ODFT – Enterprise presents:

Mouse Net

By,
Tom Woo
Roland Szczesny
Stuart MacLean
Matt Capranos

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Executive Summary

This purpose of this lab is to study the behavior of OSPF when multiple areas represent the subsets of a routing domain. With in this lab there will be four areas (area 0 – area 3), Area 0 being the backbone, and it is designed in such a way that it proves many of the characteristics of inter-area routing. This will help to provide a unique opportunity to study in detail the way that OSPF makes abstractions of the routing information coming out of different areas using the LS-type 3 or LS-Summary.

There are several that will require exploring with in the lab, those are:

- Adjusting metrics on the links
- Super-nets and metrics. How the metrics are created and advertised.
- Sub-optimal routing. When and Why, the physical layer design and effects.
- How type-3 LS-Summary are created and handled by the area border routers.

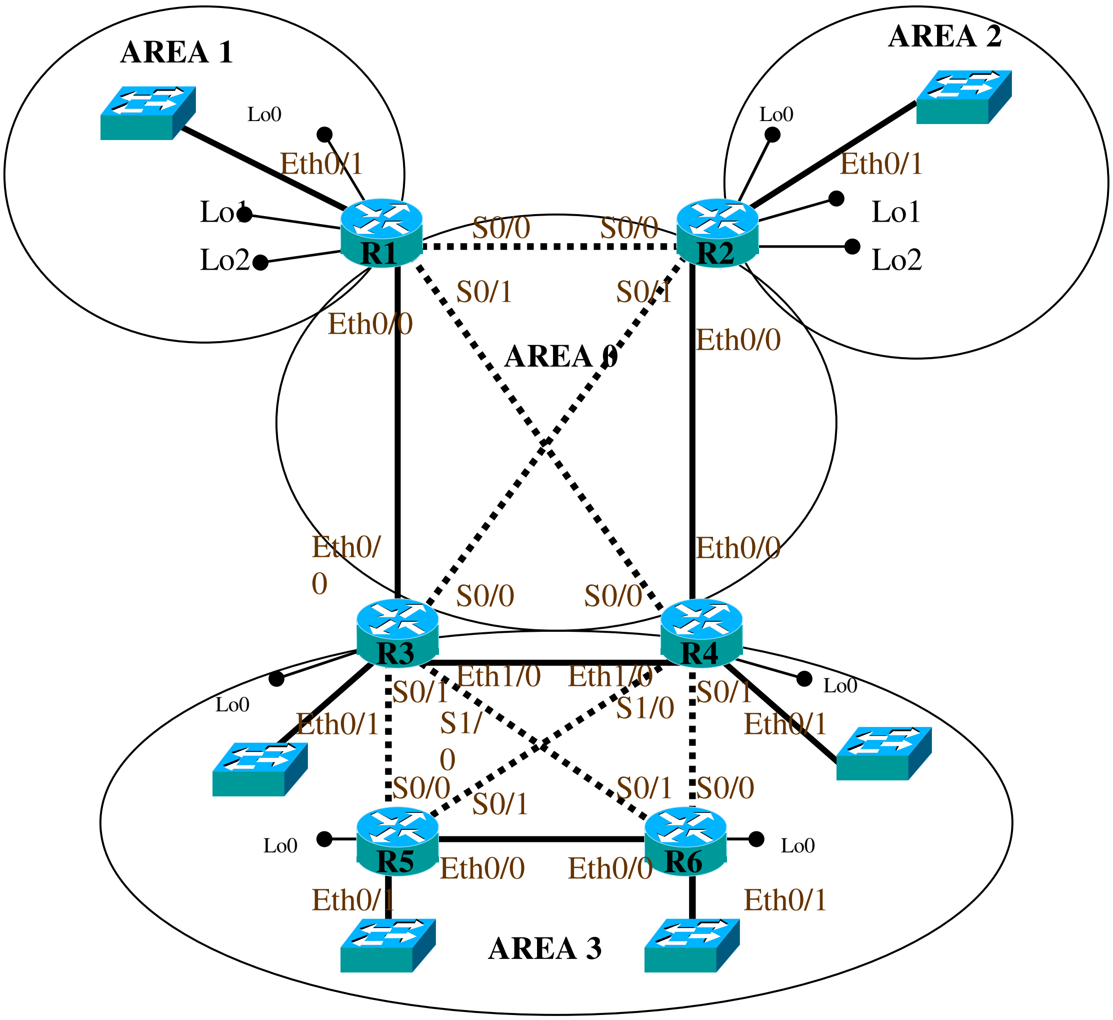
There are six phases within the lab that will be discussed, these phases are.

- Phase 1 - Set up the network, adjusting metrics.
- Phase 2 – Supernet certain networks.
- Phase 3 – Supernet all routes in all areas.
- Phase 4 – Study the effects of the physical topology in routing.
- Phase 5 – Implementation of a virtual link.
- Phase 6 – Reconnecting all interfaces that were brought down.

Within in each section there will be additional tasks that must be completed and analyzed; they will be discussed in the subsequent sections of the report.

Phase 1 – Setup the network, adjusting the metrics

The first phase of lab involved configuring the physical links between the six routes and four switches for the network. A diagram of the physical layer layout is seen below.

