计算机网络实验报告

实验五

动态路由协议 RIP，OSPF 和 BGP

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1. 实验目的：

理解自制系统（AS），观察 RIP，OSPF 以及 BGP 动态路由协议的实际运行过程。在网络拓扑结构变更的情况下观察路由表的动态变更，通过实验理解路由选择算法。具体分四个目标进行本实验：

1. 观察 rip 协议运行
2. 观察 ospf 协议运行
3. 观察 bgp 协议运行
4. 观察网络拓扑变化情况下 rip 协议的路由选择

2. 实验环境：

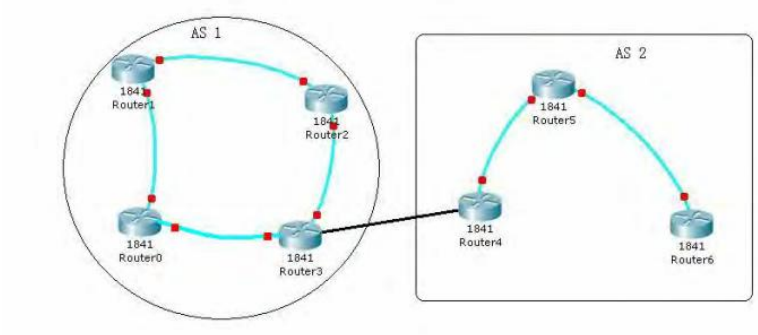
ubuntu-12.04（机房环境）

3. 网络拓扑配置：

ip 分配表：

节点名	虚拟设备名	IP	子网掩码
Router0	Router0	Eth0 192.168.0.2	255.255.255.0
		Eth1 192.168.1.1	255.255.255.0
Router1	Router1	Eth0 192.168.1.2	255.255.255.0
		Eth1 192.168.2.1	255.255.255.0
Router2	Router2	Eth0 192.168.2.2	255.255.255.0
		Eth1 192.168.3.1	255.255.255.0
Router3	Router3	Eth0 192.168.3.2	255.255.255.0
		Eth1 192.168.0.1	255.255.255.0
		Eth2 192.168.4.1	255.255.0.0
Router4	Router4	Eth0 192.168.8.1	255.255.0.0
		Eth1 192.168.9.1	255.255.255.0
Router5	Router5	Eth0 192.168.9.2	255.255.255.0
		Eth1 192.168.10.1	255.255.255.0
Router6	Router6	Eth0 192.168.10.2	255.255.255.0

网络拓扑（最终状态）：



4. 路由配置文件：

首先为所有网卡配置 ip 地址（安装 quagga 过程省略）：

ifconfig ethx a.b.c.d/m

然后打开转发控制：

echo 1 > /proc/sys/net/ipv4/ip_forward

分别在 router0-router3 四台虚拟机上配置 rip 协议：
其中各个路由器上协议配置文件参见附件（configuration/routerX/zebra.conf 和 ripd.conf）

然后分别在 router4-router6 三台虚拟机上配置 ospf 协议：
其中各个路由器上协议配置文件参见附件（configuration/routerX/zebra.conf 和 ospfd.conf）

然后分别在 router3 和 router4 上配置 bgp 协议，我选 router3 所在的 AS 系统号为 100，router4 所在的 AS 系统号为 101：
其中各个路由器上协议配置文件参见附件（configuration/routerX/zebra.conf 和 bgpd.conf）

