2200:1:1::1:0/112 [110/20] via fe80::200:ff:feaa:1, eth0, 00:01:07
O>* 2200:1:1::2:0/112 [110/20] via fe80::200:ff:feaa:2, eth1, 00:01:12
C * fe80::/64 is directly connected, eth2
C * fe80::/64 is directly connected, eth1
C>* fe80::/64 is directly connected, eth0
```

--

rtr2# **show ip route**

Codes: K - kernel route, C - connected, S - static, R - RIP,  
O - OSPF, I - IS-IS, B - BGP, A - Babel,  
> - selected route, \* - FIB route

```
C>* 10.0.0.2/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O>* 191.1.1.0/24 [110/20] via 192.77.203.1, eth0, 00:14:50
O 192.77.203.0/30 [110/10] is directly connected, eth0, 00:15:35
C>* 192.77.203.0/30 is directly connected, eth0
O>* 192.77.203.4/30 [110/20] via 192.77.203.1, eth0, 00:14:50
*                               via 192.77.203.10, eth1, 00:14:50
O 192.77.203.8/30 [110/10] is directly connected, eth1, 00:15:35
C>* 192.77.203.8/30 is directly connected, eth1
O 200.1.1.0/29 [110/10] is directly connected, eth2, 00:15:35
C>* 200.1.1.0/29 is directly connected, eth2
O>* 200.1.1.8/29 [110/20] via 192.77.203.10, eth1, 00:14:50
```

--

rtr2# **show ipv6 route**

Codes: K - kernel route, C - connected, S - static, R - RIPng,  
O - OSPFv6, I - IS-IS, B - BGP, A - Babel,  
> - selected route, \* - FIB route

```
C>* ::1/128 is directly connected, lo
C>* 2010::2/128 is directly connected, lo
O>* 2191:1::/64 [110/20] via fe80::200:ff:feaa:0, eth0, 00:15:11
O 2192:1::/127 [110/10] is directly connected, eth0, 00:15:16
C>* 2192:1::/127 is directly connected, eth0
O>* 2192:1::2/127 [110/20] via fe80::200:ff:feaa:d, eth1, 00:15:11
O 2192:1::4/127 [110/10] is directly connected, eth1, 00:15:11
C>* 2192:1::4/127 is directly connected, eth1
O 2200:1:1::1:0/112 [110/10] is directly connected, eth2, 00:15:16
C>* 2200:1:1::1:0/112 is directly connected, eth2
O>* 2200:1:1::2:0/112 [110/20] via fe80::200:ff:feaa:d, eth1, 00:15:11
C * fe80::/64 is directly connected, eth1
C * fe80::/64 is directly connected, eth2
C>* fe80::/64 is directly connected, eth0
```

--

rtr3# **show ip route**

Codes: K - kernel route, C - connected, S - static, R - RIP,  
O - OSPF, I - IS-IS, B - BGP, A - Babel,  
> - selected route, \* - FIB route

```
C>* 10.0.0.3/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
O>* 191.1.1.0/24 [110/20] via 192.77.203.5, eth1, 00:15:36
O>* 192.77.203.0/30 [110/20] via 192.77.203.5, eth1, 00:15:31
*                               via 192.77.203.9, eth0, 00:15:31
O 192.77.203.4/30 [110/10] is directly connected, eth1, 00:16:21
C>* 192.77.203.4/30 is directly connected, eth1
O 192.77.203.8/30 [110/10] is directly connected, eth0, 00:16:21
C>* 192.77.203.8/30 is directly connected, eth0
O>* 200.1.1.0/29 [110/20] via 192.77.203.9, eth0, 00:15:31
O 200.1.1.8/29 [110/10] is directly connected, eth2, 00:16:21
C>* 200.1.1.8/29 is directly connected, eth2
```

--

rtr3# **show ipv6 route**

Codes: K - kernel route, C - connected, S - static, R - RIPng,  
O - OSPFv6, I - IS-IS, B - BGP, A - Babel,  
> - selected route, \* - FIB route