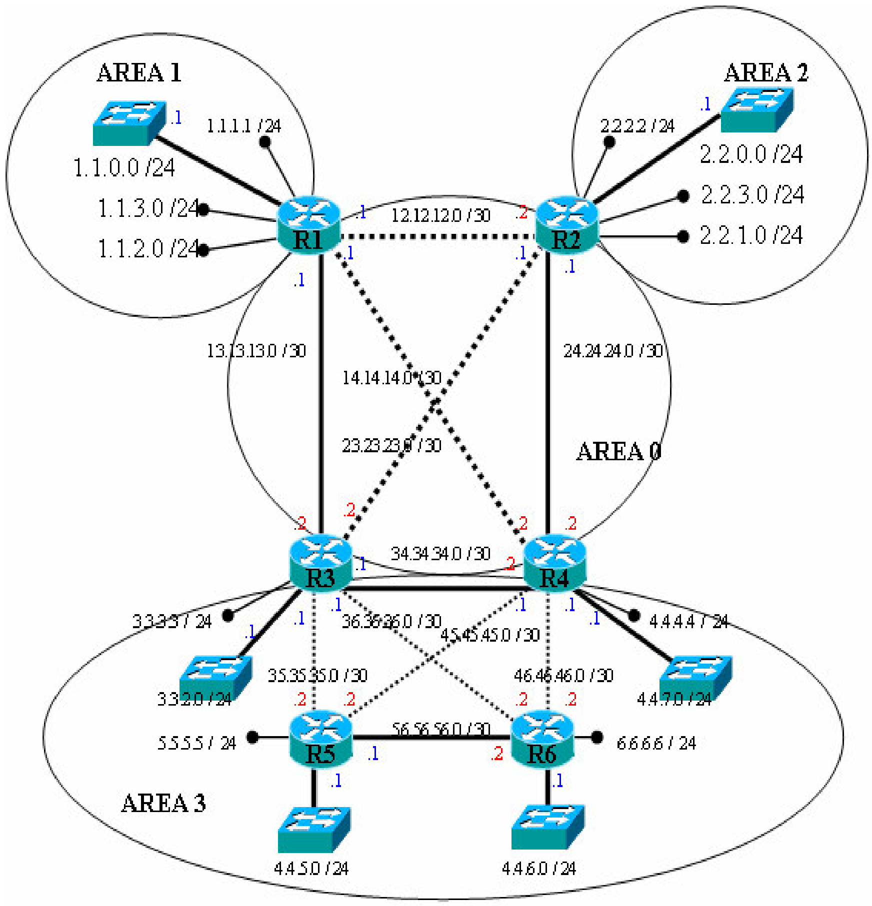


After the physical links were connected, the next step in the lab was to specify the IP address and OSPF metrics for each interface. Below is an example of the specified IP addresses as well metrics for some interfaces on Router 1.

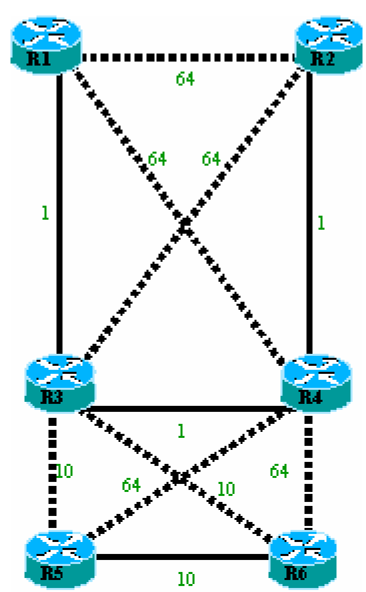
```
interface FastEthernet0/0
ip address 13.13.13.1 255.255.255.252
ip ospf cost 1                              <= OSPF Metric
duplex auto
speed auto

interface Serial0/0
ip address 12.12.12.1 255.255.255.252
ip ospf cost 64                             <= OSPF Metric
no fair-queue
clockrate 2000000
```

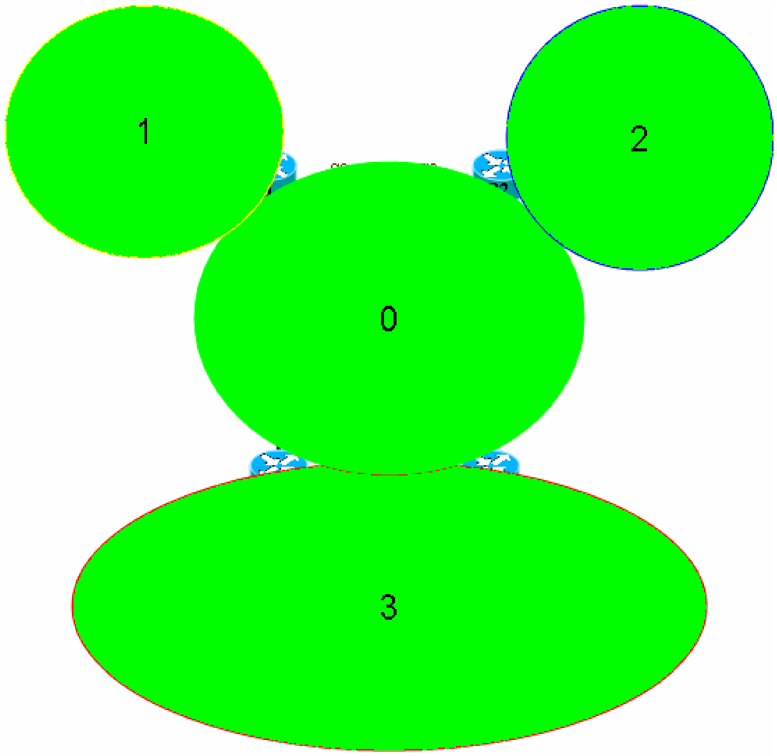
Below is a diagram showing the IP address scheme that was used for the interfaces connecting the switches and routers, since the OSPF metrics is specified only on links connecting routers, a diagram showing the metrics for each link will follow.



