Cover Page

ECE 461 Lab4 Report

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Part 2

1. Use the captured data of a single RIP packet and explain the fields in a RIP Message

Ans:

Here is one RIP packet and the RIP message section is highlighted:

No.	Time	Source	Destination	Protocol	Info
2	2.711818	10.0.1.1	224.0.0.9	RIPv2	Response

```
Frame 2 (106 bytes on wire, 106 bytes captured)
    Arrival Time: Jul 12, 2007 00:24:56.841606000
    [Time delta from previous packet: 2.711818000 seconds]
    [Time since reference or first frame: 2.711818000 seconds]
    Frame Number: 2
    Packet Length: 106 bytes
    Capture Length: 106 bytes
    [Frame is marked: False]
    [Protocols in frame: eth:ip:udp:rip]
    [Coloring Rule Name: Low TTL]
    [Coloring Rule String: ip.ttl < 5]
Ethernet II, Src: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0), Dst: 01:00:5e:00:00:09
(01:00:5e:00:00:09)
    Destination: 01:00:5e:00:00:09 (01:00:5e:00:00:09)
        Address: 01:00:5e:00:00:09 (01:00:5e:00:00:09)
        .... ...1 .... .... .... .... = IG bit: Group address (multicast/broadcast)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
    Source: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0)
        Address: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
    Type: IP (0x0800)
Internet Protocol, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.9 (224.0.0.9)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0xc0 (DSCP 0x30: Class Selector 6; ECN: 0x00)
        1100 00.. = Differentiated Services Codepoint: Class Selector 6 (0x30)
        .... ..0. = ECN-Capable Transport (ECT): 0
        .... ...0 = ECN-CE: 0
    Total Length: 92
    Identification: 0x0000 (0)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
```

Time to live: 2
Protocol: UDP (0x11)
Header checksum: 0xccc7 [correct]
[Good: True]
[Bad : False]
Source: 10.0.1.1 (10.0.1.1)
Destination: 224.0.0.9 (224.0.0.9)
User Datagram Protocol, Src Port: 520 (520), Dst Port: 520 (520)
Source port: 520 (520)
Destination port: 520 (520)
Length: 72
Checksum: 0xea32 [correct]
[Good Checksum: True]
[Bad Checksum: False]
Routing Information Protocol
Command: Response (2)
Version: RIPv2 (2)
Routing Domain: 0
IP Address: 10.0.2.0, Metric: 1
Address Family: IP (2)
Route Tag: 0
IP Address: 10.0.2.0 (10.0.2.0)
Netmask: 255.255.255.0 (255.255.255.0)
Next Hop: 0.0.0.0 (0.0.0.0)
Metric: 1
IP Address: 10.0.3.0, Metric: 2
Address Family: IP (2)
Route Tag: 0
IP Address: 10.0.3.0 (10.0.3.0)
Netmask: 255.255.255.0 (255.255.255.0)
Next Hop: 0.0.0.0 (0.0.0.0)
Metric: 2
IP Address: 10.0.4.0, Metric: 3
Address Family: IP (2)
Route Tag: 0
IP Address: 10.0.4.0 (10.0.4.0)
Netmask: 255.255.255.0 (255.255.255.0)
Next Hop: 0.0.0.0 (0.0.0.0)
Metric: 3

Fields:
● Command
Command specifies the type of RIP message, such as RIP request and RIP response
● Version
Version specifies the RIP version, such as RIPv2
● Routing Domain

Routing domain specifies the number of the routing process to which this update belongs. This field is used to associate the routing update to a specific routing process in the receiving router. A routing domain of 0 indicates the default routing domain

● IP Address

IP address specifies the IP address for the entry

● Address Family

Address family specifies the address family used

● Route Tag

Route tag provides a method for distinguishing between internal routes (learned by RIP) and external routes (learned from other protocols).

● Netmask

Netmask specifies the subnet mask for the entry

● Next Hop

Next hop indicates the IP address of the next hop to which packets for the entry should be forwarded.

● Metric

Metric indicates how many internetwork hops (routers) have been traversed in the trip to the destination

2. For PC1, include the output of the commands show ip route and netstat -rn from steps 4 and 5. Discuss the differences in the output of the commands

Ans:

The show ip rip command includes the metric, update time and the routing protocol type, which are not included in the result of netstat -rn command.The netstat -rn command displays the loopback address and other settings including MSS, window, itrr, and interface, which are now shown in the output of command show ip rip.

```
ripd# show ip rip
Codes: R - RIP, C - connected, O - OSPF, B - BGP
     (n) - normal, (s) - static, (d) - default, (r) - redistribute,
     (i) - interface

     Network         Next Hop         Metric From            Time
C(i) 10.0.1.0/24     0.0.0.0               1 self
R(n) 10.0.2.0/24     10.0.1.1              2 10.0.1.1       02:53
R(n) 10.0.3.0/24     10.0.1.1              3 10.0.1.1       02:53
R(n) 10.0.4.0/24     10.0.1.1              4 10.0.1.1       02:53

Kernel IP routing table
Destination     Gateway         Genmask         Flags   MSS Window  irtt Iface
10.0.4.0        10.0.1.1        255.255.255.0   UG        0 0          0 eth0
10.0.1.0        0.0.0.0         255.255.255.0   U         0 0          0 eth0
10.0.2.0        10.0.1.1        255.255.255.0   UG        0 0          0 eth0
10.0.3.0        10.0.1.1        255.255.255.0   UG        0 0          0 eth0
```

127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

The “show ip rip” command contains the routing protocol type, the metric and update time, which cannot be found in “netstat -rn” command.The “netstat -rn” command shows the loopback address and other settings including MSS, window, itrr, and interface, which cannot be found in the output of the command “show ip rip”.

3. Include the output of traceroute from step 7.

Data:

[root@PC1 root]# traceroute 10.0.4.10
traceroute to 10.0.4.10 (10.0.4.10), 30 hops max, 38 byte packets
1 10.0.1.1 (10.0.1.1) 33.503 ms 0.453 ms 0.431 ms
2 10.0.2.2 (10.0.2.2) 0.694 ms 0.489 ms 0.493 ms
3 10.0.3.3 (10.0.3.3) 0.747 ms 0.563 ms 0.536 ms
4 10.0.4.10 (10.0.4.10) 7.031 ms 0.290 ms 0.259 ms

4. Answer the questions posed in Step 8. For each answer, include captured packets to support your answers.

a. What is the destination IP address of RIP packets?

Ans:

The destination IP address of RIP packets is 224.0.0.9.

The following is an RIP packet captured on PC1:

Data :

No.	Time	Source	Destination	Protocol	Info
2	2.711818	10.0.1.1	224.0.0.9	RIPv2	Response

Frame 2 (106 bytes on wire, 106 bytes captured)
Arrival Time: Jul 12, 2007 00:24:56.841606000
[Time delta from previous packet: 2.711818000 seconds]
[Time since reference or first frame: 2.711818000 seconds]
Frame Number: 2
Packet Length: 106 bytes
Capture Length: 106 bytes
[Frame is marked: False]
[Protocols in frame: eth:ip:udp:rip]
[Coloring Rule Name: Low TTL]
[Coloring Rule String: ip.ttl < 5]
Ethernet II, Src: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0), Dst: 01:00:5e:00:00:09 (01:00:5e:00:00:09)
Destination: 01:00:5e:00:00:09 (01:00:5e:00:00:09)
Address: 01:00:5e:00:00:09 (01:00:5e:00:00:09)
....1 .... = IG bit: Group address (multicast/broadcast)
.... ..0. .... = LG bit: Globally unique address (factory default)

```
   Source: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0)
      Address: 00:1c:58:7e:03:c0 (00:1c:58:7e:03:c0)
      .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
      .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
   Type: IP (0x0800)
Internet Protocol, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.9 (224.0.0.9)
   Version: 4
……...
```

b. Do routers forward RIP packets? In other words, does PC1 receive RIP packets sent from Router 3?

Ans:

Routers do not forward RIP packets, since The communication of the RIP protocol is restricted among directly connected entities. Therefore, PC1 will not receive RIP packets from Router 3, because router 3 must go through router 1 in order to reach PC1.

Here is the RIP packets received from PC1:

Data:

No.	Time	Source	Destination	Protocol	Info
2	2.711818	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
6	32.181403	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
36	61.463032	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
39	89.436750	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
43	118.730367	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
47	146.760096	10.0.1.1	224.0.0.9	RIPv2	Response
No.	Time	Source	Destination	Protocol	Info
51	175.305764	10.0.1.1	224.0.0.9	RIPv2	Response

c. Which types of routing RIP messages do you observe? The type of a RIP message is indicated by the value of the field command. For each packet type that you observed, explain the role that this message type plays in the RIP protocol.

Ans:

The type of RIP message is RIP response based on the command field. Since PCs are set to passive mode, they only listen and update their routing table but not advertise their updates. The RIP response messages were therefore used to inform the network entities to update their routing table based on the up-to-date information.