5. 数据包截图（所有截图在 capture 文件夹下）：

1. rip 协议：

我在 router0 的 eth1 网卡上进行抓帧。
rip 协议截图如下：

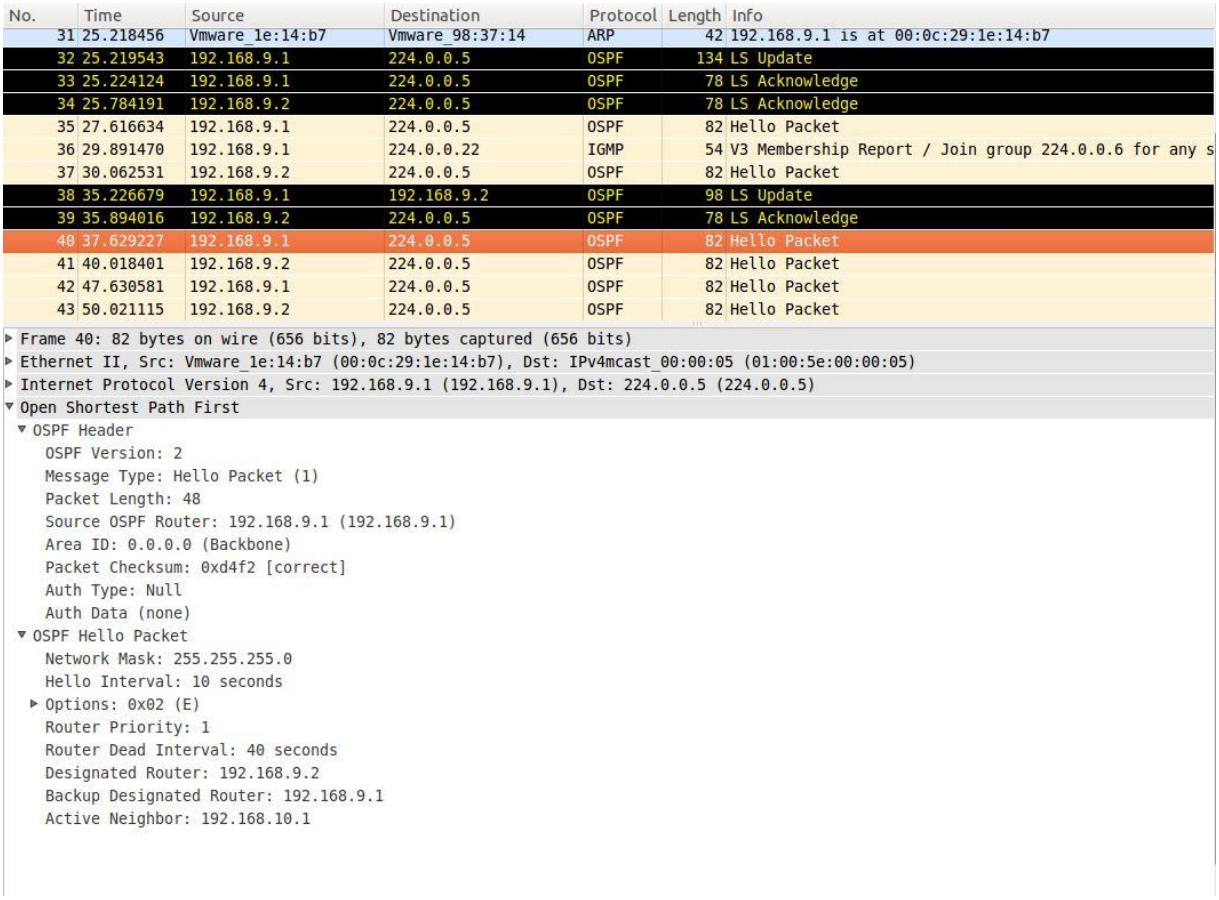
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Leave group 224.0.0.9
2	0.209104	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Leave group 224.0.0.9
3	4.307487	192.168.1.1	224.0.0.9	RIPv2	66	Request
4	4.308019	192.168.1.2	192.168.1.1	RIPv2	86	Response
5	4.313797	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.9 for any s
6	4.894946	192.168.1.1	224.0.0.9	RIPv2	86	Response
7	9.324580	Vmware_92:3e:1d	Vmware_1b:59:ed	ARP	60	Who has 192.168.1.1? Tell 192.168.1.2
8	9.324633	Vmware_1b:59:ed	Vmware_92:3e:1d	ARP	42	192.168.1.1 is at 00:0c:29:1b:59:ed
9	9.869781	192.168.1.2	224.0.0.9	RIPv2	86	Response
10	14.169075	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.9 for any s
11	31.914362	192.168.1.1	224.0.0.9	RIPv2	86	Response
12	46.884824	192.168.1.2	224.0.0.9	RIPv2	86	Response
13	63.934732	192.168.1.1	224.0.0.9	RIPv2	86	Response

```
▸ Frame 9: 86 bytes on wire (688 bits), 86 bytes captured (688 bits)
▸ Ethernet II, Src: Vmware_92:3e:1d (00:0c:29:92:3e:1d), Dst: IPv4mcast_00:00:09 (01:00:5e:00:00:09)
▸ Internet Protocol Version 4, Src: 192.168.1.2 (192.168.1.2), Dst: 224.0.0.9 (224.0.0.9)
▸ User Datagram Protocol, Src Port: router (520), Dst Port: router (520)
▾ Routing Information Protocol
    Command: Response (2)
    Version: RIPv2 (2)
  ▾ IP Address: 192.168.2.0, Metric: 1
      Address Family: IP (2)
      Route Tag: 0
      IP Address: 192.168.2.0 (192.168.2.0)
      Netmask: 255.255.255.0 (255.255.255.0)
      Next Hop: 0.0.0.0 (0.0.0.0)
      Metric: 1
  ▾ IP Address: 192.168.3.0, Metric: 2
      Address Family: IP (2)
      Route Tag: 0
      IP Address: 192.168.3.0 (192.168.3.0)
      Netmask: 255.255.255.0 (255.255.255.0)
      Next Hop: 0.0.0.0 (0.0.0.0)
      Metric: 2
```