A diagram show the metrics for the links used to interconnect the routers is below.



In the final step of the configuration of mouse net, this involved placing specific interfaces connected to each router into the corresponding areas. A diagram showing the area overview of the network is shown below.



Below is the Router OSPF network information from Router 1, it will help to illustrate how certain interfaces are placed into particular areas.

```
network 1.1.0.0 0.0.255.255 area 1
network 1.1.2.0 0.0.255.255 area 1
network 1.1.3.0 0.0.255.255 area 1
network 1.1.1.1 0.0.0.0 area 1
network 12.12.12.0 0.0.0.255 area 0
network 13.13.13.0 0.0.0.255 area 0
network 14.14.14.0 0.0.0.255 area 0
```

With the initial configuration of the network complete, certain areas of interest for the first phase of the lab will analyzed. Those areas area:

- How link state summaries are created.
- How routes are calculated.
- The role of Area border routers in the creation and handling of LSA- Type 3.
- Estimating the size of the OSPF database
- Estimating the size of the routing in bytes

How link state summaries are created

Link state summaries are sent by Area Border Routers and by default they advertise every individual network within each area to which it is connected. Networks can be condensed into a network summary so reducing the number of Link Advertisements being sent and reduces the link state database of the routers outside an area. In addition, if there is a network change then this will not be propagated into the backbone and other areas so minimizing the recalculation of shortest path first.

Link state summaries are created by defining a range of IP address within a router, in which the subnets that need to be summarized fall. This range is made up of an IP address and a summary mask, the address encompasses the range of sub networks to be included within the summary and the mask. An example of which can be found below.

```
area 1 range 1.1.0.0 255.255.0.0 <= summarization for networks below
        network 1.1.2.0 0.0.255.255 area 1
        network 1.1.3.0 0.0.255.255 area 1
        network 1.1.1.1 0.0.0.0 area 1
```

The following summarization will produce the following address that is advertised by router 1 for area 1.

```
area 1 range 1.1.0.0 255.255.0.0
       network 1.1.0.0 0.0.255.255 area 1
```

How routes are calculated

Routes are calculated with Shortest Path First tree using Dijkstra's algorithm. Each OSPF router performs a least cost path calculation called the Dijkstra algorithm on the information in their LSDB and creates a tree of shortest paths to each other router on the network with themselves as the root. This SPF tree is calculated using the metric of the link between each router, and no a hop count. Because the least cost path calculation is performed by each router with itself as the root of the tree, the SPF tree is different for each router.

The result of the Dijkstra algorithm is the SPF tree, a cost sorted list of least cost paths containing the path and its accumulated cost from the source router. The OSPF routing table entries are created from the SPF tree, and a single entry for each produced.

To calculate the IP routing table entries from the SPF Tree, the resulting SPF is analyzed. The result of the analysis is a series of OSPF routes containing the IP destination (the network ID) and its network mask (subnet mask), the forwarding IP address of the appropriate neighboring router, the interface over which the neighboring router is reachable, and the OSPF-calculated cost to the network. The OSPF routes are added to the IP routing table.

The role of Area border routers in the creation and handling of LSA-Type 3

The Area Border Router (ABR) creates Type-3 summary link advertisements that are used to generate a description of the inter-area routes. This enables routes in the interior of an area to dynamically discover destinations in other areas and to pick the best area border router when forwarding data packets to these destinations. The LSA Type-3 is used to describe the routes to networks and is used for summarization.

Splitting an OSPF routing domain into areas reduces the demands for route and network resources. The area’s link state database contains only router and network LSAs for the area’s own routers and networks, the size of the link state databases is reduced, along with the amount of flooding traffic necessary to synchronize the database.

Estimated Size of the OSPF database

The estimated size of the Area Border routers (routers 1 – 4) databases is approximately 6000 Bytes, the remaining routers (routers 5 -6) OSPF database is approximately 3000 Bytes.

Estimated Size of the Routing table

The estimated size of the Area Border routers (routers 1 – 4) database is approximately 3000 Bytes, and the routing table size for the remaining routers (routers 5 – 6) is approximately 3000 Bytes as well.