Here is the RIP message section and commend field is highlighted:

Data:

Routing Information Protocol
- **Command: Response (2)**
- Version: RIPv2 (2)
- Routing Domain: 0
- IP Address: 10.0.2.0, Metric: 1
  - Address Family: IP (2)
  - Route Tag: 0
  - IP Address: 10.0.2.0 (10.0.2.0)
  - Netmask: 255.255.255.0 (255.255.255.0)
  - Next Hop: 0.0.0.0 (0.0.0.0)
  - Metric: 1
- IP Address: 10.0.3.0, Metric: 2
  - Address Family: IP (2)
  - Route Tag: 0
  - IP Address: 10.0.3.0 (10.0.3.0)
  - Netmask: 255.255.255.0 (255.255.255.0)
  - Next Hop: 0.0.0.0 (0.0.0.0)
  - Metric: 2
- IP Address: 10.0.4.0, Metric: 3
  - Address Family: IP (2)
  - Route Tag: 0
  - IP Address: 10.0.4.0 (10.0.4.0)
  - Netmask: 255.255.255.0 (255.255.255.0)
  - Next Hop: 0.0.0.0 (0.0.0.0)
  - Metric: 3

d. A RIP message may contain multiple routing table entries. How many bytes are consumed in a RIP message to contain a routing table entry? Which information is transmitted for each message?

Ans:

20 bytes are consumed to contain a routing table entry. The information includes IP address, address family, route tag, netmast, next hop, and metric.

Here is a routing table entry:

- IP Address: 10.0.2.0, Metric: 1
  - Address Family: IP (2)
  - Route Tag: 0
  - IP Address: 10.0.2.0 (10.0.2.0)

Netmask: 255.255.255.0 (255.255.255.0)
Next Hop: 0.0.0.0 (0.0.0.0)
Metric: 1

Part3

1. Include the routing tables of the linux PCs before the topology was changed (Step 2)and after Router 4 has been added and the routing tables have been updated (Step 5). Discuss the time it took to update the routing table.

Ans:
Routing table before changed topology:

Data :

[root@PC1 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.2.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC2 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.2.2 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 10.0.2.1 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.3.0 10.0.2.2 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC3 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.3.3 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 10.0.3.2 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 10.0.3.2 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC4 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface

10.0.4.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.1.0 10.0.4.3 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 10.0.4.3 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 10.0.4.3 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

Routing table after changed topology:

[root@PC1 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.2.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 10.0.1.1 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC2 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.2.4 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 10.0.2.1 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.3.0 10.0.2.2 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC3 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 10.0.3.3 255.255.255.0 UG 0 0 0 eth0
10.0.1.0 10.0.3.2 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 10.0.3.2 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

[root@PC4 root]# netstat -rn
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.4.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.1.0 10.0.4.4 255.255.255.0 UG 0 0 0 eth0
10.0.2.0 10.0.4.4 255.255.255.0 UG 0 0 0 eth0
10.0.3.0 10.0.4.3 255.255.255.0 UG 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo

Routing table in PC2 and PC4 are updated after the the topology change. It takes

approximately 10 seconds.

2. Count the number of lost packets and calculate the time it took RIP to update the routing table.

Ans: The packets with sequence numbers between 7 and 209 are lost. Therefore, the total number of lost packets is 202. The ping command issues an ICMP echo request message approximately once every second, so it takes 202 seconds for RIP to update the routing table.

Part5

1. Count the number of lost packets and calculates the time it took OSPF to update the routing tables.

The packets with sequence numbers between 96 and 109 are lost. Therefore, the total number of lost
packets is 13. The ping command issues an ICMP echo request message approximately once every second, so it takes 13 seconds for RIP to update the routing table.

2. From your saved ethereal output, include one packet from each of the different OSPF packet type that you have observed.

There are three types of OSPF packets we have observed: OSPF hello, Link State update and Link State acknowledge packets.

Here is detailed output of each type of packets:

OSPF Hello packets

No.	Time	Source	Destination	Protocol	Info
1	0.000000	10.0.1.1	224.0.0.5	OSPF	Hello Packet