```
C>* ::1/128 is directly connected, lo
C>* 2010::3/128 is directly connected, lo
O>* 2191:1::/64 [110/20] via fe80::200:ff:feaa:3, eth1, 00:15:50
O>* 2192:1::/127 [110/20] via fe80::200:ff:feaa:c, eth0, 00:15:50
O 2192:1::2/127 [110/10] is directly connected, eth1, 00:15:55
C>* 2192:1::2/127 is directly connected, eth1
O 2192:1::4/127 [110/10] is directly connected, eth0, 00:15:50
C>* 2192:1::4/127 is directly connected, eth0
O>* 2200:1:1::1:0/112 [110/20] via fe80::200:ff:feaa:c, eth0, 00:15:50
O 2200:1:1::2:0/112 [110/10] is directly connected, eth2, 00:15:50
C>* 2200:1:1::2:0/112 is directly connected, eth2
C * fe80::/64 is directly connected, eth0
C * fe80::/64 is directly connected, eth2
C>* fe80::/64 is directly connected, eth1
```

--

nfe@NTE-i386:~\$ **brctl show**

bridge name	bridge id	STP enabled	interfaces
b.40429.1b	8000.ae5fadaaf1b6	no	veth2.1.1b veth3.0.1b
b.41782.1b	8000.ae2a676efed9	no	veth1.0.1b veth2.0.1b
b.44403.1b	8000.4a016c90fc72	no	veth3.2.1b veth0.1b
b.5.1b	8000.26cd43cdecfa	no	veth1.2.1b veth6.0.1b veth7.0.1b veth8.0.1b
b.59112.1b	8000.cac985884374	no	veth1.1.1b veth3.1.1b
b.7712.1b	8000.5a514bf83076	no	veth2.2.1b vethd.0.1b

--

root@svr1:/tmp/pycore.36743/svr1.conf# **ip addr list**

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
126: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP
    group default qlen 1000
    link/ether 00:00:00:aa:00:08 brd ff:ff:ff:ff:ff:ff
    inet 200.1.1.2/29 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2200:1:1::1:2/112 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:feaa:8/64 scope link
        valid_lft forever preferred_lft forever
```

--

root@svr2:/tmp/pycore.36743/svr2.conf# **ip addr list**

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
131: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP
    group default qlen 1000
    link/ether 00:00:00:aa:00:0a brd ff:ff:ff:ff:ff:ff
    inet 200.1.1.10/29 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2200:1:1::2:2/112 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:feaa:a/64 scope link
        valid_lft forever preferred_lft forever
```

--

```
root@lap1:/tmp/pycore.36743/lap1.conf# ping -c1 200.1.1.2
PING 200.1.1.2 (200.1.1.2) 56(84) bytes of data.
64 bytes from 200.1.1.2: icmp_seq=1 ttl=62 time=0.072 ms
```

```
--- 200.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.072/0.072/0.072/0.000 ms
```

--

```
root@lap1:/tmp/pycore.36743/lap1.conf# ping6 -c1 2200:1:1::1:2
PING 2200:1:1::1:2(2200:1:1::1:2) 56 data bytes
64 bytes from 2200:1:1::1:2: icmp_seq=1 ttl=62 time=0.112 ms
```

```
--- 2200:1:1::1:2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.112/0.112/0.112/0.000 ms
```

--

```
root@lap2:/tmp/pycore.36743/lap2.conf# ping -c1 200.1.1.10
PING 200.1.1.10 (200.1.1.10) 56(84) bytes of data.
64 bytes from 200.1.1.10: icmp_seq=1 ttl=61 time=0.066 ms
```

```
--- 200.1.1.10 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.066/0.066/0.066/0.000 ms
```

--