Phase 2 – Supernet certain networks

In this phase of the lab, super-netting of certain networks was undertaken. For this phase only Area 1 was super-netted. Super-netting allows the combining two or more blocks of IP addresses together, that compose a continuous range of addresses. In the previous phase of the lab super-netting was not undertaken, because of this, Router 1 advertised all network that were in area 1, as seen below from Router 2's perspective:

```
1.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
        1.1.0.0/24 [110/65] via 12.12.12.1, 00:08:22, Serial0/0
        1.1.1.1/32 [110/65] via 12.12.12.1, 00:08:40, Serial0/0
        1.1.3.1/32 [110/65] via 12.12.12.1, 00:08:40, Serial0/0
        1.1.2.1/32 [110/65] via 12.12.12.1, 00:08:40, Serial0/0
```

While Router 1 is only advertising 4 networks, this doesn't require a great deal of router processing or memory capabilities, however, if thousands of networks were being advertised, if links were unstable of flapping this would cause a great deal of flooding which would in turn eat up a great deal of the routers processing and memory capabilities. Below now shows the networks being advertised by Router 1 after super-netting was undertaken.

```
1.0.0.0/16 is subnetted, 1 subnets
        1.1.0.0 [110/65] via 12.12.12.1, 00:14:46, Serial0/0
```

With super-netting of area 1, only 1 network is now advertised to the routers in the network.

To test the reachability of a network after super-netting, the interface connecting Router 1 to Switch 1 (IP address 1.1.0.1 eth 0/1) was disconnected. To ensure IP reachability the loop-back interface of Router 1 (IP address 1.1.1.1 Lo 0) was pinged.

```
Router6#ping 1.1.1.1
type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/8 ms
```

After a successful ping of Router 1's loop-back interface, the IP address of Switch 1 was then pinged.

```
Router6#ping 1.1.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.0.1, timeout is 2 seconds:
U.U.U
Success rate is 0 percent (0/5)
```

With the interface disconnected, the IP address of Switch 1 (1.1.0.1) could not be reached. The benefits of super-netting in this instance, is to hide and prevent advertisements from Router 1 that the interface connecting Switch 1 is down.

Route dampening is a mechanism to minimize the instability caused by route flapping and oscillation over the network. On the other hand super-netting leads to the problem of potential network black holes. In a situation in the network where a potential black hole exist, may have packets sent to the IP address and simply dropped.

Since only Area 1 was super-netted in this phase of the lab, the potential to create black holes were reduced. However, in the subsequent section of the lab when all networks are super-netted, several black holes will be created, examples of such are shown below.

Shown from Router 1
1.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O 1.1.0.0/16 is a summary, 02:34:13, Null0

Shown from Router3
3.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
O 3.3.0.0/16 is a summary, 00:25:28, Null0

4.0.0.0/8 is variably subnetted, 5 subnets, 3 masks
O 4.4.0.0/16 is a summary, 00:25:28, Null0

With the interface connecting Router 1 to Switch 1 down, the only router to know that this link has been dropped is Router 1 as shown in the IP Routing table for Router one that is shown below.

1.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
1.1.0.0/16 is a summary, 00:01:51, Null0
1.1.1.0/24 is directly connected, Loopback0
1.1.2.0/24 is directly connected, Loopback2
1.1.3.0/24 is directly connected, Loopback1

Since all other routers in the network only see the super-netted address from Router 1, the remaining routers are unaware of this link now being down, as show in the Routing tables for Router 2 and 3.

Router2
1.0.0.0/16 is subnetted, 1 subnets
O IA 1.1.0.0 [110/65] via 12.12.12.1, 00:14:46, Serial0/0

Router3
1.0.0.0/16 is subnetted, 1 subnets
O IA 1.1.0.0 [110/2] via 13.13.13.1, 00:17:50, FastEthernet0/0

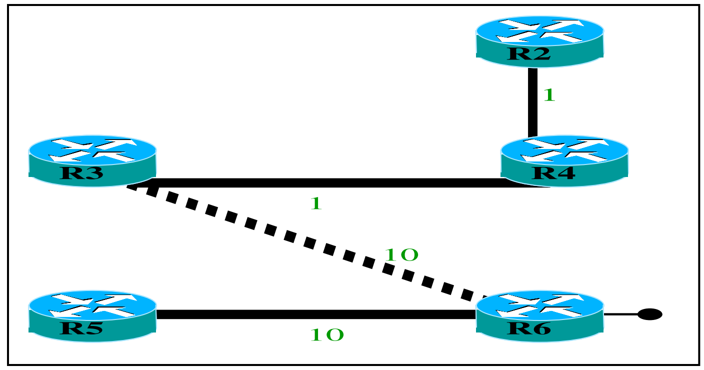
Since only one area in mouse net network was super-netted, no sub-optimal routing was discovered. However, potential routing problems have been predicted and were discovered in the next phase of the lab.

After super-netting area 3, sub optimal routing was discovered, when trace route from Router 2 to the IP address 56.56.56.1 and 56.56.56.2. In the bottom example a trace route from Router 2 to the IP address of 56.56.56.1

```
Router2#traceroute 56.56.56.1

Type escape sequence to abort.
Tracing the route to 56.56.56.1

1 24.24.24.2 4 msec 4 msec 4 msec
2 34.34.34.1 4 msec 4 msec 4 msec
3 36.36.36.2 4 msec 4 msec 4 msec
4 56.56.56.1 8 msec 4 msec *
```



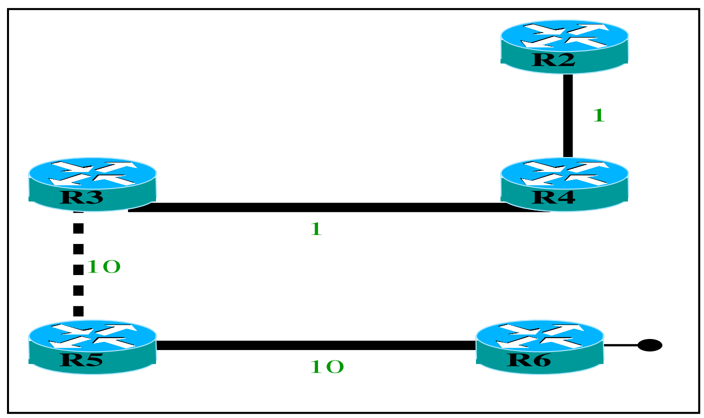
In this instance, the trace traversed a higher cost path to get to the interface (OSPF cost of 22) instead of taking the optimal path of an OSPF cost of 12. The same example can be scene while doing a trace route from Router to interface 56.56.56.2. The example is show on the top of the next page.