Frame 1 (82 bytes on wire, 82 bytes captured)
Arrival Time: Jul 11, 2007 03:30:58.662901000
[Time delta from previous packet: 0.000000000 seconds]
[Time since reference or first frame: 0.000000000 seconds]
Frame Number: 1
Packet Length: 82 bytes
Capture Length: 82 bytes
[Frame is marked: False]
[Protocols in frame: eth:ip:ospf]
[Coloring Rule Name: Low TTL]
[Coloring Rule String: ip.ttl < 5]
Ethernet II, Src: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25), Dst: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
Destination: 01:00:5e:00:00:05 (01:00:5e:00:00:05)

```
        Address: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
        .... ...1 .... .... .... .... = IG bit: Group address (multicast/broadcast)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
    Source: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25)
        Address: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
    Type: IP (0x0800)
Internet Protocol, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.5 (224.0.0.5)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0xc0 (DSCP 0x30: Class Selector 6; ECN: 0x00)
        1100 00.. = Differentiated Services Codepoint: Class Selector 6 (0x30)
        .... ..0. = ECN-Capable Transport (ECT): 0
        .... ...0 = ECN-CE: 0
    Total Length: 68
    Identification: 0x8d11 (36113)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 1
    Protocol: OSPF IGP (0x59)
    Header checksum: 0x408a [correct]
        [Good: True]
        [Bad : False]
    Source: 10.0.1.1 (10.0.1.1)
    Destination: 224.0.0.5 (224.0.0.5)
Open Shortest Path First
    OSPF Header
        OSPF Version: 2
        Message Type: Hello Packet (1)
        Packet Length: 48
        Source OSPF Router: 10.0.1.1 (10.0.1.1)
        Area ID: 0.0.0.1
        Packet Checksum: 0xd093 [correct]
        Auth Type: Null
        Auth Data (none)
    OSPF Hello Packet
        Network Mask: 255.255.255.0
        Hello Interval: 10 seconds
        Options: 0x02 (E)
            0... .... = DN: DN-bit is NOT set
            .0.. .... = O: O-bit is NOT set
            ..0. .... = DC: Demand circuits are NOT supported
```

...0 .... = L: The packet does NOT contain LLS data block
.... 0... = NP: Nssa is NOT supported
.... .0.. = MC: NOT multicast capable
.... ..1. = E: ExternalRoutingCapability
Router Priority: 1
Router Dead Interval: 40 seconds
Designated Router: 10.0.1.1
Backup Designated Router: 10.0.1.2
Active Neighbor: 10.0.1.2

OSPF Link State update packets

No.	Time	Source	Destination	Protocol	Info
266	177.196960	10.0.1.2	224.0.0.5	OSPF	LS Update

No.	Time	Source	Destination	Protocol	Info
338	208.890049	10.0.1.2	224.0.0.5	OSPF	LS Update

Frame 338 (94 bytes on wire, 94 bytes captured)
Arrival Time: Jul 11, 2007 03:34:27.552950000
[Time delta from previous packet: 31.693089000 seconds]
[Time since reference or first frame: 208.890049000 seconds]
Frame Number: 338
Packet Length: 94 bytes
Capture Length: 94 bytes
[Frame is marked: False]
[Protocols in frame: eth:ip:ospf]
[Coloring Rule Name: OSPF State Change]
[Coloring Rule String: ospf.msg != 1]
Ethernet II, Src: 00:04:5a:7a:c8:ca (00:04:5a:7a:c8:ca), Dst: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
Destination: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
Address: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
....1 .... = IG bit: Group address (multicast/broadcast)
.... ..0. .... = LG bit: Globally unique address (factory default)
Source: 00:04:5a:7a:c8:ca (00:04:5a:7a:c8:ca)
Address: 00:04:5a:7a:c8:ca (00:04:5a:7a:c8:ca)
....0 .... = IG bit: Individual address (unicast)
.... ..0. .... = LG bit: Globally unique address (factory default)
Type: IP (0x0800)
Internet Protocol, Src: 10.0.1.2 (10.0.1.2), Dst: 224.0.0.5 (224.0.0.5)
Version: 4
Header length: 20 bytes
Differentiated Services Field: 0xc0 (DSCP 0x30: Class Selector 6; ECN: 0x00)
1100 00.. = Differentiated Services Codepoint: Class Selector 6 (0x30)
.... ..0. = ECN-Capable Transport (ECT): 0
....0 = ECN-CE: 0

```
    Total Length: 80
    Identification: 0x9988 (39304)
    Flags: 0x00
      0... = Reserved bit: Not set
      .0.. = Don't fragment: Not set
      ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 1
    Protocol: OSPF IGP (0x59)
    Header checksum: 0x3406 [correct]
      [Good: True]
      [Bad : False]
    Source: 10.0.1.2 (10.0.1.2)
    Destination: 224.0.0.5 (224.0.0.5)
Open Shortest Path First
    OSPF Header
      OSPF Version: 2
      Message Type: LS Update (4)
      Packet Length: 60
      Source OSPF Router: 10.0.1.2 (10.0.1.2)
      Area ID: 0.0.0.1
      Packet Checksum: 0xcbc4 [correct]
      Auth Type: Null
      Auth Data (none)
    LS Update Packet
      Number of LSAs: 1
      LS Type: Network-LSA
        LS Age: 3600 seconds
        Options: 0x02 (E)
          0... .... = DN: DN-bit is NOT set
          .0.. .... = O: O-bit is NOT set
          ..0. .... = DC: Demand circuits are NOT supported
          ...0 .... = L: The packet does NOT contain LLS data block
          .... 0... = NP: Nssa is NOT supported
          .... .0.. = MC: NOT multicast capable
          .... ..1. = E: ExternalRoutingCapability
        Link-State Advertisement Type: Network-LSA (2)
        Link State ID: 10.0.7.7
        Advertising Router: 10.0.6.7 (10.0.6.7)
        LS Sequence Number: 0x80000002
        LS Checksum: 58a8
        Length: 32
        Netmask: 255.255.255.0
        Attached Router: 10.0.6.7
        Attached Router: 10.0.4.4
```

OSPF Link State acknowledge packets.