2. ospf 协议：

我在 router4 的 eth1 网卡上进行抓帧：

ospf 协议截图如下：



No.	Time	Source	Destination	Protocol	Length	Info
31	25.218456	Vmware_1e:14:b7	Vmware_98:37:14	ARP	42	192.168.9.1 is at 00:0c:29:1e:14:b7
32	25.219543	192.168.9.1	224.0.0.5	OSPF	134	LS Update
33	25.224124	192.168.9.1	224.0.0.5	OSPF	78	LS Acknowledge
34	25.784191	192.168.9.2	224.0.0.5	OSPF	78	LS Acknowledge
35	27.616634	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
36	29.891470	192.168.9.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.6 for any s
37	30.062531	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet
38	35.226679	192.168.9.1	192.168.9.2	OSPF	98	LS Update
39	35.894016	192.168.9.2	224.0.0.5	OSPF	78	LS Acknowledge
40	37.629227	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
41	40.018401	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet
42	47.630581	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
43	50.021115	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet

3. bgp 协议：

我在 router3 的 eth2 网卡上进行抓帧：

bgp 协议截图如下：

No.	Time	Source	Destination	Protocol	Length	Info
45	257.757511	Vmware_1e:14:ad	Broadcast	ARP	60	Who has 192.168.4.1? Tell 192.168.8.1
46	257.757535	Vmware_19:44:f4	Vmware_1e:14:ad	ARP	42	192.168.4.1 is at 00:0c:29:19:44:f4
47	257.757764	192.168.8.1	192.168.4.1	TCP	74	56898 > bgp [SYN] Seq=0 Win=14600 Len=0 MSS=1460 SACK
48	257.757787	192.168.4.1	192.168.8.1	TCP	74	bgp > 56898 [SYN, ACK] Seq=0 Ack=1 Win=14480 Len=0 MS
49	257.758137	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=1 Ack=1 Win=14600 Len=0 TSval=1
50	257.758547	192.168.8.1	192.168.4.1	BGP	119	OPEN Message
51	257.758554	192.168.4.1	192.168.8.1	TCP	66	bgp > 56898 [ACK] Seq=1 Ack=54 Win=14480 Len=0 TSval=
52	257.758952	192.168.4.1	192.168.8.1	BGP	138	OPEN Message, KEEPALIVE Message
53	257.759266	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=54 Ack=73 Win=14600 Len=0 TSval
54	257.759553	192.168.8.1	192.168.4.1	BGP	104	KEEPALIVE Message, KEEPALIVE Message
55	257.762308	192.168.4.1	192.168.8.1	BGP	85	KEEPALIVE Message
56	257.803888	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=92 Ack=92 Win=14600 Len=0 TSval
57	258.771943	192.168.8.1	192.168.4.1	BGP	121	UPDATE Message

```
▸ Frame 50: 119 bytes on wire (952 bits), 119 bytes captured (952 bits)
▸ Ethernet II, Src: Vmware_1e:14:ad (00:0c:29:1e:14:ad), Dst: Vmware_19:44:f4 (00:0c:29:19:44:f4)
▸ Internet Protocol Version 4, Src: 192.168.8.1 (192.168.8.1), Dst: 192.168.4.1 (192.168.4.1)
▸ Transmission Control Protocol, Src Port: 56898 (56898), Dst Port: bgp (179), Seq: 1, Ack: 1, Len: 53
▾ Border Gateway Protocol
  ▾ OPEN Message
      Marker: 16 bytes
      Length: 53 bytes
      Type: OPEN Message (1)
      Version: 4
      My AS: 101
      Hold time: 180
      BGP identifier: 192.168.8.1
      Optional parameters length: 24 bytes
    ▾ Optional parameters
      ▸ Capabilities Advertisement (8 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (8 bytes)
```