When doing a trace route from Router 2 to the IP address of 56.56.56.2 the OSPF cost was 22.

```
Router2#traceroute 56.56.56.2

Type escape sequence to abort.
Tracing the route to 56.56.56.2

1 24.24.24.2 4 msec 4 msec 4 msec
2 34.34.34.1 4 msec 4 msec 4 msec
3 35.35.35.2 4 msec 4 msec 4 msec
4 56.56.56.2 4 msec 4 msec *
```



The ideal cost for reaching 56.56.56.2 would have been an OSPF cost of 12 instead of 22.

Phase 3 – Supernet all routes in all areas

In this phase of the lab, all the routes in all areas were super-netted. With all routes now super-netted a noticeable reduction in the Link State summaries can now be achieved. To help illustrate the reduction of the Link State Summaries, the OSPF database for Router 1 after super-netting all networks is show on the left side, versus the super-netting of no networks,

Please refer to spread sheet on next page

As shown in the table comparing the different phases of the lab, with super-netting all networks a noticeable reduction in the number of entries for Area border routers can be achieved.

Estimated LSA database and Routing Table size

The estimated size for the LSA databases in phase three for Area border routers (Router 1 – Router 4) is approximately 4000 Bytes each; the estimated size for Non Area border routers (Router 5 – Router 6) is approximately 2500 Bytes each.

The estimated size for the routing tables for the Area boarder routers (Router 1 – Router 4) is approximately 3000 bytes each; the estimated size for the Non Area border routers (Router 5 – Router 6) is approximately 2500 bytes as well.

Comparison of before and after aggregation

Below is a table showing the difference in size of the OSPF database and Routing Tables prior to aggregation and after aggregation.

	Before	**After**
OSPF Database		
ABR Routers	6000 Bytes	4000 Bytes
Non ABR Routers	3000 Bytes	2000 Bytes
Routing Tables		
ABR Routers	3000 Bytes	2500 Bytes
Non ABR Routers	3000 Bytes	2500 Bytes

After aggregation a noticeable reduction in the size of the OSPF database was achieved. The size of the databases for both the ABR and for the Non-ABR Routers had dropped by approximately 1/3. The estimated size of the routing tables also achieved a slight reduction for both the ABR and Non-ABR routers.

The following table is a comparison of the Link State summaries, on the left column show the LS-Summary after all network have been aggregated, the column on the right show the LS-Summary prior to aggregation.

Summary Net Link States (Area 0)			
After Supernetting all networks		**No supernetting of any networks**	
Link ID	ADV Router	Link ID	ADV Router
1.1.0.0	1.1.1.1	1.1.0.0	1.1.1.1
2.2.0.0	2.2.3.0	1.1.1.1	1.1.1.1
3.3.0.0	3.3.3.3	1.1.2.1	1.1.1.1
3.3.0.0	4.4.4.4	1.1.3.1	1.1.1.1
4.4.0.0	3.3.3.3	2.2.0.0	2.2.3.0
4.4.0.0	4.4.4.4	2.2.1.1	2.2.3.0
5.5.5.5	3.3.3.3	2.2.2.2	2.2.3.0
5.5.5.5	4.4.4.4	2.2.3.1	2.2.3.0
6.6.6.6	3.3.3.3	3.3.2.0	3.3.3.3
6.6.6.6	4.4.4.4	3.3.2.0	4.4.4.4
34.34.34.0	3.3.3.3	3.3.3.3	3.3.3.3
34.34.34.0	4.4.4.4	3.3.3.3	4.4.4.4
35.35.35.0	3.3.3.3	4.4.4.4	3.3.3.3
35.35.35.0	4.4.4.4	4.4.4.4	4.4.4.4
36.36.36.0	3.3.3.3	4.4.5.0	3.3.3.3
36.36.36.0	4.4.4.4	4.4.5.0	4.4.4.4
45.45.45.0	3.3.3.3	4.4.6.0	3.3.3.3
45.45.45.0	4.4.4.4	4.4.6.0	4.4.4.4
45.45.45.3	3.3.3.3	4.4.7.0	3.3.3.3
45.45.45.3	4.4.4.4	4.4.7.0	4.4.4.4
46.46.46.0	3.3.3.3	5.5.5.5	3.3.3.3
46.46.46.0	4.4.4.4	5.5.5.5	4.4.4.4
56.56.56.0	3.3.3.3	6.6.6.6	3.3.3.3
56.56.56.0	4.4.4.4	6.6.6.6	4.4.4.4
		34.34.34.0	3.3.3.3
		34.34.34.0	4.4.4.4
		35.35.35.0	3.3.3.3
		35.35.35.0	4.4.4.4
		36.36.36.0	3.3.3.3
		36.36.36.0	4.4.4.4
		45.45.45.0	3.3.3.3
		45.45.45.0	4.4.4.4
		45.45.45.3	3.3.3.3
		45.45.45.3	4.4.4.4
		46.46.46.0	3.3.3.3
		46.46.46.0	4.4.4.4
		56.56.56.0	3.3.3.3
		56.56.56.0	4.4.4.4

Observation of Area 3's metric for the advertised super-net

Observing the metrics for the advertised supernetted networks at ABR Routers 3 and 4, yield the same results as shown below.