No.	Time	Source	Destination	Protocol	Info
269	177.832555	10.0.1.1	224.0.0.5	OSPF	LS Acknowledge

Frame 269 (78 bytes on wire, 78 bytes captured)
Arrival Time: Jul 11, 2007 03:33:56.495456000
[Time delta from previous packet: 177.832555000 seconds]
[Time since reference or first frame: 177.832555000 seconds]
Frame Number: 269
Packet Length: 78 bytes
Capture Length: 78 bytes
[Frame is marked: False]
[Protocols in frame: eth:ip:ospf]
[Coloring Rule Name: OSPF State Change]
[Coloring Rule String: ospf.msg != 1]
Ethernet II, Src: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25), Dst: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
Destination: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
Address: 01:00:5e:00:00:05 (01:00:5e:00:00:05)
....1 .... = IG bit: Group address (multicast/broadcast)
.... ..0. .... = LG bit: Globally unique address (factory default)
Source: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25)
Address: 00:04:5a:7a:c8:25 (00:04:5a:7a:c8:25)
....0 .... = IG bit: Individual address (unicast)
.... ..0. .... = LG bit: Globally unique address (factory default)
Type: IP (0x0800)
Internet Protocol, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.5 (224.0.0.5)
Version: 4
Header length: 20 bytes
Differentiated Services Field: 0xc0 (DSCP 0x30: Class Selector 6; ECN: 0x00)
1100 00.. = Differentiated Services Codepoint: Class Selector 6 (0x30)
.... ..0. = ECN-Capable Transport (ECT): 0
....0 = ECN-CE: 0
Total Length: 64
Identification: 0x8d35 (36149)
Flags: 0x00
0... = Reserved bit: Not set
.0.. = Don't fragment: Not set
..0. = More fragments: Not set
Fragment offset: 0
Time to live: 1
Protocol: OSPF IGP (0x59)
Header checksum: 0x406a [correct]
[Good: True]
[Bad : False]

```
   Source: 10.0.1.1 (10.0.1.1)
   Destination: 224.0.0.5 (224.0.0.5)
Open Shortest Path First
   OSPF Header
      OSPF Version: 2
      Message Type: LS Acknowledge (5)
      Packet Length: 44
      Source OSPF Router: 10.0.1.1 (10.0.1.1)
      Area ID: 0.0.0.1
      Packet Checksum: 0xf3f9 [correct]
      Auth Type: Null
      Auth Data (none)
   LSA Header
      LS Age: 2 seconds
      Options: 0x22 (DC, E)
         0... .... = DN: DN-bit is NOT set
         .0.. .... = O: O-bit is NOT set
         ..1. .... = DC: Demand Circuits are supported
         ...0 .... = L: The packet does NOT contain LLS data block
         .... 0... = NP: Nssa is NOT supported
         .... .0.. = MC: NOT multicast capable
         .... ..1. = E: ExternalRoutingCapability
      Link-State Advertisement Type: Router-LSA (1)
      Link State ID: 10.0.4.4
      Advertising Router: 10.0.4.4 (10.0.4.4)
      LS Sequence Number: 0x8000000c
      LS Checksum: 4097
      Length: 36
```

3. Include the output of the link state database of PC2.

Ans:

```
ospfd# show ip ospf database

       OSPF Router with ID (10.0.1.2)

                Router Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.0.1.1        10.0.1.1          9 0x80000028 0x12a9 2
10.0.1.2        10.0.1.2       1193 0x80000004 0x13c1 2
10.0.3.2        10.0.3.2       1813 0x80000009 0xad08 2
10.0.3.3        10.0.3.3       1814 0x80000003 0x2b94 2
10.0.3.4        10.0.3.4         22 0x80000006 0x0bb8 2
10.0.4.3        10.0.4.3        327 0x80000009 0x7a27 2
```

10.0.4.4 10.0.4.4 490 0x8000000c 0x4097 1
10.0.6.7 10.0.6.7 459 0x80000005 0x7f3f 2

Net Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum
10.0.1.1	10.0.1.1	1238	0x80000002	0x71b6
10.0.2.5	10.0.3.2	1813	0x80000001	0x608a
10.0.3.4	10.0.3.4	22	0x80000002	0x799c
10.0.4.4	10.0.3.4	1077	0x80000002	0x5cb9
10.0.5.6	10.0.4.3	1105	0x80000005	0x6477
10.0.6.7	10.0.6.7	971	0x80000002	0x6d95

4. Pick a single link state advertisement packet captured by ethereal, and describe how to interpret the information contained in the link state advertisement.