```
root@lap2:/tmp/pycore.36743/lap2.conf# ping6 -c1 2200:1:1::1:2
PING 2200:1:1::1:2(2200:1:1::1:2) 56 data bytes
64 bytes from 2200:1:1::1:2: icmp_seq=1 ttl=62 time=0.071 ms
```

```
--- 2200:1:1::1:2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.071/0.071/0.071/0.000 ms
```

--

```
root@lap3:/tmp/pycore.36743/lap3.conf# traceroute 200.1.1.2
traceroute to 200.1.1.2 (200.1.1.2), 30 hops max, 60 byte packets
 1  191.1.1.1 (191.1.1.1)  0.038 ms  0.008 ms  0.006 ms
 2  192.77.203.2 (192.77.203.2)  0.018 ms  0.011 ms  0.010 ms
 3  200.1.1.2 (200.1.1.2)  0.022 ms  0.013 ms  0.013 ms
```

--

```
root@lap3:/tmp/pycore.36743/lap3.conf# traceroute6 2200:1:1::1:2
traceroute to 2200:1:1::1:2 (2200:1:1::1:2), 30 hops max, 80 byte packets
 1  2191:1::1 (2191:1::1)  0.093 ms  0.012 ms  0.008 ms
 2  2192:1::1 (2192:1::1)  0.023 ms  0.012 ms  0.011 ms
 3  2200:1:1::1:2 (2200:1:1::1:2)  0.021 ms  0.012 ms  0.012 ms
```

--

## 8. IP Address calculation

### 8.1 IPv4 Inter-links

Given a /24 and each link will be a /30 so  $30-24=6$  giving the potential for  $64-2=62$  subnetworks with two useable addresses in each subnetwork.

192.77.203.0/24

#### 8.1.1 /30 subnetworks

There are 62 /30 subnetworks of the given /24:

			Network	Addr #1	Addr #2	Broadcast
192.77.203	000000	00 /30	192.77.203.0	192.77.203.1	192.77.203.2	192.77.203.3
192.77.203	000001	00 /30	192.77.203.4	192.77.203.5	192.77.203.6	192.77.203.7
192.77.203	000010	00 /30	192.77.203.8	192.77.203.9	192.77.203.10	192.77.203.11
....						
....						
192.77.203	111101	00 /30	192.77.203.244	192.77.203.245	192.77.203.246	192.77.203.247
192.77.203	111110	00 /30	192.77.203.248	192.77.203.249	192.77.203.250	192.77.203.251
192.77.203	111111	00 /30	192.77.203.252	192.77.203.253	192.77.203.254	192.77.203.255

### 8.2 IPv4 Servers

Servers are being given static IPv4 addresses.

200.1.1.0/24

#### 8.2.1 /29 subnetworks

Given a /24 and each network will be a /29 so  $29-24=5$  giving the potential for  $32-2=30$  subnetworks with 8-2=6 useable addresses in each subnetwork.

			Network	1 <sup>st</sup> Addr	last Addr	Broadcast
200.1.1	00000	000 /29	200.1.1.0	200.1.1.1	200.1.1.6	200.1.1.7
200.1.1	00001	000 /29	200.1.1.8	200.1.1.9	200.1.1.14	200.1.1.15
200.1.1	00010	000 /29	200.1.1.16	200.1.1.17	200.1.1.22	200.1.1.23
200.1.1	00011	000 /29	200.1.1.24	200.1.1.25	200.1.1.30	200.1.1.31
....						
....						
200.1.1	11110	000 /29	200.1.1.240	200.1.1.241	200.1.1.246	200.1.1.247
200.1.1	11111	000 /29	200.1.1.248	200.1.1.249	200.1.1.254	200.1.1.255



## 8.3 IPv4 Laptops

Laptops are being assigned IPv4 addresses via DHCP.

191.1.0.0/16

### 8.3.1 /24 subnetworks

Given a /16 and each network will be a /24 so  $24-16=8$  giving the potential for  $256-2=254$  subnetworks with 256-2=254 useable addresses in each subnetwork.

			<b>Network</b>	<b>1<sup>st</sup> Addr</b>	<b>last Addr</b>	<b>Broadcast</b>
191.1	00000001	.0 /29	191.1.1.0	191.1.1.1	191.1.1.254	191.1.1.255
191.1	00000010	.0 /29	191.1.2.0	191.1.2.1	191.1.2.254	191.1.2.255
191.1	00000011	.0 /29	191.1.3.0	191.1.3.1	191.1.3.254	191.1.3.255
191.1	00000100	.0 /29	191.1.4.0	191.1.4.1	191.1.4.254	191.1.4.255
....						
....						
191.1	11111101	.0 /29	191.1.253.0	191.1.253.1	191.1.253.254	191.1.253.255
191.1	11111110	.0 /29	191.1.254.0	191.1.254.1	191.1.254.254	191.1.254.255

## 8.4 IPv4 Local interfaces

Local interfaces are being given static IPv4 host routes.

10.0.0.0/8

### 8.4.1 /32 host routes

Given a /8 and each host route will be a /32 so  $32-8=24$  or 16,777,216 host routes.

		<b>Network</b>
10	0.0.0 /32	10.0.0.0/32
10	0.0.1 /32	10.0.0.1/32
10	0.0.2 /32	10.0.0.2/32
10	0.0.4 /32	10.0.0.3/32
....		
....		
10	255.255.253 /32	10.255.255.253/32
10	255.255.254 /32	10.255.255.254/32
10	255.255.255 /32	10.255.255.255/32

## 8.5 IPv6 Inter-links

Given a /112 and each link will be a /127 so  $2^{127-112}=15$  giving the potential for 32768 subnetworks with two addresses in each subnetwork.

2192:1::/112

2192:0001:0000:0000:0000:0000:0000:0000/112

### 8.5.1 /127 subnetworks

There are 32,768 /127 subnetworks of the given /112:

Note: representing last four nibbles in binary for simplicity of understanding.