Router5# show ip route

```
     3.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       3.3.3.3/32 [110/11] via 35.35.35.1, 00:41:34, Serial0/0
O       3.3.2.0/24 [110/11] via 35.35.35.1, 00:41:34, Serial0/0
     4.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O       4.4.4.4/32 [110/12] via 35.35.35.1, 00:41:34, Serial0/0
C       4.4.5.0/24 is directly connected, FastEthernet0/1
O       4.4.6.0/24 [110/11] via 56.56.56.2, 00:41:34, FastEthernet0/0
O       4.4.7.0/24 [110/12] via 35.35.35.1, 00:41:34, Serial0/0
```

Router6#show ip route

```
     3.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       3.3.3.3/32 [110/11] via 36.36.36.1, 00:46:05, Serial0/1
O       3.3.2.0/24 [110/11] via 36.36.36.1, 00:46:05, Serial0/1
     4.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O       4.4.4.4/32 [110/12] via 36.36.36.1, 00:46:06, Serial0/1
O       4.4.5.0/24 [110/11] via 56.56.56.1, 00:46:06, FastEthernet0/0
C       4.4.6.0/24 is directly connected, FastEthernet0/1
O       4.4.7.0/24 [110/12] via 36.36.36.1, 00:46:06, Serial0/1
```

For intra-area traffic, OSPF uses the shortest path to calculate what link to use to reach the particular network + 1. For inter-area traffic, the metrics for the links to Area 1 or 2, the most expensive cost is used.

Phase 4 - Study the effects of the physical topology in routing

Trace route from R1 to R2

In the fourth phase of the lab, the links 14.14.14.0 / 30 and 23.23.23.0 /30 were disconnected and a trace-router was preformed to study how routing in Area 0 would operate. With the serial links between Router 1 and 4, as well as Router 2 and 3 disabled a packet attempting to reach Router 2 from Router 1 would have to traverse link 12.12.12.0 /30 as shown in the trace route below.

```
Router1#traceroute 2.2.2.2

Type escape sequence to abort.
Tracing the route to 2.2.2.2

1 12.12.12.2 4 msec 4 msec *
```

At first glance, the idea of why would the links 13.13.13.0 / 30 – 34.34.34.0 / 30 and 24.24.24.0 /30 be used, their OSPF metric is 3 compared to that of 64 for the link 12.12.12.0 /30. The reason why, the lower metric route is not used, is due to the fact link 34.34.34.0 exists in Area 3 and not in Area 0.

Trace route from R1 to R3

In this phase of the lab the links 12.12.12.0 / 30 is now shutdown, as well as the links that were initially disconnected in the being of this phase. After the links are disconnected a trace route is preformed between Router 1 and Router 3. As shown below.

```
Router1#traceroute 3.3.3.3

Type escape sequence to abort.
Tracing the route to 3.3.3.3

 1 13.13.13.2 4 msec 4 msec *
```

Even with the links between Routers 1, 2 and 4 severed, it is still possible to perform the trace route between Routers 1 and Router 3. However, with this link now severed, Area 0 has been effectively split into two separate areas, with Routers 1 and 3 in one half of Area 0 and Routers 2 and 4 in the other half.

How Area 0 works.

OSPF divides its routing domain into *areas*. Area 0, is the backbone and is required. This divides interior routing into two levels. If traffic must travel between two areas, the packets are first routed to the backbone (Area 0). This may cause non-optimal routes, since inter-area routing is not done until the packet reaches the backbone. Once there, it is routed to the destination area, which is then responsible for final delivery. This layering permits addresses to be consolidated by area, reducing the size of the link state databases. Small networks can operate with a single OSPF area, which must be area 0.

Phase 5 – Implementation of a Virtual link

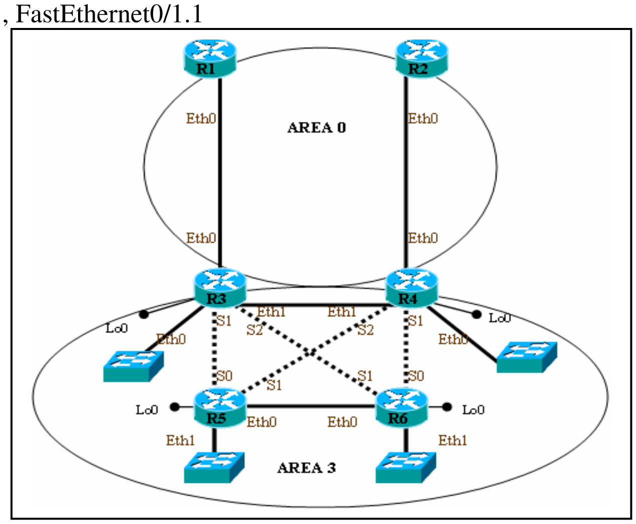
Define virtual link between Router 3 and Router 4