（open message）

No.	Time	Source	Destination	Protocol	Length	Info
45	257.757511	Vmware_1e:14:ad	Broadcast	ARP	60	Who has 192.168.4.1? Tell 192.168.8.1
46	257.757535	Vmware_19:44:f4	Vmware_1e:14:ad	ARP	42	192.168.4.1 is at 00:0c:29:19:44:f4
47	257.757764	192.168.8.1	192.168.4.1	TCP	74	56898 > bgp [SYN] Seq=0 Win=14600 Len=0 MSS=1460 SACK
48	257.757787	192.168.4.1	192.168.8.1	TCP	74	bgp > 56898 [SYN, ACK] Seq=0 Ack=1 Win=14480 Len=0 MS
49	257.758137	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=1 Ack=1 Win=14600 Len=0 TSval=1
50	257.758547	192.168.8.1	192.168.4.1	BGP	119	OPEN Message
51	257.758554	192.168.4.1	192.168.8.1	TCP	66	bgp > 56898 [ACK] Seq=1 Ack=54 Win=14480 Len=0 TSval=
52	257.758952	192.168.4.1	192.168.8.1	BGP	138	OPEN Message, KEEPALIVE Message
53	257.759266	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=54 Ack=73 Win=14600 Len=0 TSval
54	257.759553	192.168.8.1	192.168.4.1	BGP	104	KEEPALIVE Message, KEEPALIVE Message
55	257.762308	192.168.4.1	192.168.8.1	BGP	85	KEEPALIVE Message
56	257.803888	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=92 Ack=92 Win=14600 Len=0 TSval
57	258.771943	192.168.8.1	192.168.4.1	BGP	121	UPDATE Message

```
▸ Frame 52: 138 bytes on wire (1104 bits), 138 bytes captured (1104 bits)
▸ Ethernet II, Src: Vmware_19:44:f4 (00:0c:29:19:44:f4), Dst: Vmware_1e:14:ad (00:0c:29:1e:14:ad)
▸ Internet Protocol Version 4, Src: 192.168.4.1 (192.168.4.1), Dst: 192.168.8.1 (192.168.8.1)
▸ Transmission Control Protocol, Src Port: bgp (179), Dst Port: 56898 (56898), Seq: 1, Ack: 54, Len: 72
▾ Border Gateway Protocol
  ▾ OPEN Message
      Marker: 16 bytes
      Length: 53 bytes
      Type: OPEN Message (1)
      Version: 4
      My AS: 100
      Hold time: 180
      BGP identifier: 192.168.4.1
      Optional parameters length: 24 bytes
    ▾ Optional parameters
      ▸ Capabilities Advertisement (8 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (8 bytes)
▾ Border Gateway Protocol
  ▾ KEEPALIVE Message
      Marker: 16 bytes
      Length: 19 bytes
      Type: KEEPALIVE Message (4)
```