```

←          /112 network          →|←          subnet          →|
2192:0001:0000:0000:0000:0000:0000 | 0000 0000 0000 000 | 0 /127

Subnet #1: 2192:1:0:0:0:0:0:0 | 0000 000 | 0 /127 - 2192:1:0:0:0:0:0:0 | 0000 000 | 1 /127
Subnet #2: 2192:1:0:0:0:0:0:0 | 0000 001 | 0 /127 - 2192:1:0:0:0:0:0:0 | 0000 001 | 1 /127
Subnet #3: 2192:1:0:0:0:0:0:0 | 0000 010 | 0 /127 - 2192:1:0:0:0:0:0:0 | 0000 010 | 1 /127
Subnet #4: 2192:1:0:0:0:0:0:0 | 0000 011 | 0 /127 - 2192:1:0:0:0:0:0:0 | 0000 011 | 1 /127
Subnet #5: 2192:1:0:0:0:0:0:0 | 0000 101 | 0 /127 - 2192:1:0:0:0:0:0:0 | 0000 101 | 1 /127
....
....
Subnet #32766: 2192:1:0:0:0:0:0:0 | 1111 101 | 0 /127 - 2192:1:0:0:0:0:0:0 | 1111 101 | 1 /127
Subnet #32767: 2192:1:0:0:0:0:0:0 | 1111 110 | 0 /127 - 2192:1:0:0:0:0:0:0 | 1111 110 | 1 /127
Subnet #32768: 2192:1:0:0:0:0:0:0 | 1111 111 | 0 /127 - 2192:1:0:0:0:0:0:0 | 1111 111 | 1 /127

```

Simplified range of 32,768 subnetworks, each with two host address:

```

Subnet #1: 2192:1::/127 - 2192:1::1/127
Subnet #2: 2192:1::2/127 - 2192:1::3/127
Subnet #3: 2192:1::4/127 - 2192:1::5/127
Subnet #4: 2192:1::6/127 - 2192:1::7/127
Subnet #5: 2192:1::8/127 - 2192:1::9/127
....
....
Subnet #32766: 2192:1::fa/127 - 2192:1::fb/127
Subnet #32767: 2192:1::fc/127 - 2192:1::fd/127
Subnet #32768: 2192:1::fe/127 - 2192:1::ff/127

```

## 8.6 IPv6 Servers

Servers are being given static IPv6 addresses.

2200:1:1::/64

2200:1:1::- 2200:1:1::ffff:ffff:ffff:ffff

### 8.6.1 /112 subnetworks

There are 281,474,976,710,656 /112 subnetworks of the given /64:

2200:0001:0001:0000:0000:0000:0000:0000/64

```

← /64 network      →|← subnet      →|
2200:0001:0001:0000 | 0000:0000:0000 | 0000 /112

Subnet #1: 2200:1:1:0 | 0:0:0 | 0 - 2200:1:1:0 | 0:0:0 | ffff /112
Subnet #2: 2200:1:1:0 | 0:0:1 | 0 - 2200:1:1:0 | 0:0:1 | ffff /112
Subnet #3: 2200:1:1:0 | 0:0:2 | 0 - 2200:1:1:0 | 0:0:2 | ffff /112
Subnet #4: 2200:1:1:0 | 0:0:3 | 0 - 2200:1:1:0 | 0:0:3 | ffff /112
Subnet #5: 2200:1:1:0 | 0:0:4 | 0 - 2200:1:1:0 | 0:0:4 | ffff /112
....
....
Subnet #281474976710654: 2200:1:1:0 | ffff:ffff:ffffd | 0 - 2200:1:1:0 | ffff:ffff:ffffd | ffff /112
Subnet #281474976710655: 2200:1:1:0 | ffff:ffff:ffffe | 0 - 2200:1:1:0 | ffff:ffff:ffffe | ffff /112
Subnet #281474976710656: 2200:1:1:0 | ffff:ffff:fffff | 0 - 2200:1:1:0 | ffff:ffff:fffff | ffff /112

```

Simplified range of 281,474,976,710,656 subnetworks, each with 65,536 host address:

```

Subnet #1: 2200:1:1::/112      - 2200:1:1::ffff/112
Subnet #2: 2200:1:1::1:0/112   - 2200:1:1::1:ffff/112
Subnet #3: 2200:1:1::2:0/112   - 2200:1:1::2:ffff/112
Subnet #4: 2200:1:1::3:0/112   - 2200:1:1::3:ffff/112
Subnet #5: 2200:1:1::4:0/112   - 2200:1:1::4:ffff/112
....
....
Subnet #281474976710654: 2200:1:1::ffff:ffff:ffffd:0/112 - 2200:1:1::ffff:ffff:ffffd:ffff/112
Subnet #281474976710655: 2200:1:1::ffff:ffff:ffffe:0/112 - 2200:1:1::ffff:ffff:ffffe:ffff/112
Subnet #281474976710656: 2200:1:1::ffff:ffff:fffff:0/112 - 2200:1:1::ffff:ffff:fffff:ffff/112

```

## 8.7 IPv6 Laptops

Laptops are being assigned IPv6 addresses by SLAAC. This means the networks are /64. 2191:1::/60 was given in the exercise.

2191:1::/60

2191:1:: - 2191:1:0:f:ffff:ffff:ffff:ffff

### 8.7.1 /64 subnetworks

There are 16 /64 subnetworks of the given /60:

2191:0001:0000:0000:0000:0000:0000:0000/64

← /60 network → |← SN → |← subnet of a single nibble (4 bits)  
2191:0001:0000:000 | 0 | 0000:0000:0000:0000 /112

Subnet #1: 2191:1:0:0 | 0 | 0 - 2191:1:0:0 | 0 | ffff:ffff:ffff:ffff /64  
Subnet #2: 2191:1:0:0 | 1 | 0 - 2191:1:0:0 | 1 | ffff:ffff:ffff:ffff /64  
Subnet #3: 2191:1:0:0 | 2 | 0 - 2191:1:0:0 | 2 | ffff:ffff:ffff:ffff /64  
Subnet #4: 2191:1:0:0 | 3 | 0 - 2191:1:0:0 | 3 | ffff:ffff:ffff:ffff /64  
Subnet #5: 2191:1:0:0 | 4 | 0 - 2191:1:0:0 | 4 | ffff:ffff:ffff:ffff /64  
....  
....  
Subnet #14: 2191:1:0:0 | d | 0 - 2191:1:0:0 | d | ffff:ffff:ffff:ffff /64  
Subnet #15: 2191:1:0:0 | e | 0 - 2191:1:0:0 | e | ffff:ffff:ffff:ffff /64  
Subnet #16: 2191:1:0:0 | f | 0 - 2191:1:0:0 | f | ffff:ffff:ffff:ffff /64

Simplified range of 16 subnetworks, each with 18,446,744,073,709,551,616 host address:

Subnet #1: 2191:1::/64 - 2191:1:ffff:ffff:ffff:ffff:ffff/64  
Subnet #2: 2191:1:0:1::/64 - 2191:1:0:1:ffff:ffff:ffff:ffff/64  
Subnet #3: 2191:1:0:2::/64 - 2191:1:0:2:ffff:ffff:ffff:ffff/64  
Subnet #4: 2191:1:0:3::/64 - 2191:1:0:3:ffff:ffff:ffff:ffff/64  
Subnet #5: 2191:1:0:4::/64 - 2191:1:0:4:ffff:ffff:ffff:ffff/64  
Subnet #6: 2191:1:0:5::/64 - 2191:1:0:5:ffff:ffff:ffff:ffff/64  
Subnet #7: 2191:1:0:6::/64 - 2191:1:0:6:ffff:ffff:ffff:ffff/64  
Subnet #8: 2191:1:0:7::/64 - 2191:1:0:7:ffff:ffff:ffff:ffff/64  
Subnet #9: 2191:1:0:8::/64 - 2191:1:0:8:ffff:ffff:ffff:ffff/64  
Subnet #10: 2191:1:0:9::/64 - 2191:1:0:9:ffff:ffff:ffff:ffff/64  
Subnet #11: 2191:1:0:a::/64 - 2191:1:0:a:ffff:ffff:ffff:ffff/64  
Subnet #12: 2191:1:0:b::/64 - 2191:1:0:b:ffff:ffff:ffff:ffff/64  
Subnet #13: 2191:1:0:c::/64 - 2191:1:0:c:ffff:ffff:ffff:ffff/64  
Subnet #14: 2191:1:0:d::/64 - 2191:1:0:d:ffff:ffff:ffff:ffff/64  
Subnet #15: 2191:1:0:e::/64 - 2191:1:0:e:ffff:ffff:ffff:ffff/64  
Subnet #16: 2191:1:0:f::/64 - 2191:1:0:f:ffff:ffff:ffff:ffff/64

## 8.8 IPv6 Local interfaces

Local interfaces are being given static IPv6 host routes.

2010::/32

### 8.8.1 /128 host routes

Given a /32 and each host route will be a /128 so  $2^{128-32}=2^{96}$  or  $7.9228163e^{28}$  host routes.

		Network
2010::	/128	2010::/128
2010   1	/128	2010::1/128
2010   2	/128	2010::2/128
2010   3	/128	2010::3/128
....		
....		
2010	ffff:ffff:ffff:ffff:ffff:ffff:ffff:fffd	/128 2010:ffff:ffff:ffff:ffff:ffff:ffff:fffd/128
2010	ffff:ffff:ffff:ffff:ffff:ffff:ffff:fffe	/128 2010:ffff:ffff:ffff:ffff:ffff:ffff:fffe/128
2010	ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff	/128 2010:ffff:ffff:ffff:ffff:ffff:ffff:ffff/128