For the first part of phase five, a virtual link was created between Router 3 and Router 4, using the interface 34.34.34.1 /30 and 34.34.34.2 /30. This virtual link this virtual link was used to connect the severed parts of Area 0 (In the previous section of the lab, interfaces connecting 12.12.12.0 /30, 14.14.14.0 /30 and 23.23.23.0 /30 were brought down). During the testing of this link, we were received the following error message:

Router4#
1d04h: %OSPF-4-ERRRCV: Received invalid packet: mismatch area ID, from backbone area must be virtual-link but not found from 34.34.34.1, FastEthernet0/1

1d04h: %OSPF-4-ERRRCV: Received invalid packet: mismatch area ID, from backbone area must be virtual-link but not found from 34.34.34.1, FastEthernet0/1.1

The Reason for this error message has to do with the fact that the virtual link crosses through Area 3. In order for the virtual link to work it has to connect a Router from Area 3 to Area 0. An Example would be a Virtual link between Router 3 Area 3 to Router 4 Area 0. This would reconnect the separated Area 0.



What is a Virtual Link?

A Virtual link is used to connect Area X to the backbone Area 0 through a non-backbone area. All areas in an Open Shortest Path First (OSPF) autonomous system must be physically connected to the backbone area (area 0). In some cases where this is not possible, you can use a virtual link to connect to the backbone through a non-backbone area. You can also use virtual links to connect two parts of a partitioned backbone through a non-backbone area. The area through which you configure the virtual link, known as a transit area, must have full routing information. The transit area cannot be a stub area.

Redefine virtual link to Router 3 and Router 4 loopback addresses

In this part of the lab, the previously defined Virtual link using 34.34.34.1 /30 to 34.34.34.2 /30 is redefined using Router 3 and Router's 4 loop back address. Even after re-defining the virtual link, results similar to that in the previous section were yielded. A similar problem still exists, the loopback addresses still exist in Area 3.

<u>Move Router 4's loopback into Area 0</u>

With Router 4's loopback address existing in Area 3 the Virtual link that was defined

Router 3 networks
router ospf 3
area 3 range 3.3.0.0 255.255.0.0
area 3 range 4.4.0.0 255.255.0.0
network 3.3.3.3 0.0.0.0 area 3
area 3 virtual-link 4.4.4.4

Router 4 networks
router ospf 4
area 3 range 3.3.0.0 255.255.0.0
area 3 range 4.4.0.0 255.255.0.0
network 4.4.4.4 0.0.0.0 area 0
area 0 virtual-link 3.3.3.3

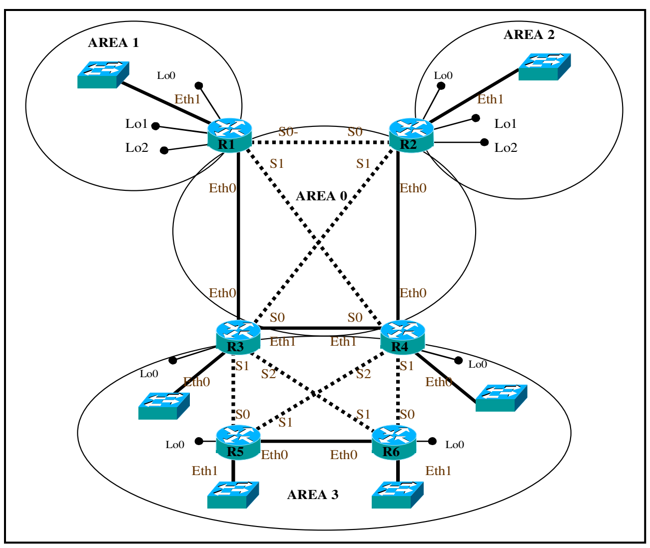
With Router 4's loop back address now defined in Area 0, different results were achieved compared to that of the previous step in this section as shown below.

```
Router4#show ip ospf virtual-links
Virtual Link OSPF_VL3 to router 3.3.3.3 is up
Run as demand circuit
DoNotAge LSA allowed.
Transit area 3, via interface FastEthernet0/1, Cost of using 1
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
 Hello due in 00:00:01
Adjacency State FULL (Hello suppressed)
Index 3/6, retransmission queue length 0, number of retransmission 0
First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
Last retransmission scan length is 0, maximum is 0
Last retransmission scan time is 0 msec, maximum is 0 msec
```

With one interface now in Area 0 and in Area 3, the virtual link is now active and is able to re-connect the severed Area 0.

<u>Move interface 34.34.34.0 /30 into Area 0</u>

In the last step of phase 5 is to move the interface 34.34.34.0 /30 from Area 3 to Area 0. Moving this interface will help to give a comparison between Physical and Virtual links.



The influence of a good physical and logical layer design based on results

Two characteristic of any network is the Physical and Logical layer design, far too often both are terribly overlooked. In the first 3 phases of the network, the link 34.34.34.0 / 30 existed in Area 3, while this link does provide a fast link between Routers 3 and Router 4 while in Area 3, Routers 5 and 6 can easily be reached taking fast Ethernet or Serial links. However, Router 1 if would like to forward to Router 2 had to traverse slower Serial links. This is ineffective, by moving 34.34.34.0 /30 link into Area 0, Router 1 can now traverse a fast Ethernet links through Router 1 > Router 3 > Router 4 > Router 2. This allows more effective routing between Area's 1 and 2.