Ans:
The Link State Update packet has two sections, the header section and the data section. The header includes LS age, link-state advertisement type, link state ID, advertising router, LS sequence number, LS checksum, and length. In this case, the LS age i is 3600 seconds; the link-state advertisement type is Network-LSA (2); link state ID is 10.0.7.7; advertising router is 10.0.6.7 (10.0.6.7); LS sequence number is 0x80000002; LS checksum is 58a8; and length is 32. The data includes netmask, and 2 attached routers. In this case, netmask is 255.255.255.0 and the attached routers are 10.0.6.7 and 10.0.4.4.

Here is the OSPF message section in the OSPF Link State update packets:
Open Shortest Path First
  OSPF Header
    OSPF Version: 2
    Message Type: LS Update (4)
    Packet Length: 60
    Source OSPF Router: 10.0.1.2 (10.0.1.2)
    Area ID: 0.0.0.1
    Packet Checksum: 0xcbc4 [correct]
    Auth Type: Null
    Auth Data (none)
  LS Update Packet
    Number of LSAs: 1
    LS Type: Network-LSA
      LS Age: 3600 seconds
      Options: 0x02 (E)
        0... .... = DN: DN-bit is NOT set
        .0.. .... = O: O-bit is NOT set
        ..0. .... = DC: Demand circuits are NOT supported

...0 .... = L: The packet does NOT contain LLS data block
.... 0... = NP: Nssa is NOT supported
.... .0.. = MC: NOT multicast capable
.... ..1. = E: ExternalRoutingCapability
Link-State Advertisement Type: Network-LSA (2)
Link State ID: 10.0.7.7
Advertising Router: 10.0.6.7 (10.0.6.7)
LS Sequence Number: 0x80000002
LS Checksum: 58a8
Length: 32
Netmask: 255.255.255.0
Attached Router: 10.0.6.7
Attached Router: 10.0.4.4

5. Answer the questions from Step 5 and 9.

a. How quickly are OSPF messages sent after the cable is disconnected?
Ans: OSPF sends out hello messages around every 10 seconds before disconnecting the cable. After disconnecting the cable, instead of hello message, OSPF starts to send out LS update messages every three seconds to require the new routing information.

b. How many OSPF messages are sent?
Ans: 15 OSPF messages in total are sent during the two continuous series of OSPF hello messages session. There are a total number of 10 hello OSPF messages are sent since after disconnecting the cable , OSPF stops sending hello messages. Hence the number of hello messages can be determined. The rest 5 OSPF messages are 3 Link State Update messages and 2 Link State Acknowledge message.

c. Which type of OSPF packet is used for flooding link state information?
Ans:
Link State Update message is used for flooding link state information.

d. Describe the flooding of LSAs to all routers.
Ans:
Flooding method performs somewhat similar to recursive broadcast. It copies the packet received before , and send it to all neighbours. Then repeat the same action on the neighbour until all live stations receives the packet. Specifically , in flooding of LSAs , if one router is changed, then firstly it will update its own database , then send LS update message to its neighbours routers. After receiving the LS update message, the neighbour router will update its database according to the message then send LS acknowledge message back to the mother router. This process will be operated until all live nodes are synchronized.

e. Which type of encapsulation is used for OSPF packets (TCP, UDP, or other)?

Ans:

OSPF forms IP datagrams directly, packaging them using protocol number 89 for the IP Protocol field in the IP header.

f. What is the destination address of OSPF packets?

Ans:
The destination is 224.0.0.5.

Output segments:

No.	Time	Source	Destination	Protocol	Info
1	0.000000	10.0.1.1	**224.0.0.5**	OSPF	Hello Packet
No.	Time	Source	Destination	Protocol	Info
266	177.196960	10.0.1.2	**224.0.0.5**	OSPF	LS Update
No.	Time	Source	Destination	Protocol	Info
269	177.832555	10.0.1.1	**224.0.0.5**	OSPF	LS Acknowledge

g.Can you confirm that the link state databases are identical? Compare the output of the command show ip ospf database from the Cisco routers and the Linux PCs.