The movement of this Link does not reduce the effective ability routing in Area 3, this is due to Fast Serial and Ethernet links link Routers Area 3 Router's 3, 4, 5 and 6. A virtual link could be created using Router 3's loop back address and leaving it in Area 3, and moving Router 4's loop back address into Area 0. This however, could lead to a situation were it is complex and time consuming to determine where a faulty link might exist.

Phase 6 – Reconnect all interfaces that were brought down

In this phase of the lab, the interfaces that were disconnected in the previous section is now reconnected. In addition to reconnecting the interfaces the Metric for link 12.12.12.0 /30 were modified from an IP OSPF cost of 64 to a new cost of 1. As shown below.

Router1

```
interface Serial0/0
ip address 12.12.12.1 255.255.255.252
ip ospf cost 1
```

Router2

```
interface Serial0/0
ip address 12.12.12.2 255.255.255.252
ip ospf cost 1
```

After adjusting the metrics for 12.12.12.0 /30 the link is then removed from Area 0 to Area 1. The result of moving the link effects the Link State summary, for example the Link State Summary for Router 1 in Phase 1 and again in Phase 6 is shown.

Router 1 Part 1

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
6.6.6.6	3.3.3.3	1842	0x80000002	0x00EA18
6.6.6.6	4.4.4.4	1688	0x80000002	0x00D627
34.34.34.0	3.3.3.3	598	0x80000005	0x005276
34.34.34.0	4.4.4.4	664	0x80000003	0x00388E

Router 1 Part 6

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
6.6.6.6	3.3.3.3	501	0x80000004	0x008288
6.6.6.6	4.4.4.4	416	0x80000005	0x00804F
12.12.12.0	1.1.1.1	369	0x80000001	0x00B165
35.35.35.0	3.3.3.3	2010	0x80000004	0x008A33
35.35.35.0	4.4.4.4	1148	0x80000006	0x00EA8C

When link 12.12.12.0 /30 existed in Area 0 the link was not advertised as a Link State summary from Area 0, after changing it to Area 1, the Link State Summary is then being advertised. After analyzing the IP routing table for phase 6 of the lab, it appeared the advertisement for link 12.12.12.0 /30 did not change as shown below.

Router 2 Part 1

```
12.0.0.0/30 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Serial0/0
```

Router 2 Part 6

```
12.0.0.0/30 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Serial0/0
```

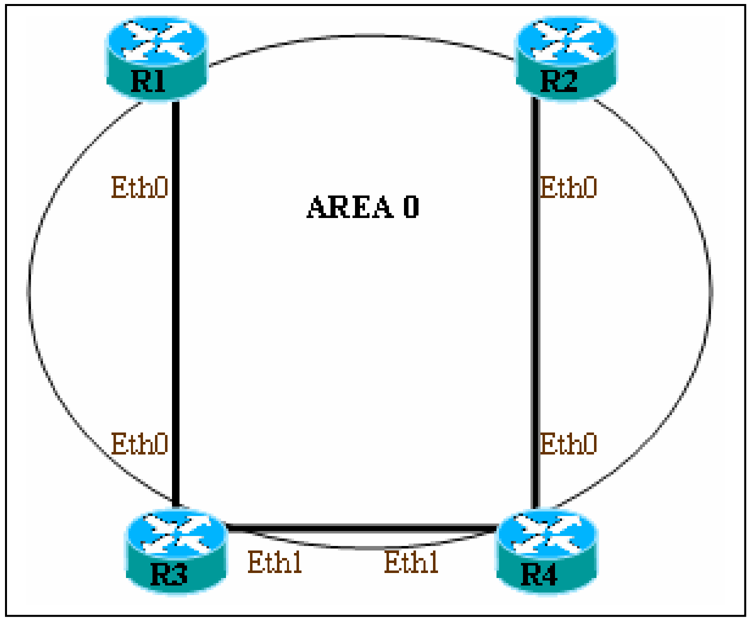
Trace route from Router 1 to Router 2

The last set in the phase of the lab is to do a trace router form Router 1 to Router 2, after link 12.12.12.0 /30 had been disconnected. The trace route and path is shown below.

```
R1#traceroute  2.2.2.2

Type escape sequence to abort.
Tracing the route to 2.2.2.2

  1 13.13.13.2 4 msec 4 msec 4 msec
  2 34.34.34.2 4 msec 4 msec 4 msec
  3 24.24.24.1 8 msec 4 msec *
```



The reason why the trace route uses this path, is due to the fact that the Fast Ethernet links that are in Area 0, have an OSPF metric of 1. In addition to the lower metric, Fast Ethernet link 34.34.34.0 /30 was moved from Area 3 into Area 0. The reason why the link 12.12.12.0 /30 even with a lower metric (link 12.12.12.0 /30 = OSPF metric 1, compared to 13.13.13.0 /30 => 34.34.34.0 => 24.24.24.0 /30 = OSPF metric 3) was not used due to the fact link 12.12.12.0 /30 is now located in Area 1.