Ans:
All of the OSPF databases are identical due to flooding. Here is the output of OSPF database in all routers and PCs, which proves the answer:

ospfd# show ip ospf database

OSPF Router with ID (10.0.1.1)

Router Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
10.0.1.1	10.0.1.1	208	0x80000028	0x12a9	2
10.0.1.2	10.0.1.2	1394	0x80000004	0x13c1	2
10.0.3.2	10.0.3.2	98	0x8000000a	0xab09	2
10.0.3.3	10.0.3.3	30	0x80000004	0x2995	2
10.0.3.4	10.0.3.4	221	0x80000006	0x0bb8	2
10.0.4.3	10.0.4.3	528	0x80000009	0x7a27	2
10.0.4.4	10.0.4.4	691	0x8000000c	0x4097	1
10.0.6.7	10.0.6.7	661	0x80000005	0x7f3f	2

Net Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum
10.0.1.1	10.0.1.1	1437	0x80000002	0x71b6
10.0.2.5	10.0.3.2	99	0x80000002	0x5e8b
10.0.3.4	10.0.3.4	221	0x80000002	0x799c
10.0.4.4	10.0.3.4	1276	0x80000002	0x5cb9

```
10.0.5.6        10.0.4.3        1306 0x80000005 0x6477
10.0.6.7        10.0.6.7        1173 0x80000002 0x6d95

ospfd# show ip ospf database

       OSPF Router with ID (10.0.1.2)

                Router Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.0.1.1        10.0.1.1          9 0x80000028 0x12a9 2
10.0.1.2        10.0.1.2       1193 0x80000004 0x13c1 2
10.0.3.2        10.0.3.2       1813 0x80000009 0xad08 2
10.0.3.3        10.0.3.3       1814 0x80000003 0x2b94 2
10.0.3.4        10.0.3.4         22 0x80000006 0x0bb8 2
10.0.4.3        10.0.4.3        327 0x80000009 0x7a27 2
10.0.4.4        10.0.4.4        490 0x8000000c 0x4097 1
10.0.6.7        10.0.6.7        459 0x80000005 0x7f3f 2

                Net Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum
10.0.1.1        10.0.1.1       1238 0x80000002 0x71b6
10.0.2.5        10.0.3.2       1813 0x80000001 0x608a
10.0.3.4        10.0.3.4         22 0x80000002 0x799c
10.0.4.4        10.0.3.4       1077 0x80000002 0x5cb9
10.0.5.6        10.0.4.3       1105 0x80000005 0x6477
10.0.6.7        10.0.6.7        971 0x80000002 0x6d95

ospfd# show ip ospf database

       OSPF Router with ID (10.0.3.4)

                Router Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.0.1.1        10.0.1.1       1539 0x80000027 0x14a8 2
10.0.1.2        10.0.1.2        925 0x80000004 0x13c1 2
10.0.3.2        10.0.3.2       1541 0x80000009 0xad08 2
10.0.3.3        10.0.3.3       1543 0x80000003 0x2b94 2
10.0.3.4        10.0.3.4       1549 0x80000005 0x0db7 2
10.0.4.3        10.0.4.3         59 0x80000009 0x7a27 2
10.0.4.4        10.0.4.4        223 0x8000000c 0x4097 1
10.0.6.7        10.0.6.7        192 0x80000005 0x7f3f 2

                Net Link States (Area 0.0.0.1)
```

```
Link ID         ADV Router      Age  Seq#       CkSum
10.0.1.1        10.0.1.1        968 0x80000002 0x71b6
10.0.2.5        10.0.3.2       1541 0x80000001 0x608a
10.0.3.4        10.0.3.4       1549 0x80000001 0x7b9b
10.0.4.4        10.0.3.4        803 0x80000002 0x5cb9
10.0.5.6        10.0.4.3        837 0x80000005 0x6477
10.0.6.7        10.0.6.7        704 0x80000002 0x6d95

ospfd# show ip ospf database

       OSPF Router with ID (10.0.6.7)

                Router Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
10.0.1.1        10.0.1.1       1681 0x80000027 0x14a8 2
10.0.1.2        10.0.1.2       1065 0x80000004 0x13c1 2
10.0.3.2        10.0.3.2       1686 0x80000009 0xad08 2
10.0.3.3        10.0.3.3       1686 0x80000003 0x2b94 2
10.0.3.4        10.0.3.4       1695 0x80000005 0x0db7 2
10.0.4.3        10.0.4.3        197 0x80000009 0x7a27 2
10.0.4.4        10.0.4.4        362 0x8000000c 0x4097 1
10.0.6.7        10.0.6.7        328 0x80000005 0x7f3f 2

                Net Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum
10.0.1.1        10.0.1.1       1110 0x80000002 0x71b6
10.0.2.5        10.0.3.2       1686 0x80000001 0x608a
10.0.3.4        10.0.3.4       1695 0x80000001 0x7b9b
10.0.4.4        10.0.3.4        949 0x80000002 0x5cb9
10.0.5.6        10.0.4.3        976 0x80000005 0x6477
10.0.6.7        10.0.6.7        840 0x80000002 0x6d95

Router1#show ip ospf database

            OSPF Router with ID (10.0.3.3) (Process ID 1)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.0.1.1        10.0.1.1        287         0x80000028 0x0012A9 2
10.0.1.2        10.0.1.2        1472         0x80000004 0x0013C1 2
10.0.3.2        10.0.3.2        176         0x8000000A 0x00AB09 2
10.0.3.3        10.0.3.3        106         0x80000004 0x002995 2
```

10.0.3.4 10.0.3.4 298 0x80000006 0x000BB8 2
10.0.4.3 10.0.4.3 607 0x80000009 0x007A27 2
10.0.4.4 10.0.4.4 770 0x8000000C 0x004097 1
10.0.6.7 10.0.6.7 739 0x80000005 0x007F3F 2

Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum
10.0.1.1 10.0.1.1 1516 0x80000002 0x0071B6
10.0.2.5 10.0.3.2 176 0x80000002 0x005E8B
10.0.3.4 10.0.3.4 298 0x80000002 0x00799C
10.0.4.4 10.0.3.4 1352 0x80000002 0x005CB9
10.0.5.6 10.0.4.3 1386 0x80000005 0x006477
10.0.6.7 10.0.6.7 1252 0x80000002 0x006D95

Router2#show ip ospf database

OSPF Router with ID (10.0.3.2) (Process ID 1)

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count
10.0.1.1 10.0.1.1 25 0x80000028 0x0012A9 2
10.0.1.2 10.0.1.2 1211 0x80000004 0x0013C1 2
10.0.3.2 10.0.3.2 1828 0x80000009 0x00AD08 2
10.0.3.3 10.0.3.3 1830 0x80000003 0x002B94 2
10.0.3.4 10.0.3.4 37 0x80000006 0x000BB8 2
10.0.4.3 10.0.4.3 345 0x80000009 0x007A27 2
10.0.4.4 10.0.4.4 509 0x8000000C 0x004097 1
10.0.6.7 10.0.6.7 478 0x80000005 0x007F3F 2

Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum
10.0.1.1 10.0.1.1 1254 0x80000002 0x0071B6
10.0.2.5 10.0.3.2 1828 0x80000001 0x00608A
10.0.3.4 10.0.3.4 37 0x80000002 0x00799C
10.0.4.4 10.0.3.4 1091 0x80000002 0x005CB9
10.0.5.6 10.0.4.3 1125 0x80000005 0x006477
10.0.6.7 10.0.6.7 991 0x80000002 0x006D95

Router3#show ip ospf database

OSPF Router with ID (10.0.4.3) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
10.0.1.1	10.0.1.1	1512	0x80000027	0x0014A8	2
10.0.1.2	10.0.1.2	896	0x80000004	0x0013C1	2
10.0.3.2	10.0.3.2	1516	0x80000009	0x00AD08	2
10.0.3.3	10.0.3.3	1517	0x80000003	0x002B94	2
10.0.3.4	10.0.3.4	1525	0x80000005	0x000DB7	2
10.0.4.3	10.0.4.3	28	0x80000009	0x007A27	2
10.0.4.4	10.0.4.4	192	0x8000000C	0x004097	1
10.0.6.7	10.0.6.7	160	0x80000005	0x007F3F	2

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
10.0.1.1	10.0.1.1	941	0x80000002	0x0071B6
10.0.2.5	10.0.3.2	1516	0x80000001	0x00608A
10.0.3.4	10.0.3.4	1525	0x80000001	0x007B9B
10.0.4.4	10.0.3.4	780	0x80000002	0x005CB9
10.0.5.6	10.0.4.3	807	0x80000005	0x006477
10.0.6.7	10.0.6.7	674	0x80000002	0x006D95

Router4#show ip ospf database

OSPF Router with ID (10.0.4.4) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
10.0.1.1	10.0.1.1	1702	0x80000027	0x0014A8	2
10.0.1.2	10.0.1.2	1086	0x80000004	0x0013C1	2
10.0.3.2	10.0.3.2	1706	0x80000009	0x00AD08	2
10.0.3.3	10.0.3.3	1707	0x80000003	0x002B94	2
10.0.3.4	10.0.3.4	1715	0x80000005	0x000DB7	2
10.0.4.3	10.0.4.3	219	0x80000009	0x007A27	2
10.0.4.4	10.0.4.4	381	0x8000000C	0x004097	1
10.0.6.7	10.0.6.7	351	0x80000005	0x007F3F	2

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
10.0.1.1	10.0.1.1	1131	0x80000002	0x0071B6
10.0.2.5	10.0.3.2	1706	0x80000001	0x00608A
10.0.3.4	10.0.3.4	1715	0x80000001	0x007B9B
10.0.4.4	10.0.3.4	969	0x80000002	0x005CB9
10.0.5.6	10.0.4.3	999	0x80000005	0x006477
10.0.6.7	10.0.6.7	863	0x80000002	0x006D95