（keep message）

6. 协议报文分析：

1. rip 协议报文分析：

首先进行 rip 报文的分析：

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Leave group 224.0.0.9
2	0.209104	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Leave group 224.0.0.9
3	4.307487	192.168.1.1	224.0.0.9	RIPv2	66	Request
4	4.308019	192.168.1.2	192.168.1.1	RIPv2	86	Response
5	4.313797	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.9 for any s
6	4.894946	192.168.1.1	224.0.0.9	RIPv2	86	Response
7	9.324580	Vmware_92:3e:1d	Vmware_1b:59:ed	ARP	60	Who has 192.168.1.1? Tell 192.168.1.2
8	9.324633	Vmware_1b:59:ed	Vmware_92:3e:1d	ARP	42	192.168.1.1 is at 00:0c:29:1b:59:ed
9	9.869781	192.168.1.2	224.0.0.9	RIPv2	86	Response
10	14.169075	192.168.1.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.9 for any s
11	31.914362	192.168.1.1	224.0.0.9	RIPv2	86	Response
12	46.884824	192.168.1.2	224.0.0.9	RIPv2	86	Response
13	63.934732	192.168.1.1	224.0.0.9	RIPv2	86	Response

```
▸ Frame 9: 86 bytes on wire (688 bits), 86 bytes captured (688 bits)
▸ Ethernet II, Src: Vmware_92:3e:1d (00:0c:29:92:3e:1d), Dst: IPv4mcast_00:00:09 (01:00:5e:00:00:09)
▸ Internet Protocol Version 4, Src: 192.168.1.2 (192.168.1.2), Dst: 224.0.0.9 (224.0.0.9)
▸ User Datagram Protocol, Src Port: router (520), Dst Port: router (520)
▾ Routing Information Protocol
    Command: Response (2)
    Version: RIPv2 (2)
  ▾ IP Address: 192.168.2.0, Metric: 1
      Address Family: IP (2)
      Route Tag: 0
      IP Address: 192.168.2.0 (192.168.2.0)
      Netmask: 255.255.255.0 (255.255.255.0)
      Next Hop: 0.0.0.0 (0.0.0.0)
      Metric: 1
  ▾ IP Address: 192.168.3.0, Metric: 2
      Address Family: IP (2)
      Route Tag: 0
      IP Address: 192.168.3.0 (192.168.3.0)
      Netmask: 255.255.255.0 (255.255.255.0)
      Next Hop: 0.0.0.0 (0.0.0.0)
      Metric: 2
```

如图，在执行了第一帧 request 之后，第二帧受到了来自 router1 的 response。协议类型为 RIPv2：

command：respnse（2）

version：RIPv2（2）

然后是从 router1 上返回的路由信息：可以看到 router1 总共有两条路由路径，这两条分别是：

IP：192.168.2.0　Metric：1

IP：192.168.3.0　Metric：2

两条路径打开后可以看到每一条路径的网络 ip 和网络掩码等信息：

```
▼ IP Address: 192.168.2.0, Metric: 1
    Address Family: IP (2)
    Route Tag: 0
    IP Address: 192.168.2.0 (192.168.2.0)
    Netmask: 255.255.255.0 (255.255.255.0)
    Next Hop: 0.0.0.0 (0.0.0.0)
    Metric: 1
▼ IP Address: 192.168.3.0, Metric: 2
    Address Family: IP (2)
    Route Tag: 0
    IP Address: 192.168.3.0 (192.168.3.0)
    Netmask: 255.255.255.0 (255.255.255.0)
    Next Hop: 0.0.0.0 (0.0.0.0)
    Metric: 2
```

2. ospf 协议报文分析：

然后进行 ospf 报文的分析：

No.	Time	Source	Destination	Protocol	Length	Info
31	25.218456	Vmware_1e:14:b7	Vmware_98:37:14	ARP	42	192.168.9.1 is at 00:0c:29:1e:14:b7
32	25.219543	192.168.9.1	224.0.0.5	OSPF	134	LS Update
33	25.224124	192.168.9.1	224.0.0.5	OSPF	78	LS Acknowledge
34	25.784191	192.168.9.2	224.0.0.5	OSPF	78	LS Acknowledge
35	27.616634	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
36	29.891470	192.168.9.1	224.0.0.22	IGMP	54	V3 Membership Report / Join group 224.0.0.6 for any s
37	30.062531	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet
38	35.226679	192.168.9.1	192.168.9.2	OSPF	98	LS Update
39	35.894016	192.168.9.2	224.0.0.5	OSPF	78	LS Acknowledge
40	37.629227	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
41	40.018401	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet
42	47.630581	192.168.9.1	224.0.0.5	OSPF	82	Hello Packet
43	50.021115	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet

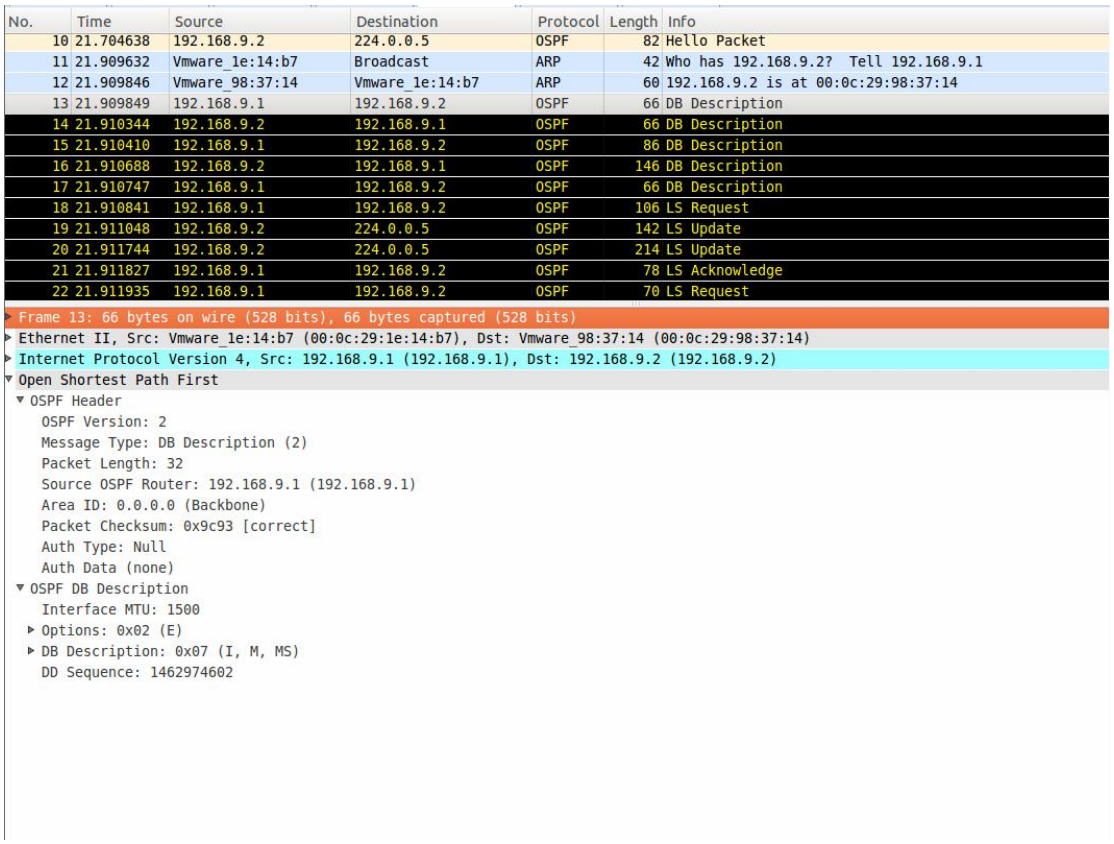
```
▸ Frame 40: 82 bytes on wire (656 bits), 82 bytes captured (656 bits)
▸ Ethernet II, Src: Vmware_1e:14:b7 (00:0c:29:1e:14:b7), Dst: IPv4mcast_00:00:05 (01:00:5e:00:00:05)
▸ Internet Protocol Version 4, Src: 192.168.9.1 (192.168.9.1), Dst: 224.0.0.5 (224.0.0.5)
▾ Open Shortest Path First
  ▾ OSPF Header
      OSPF Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 48
      Source OSPF Router: 192.168.9.1 (192.168.9.1)
      Area ID: 0.0.0.0 (Backbone)
      Packet Checksum: 0xd4f2 [correct]
      Auth Type: Null
      Auth Data (none)
  ▾ OSPF Hello Packet
      Network Mask: 255.255.255.0
      Hello Interval: 10 seconds
    ▸ Options: 0x02 (E)
      Router Priority: 1
      Router Dead Interval: 40 seconds
      Designated Router: 192.168.9.2
      Backup Designated Router: 192.168.9.1
      Active Neighbor: 192.168.10.1
```

如图，看 NO.40 号帧，可以看到这是一个 hello 帧。

其源 IP 为：192.168.9.1 这是 router4 的地址，然后目标地址是 192.168.9.2，这是 router5 的地址。

并且给出了该帧的长度和头部校验和等信息。

在交换了 hello 信息后，开始进行路由信息交换：



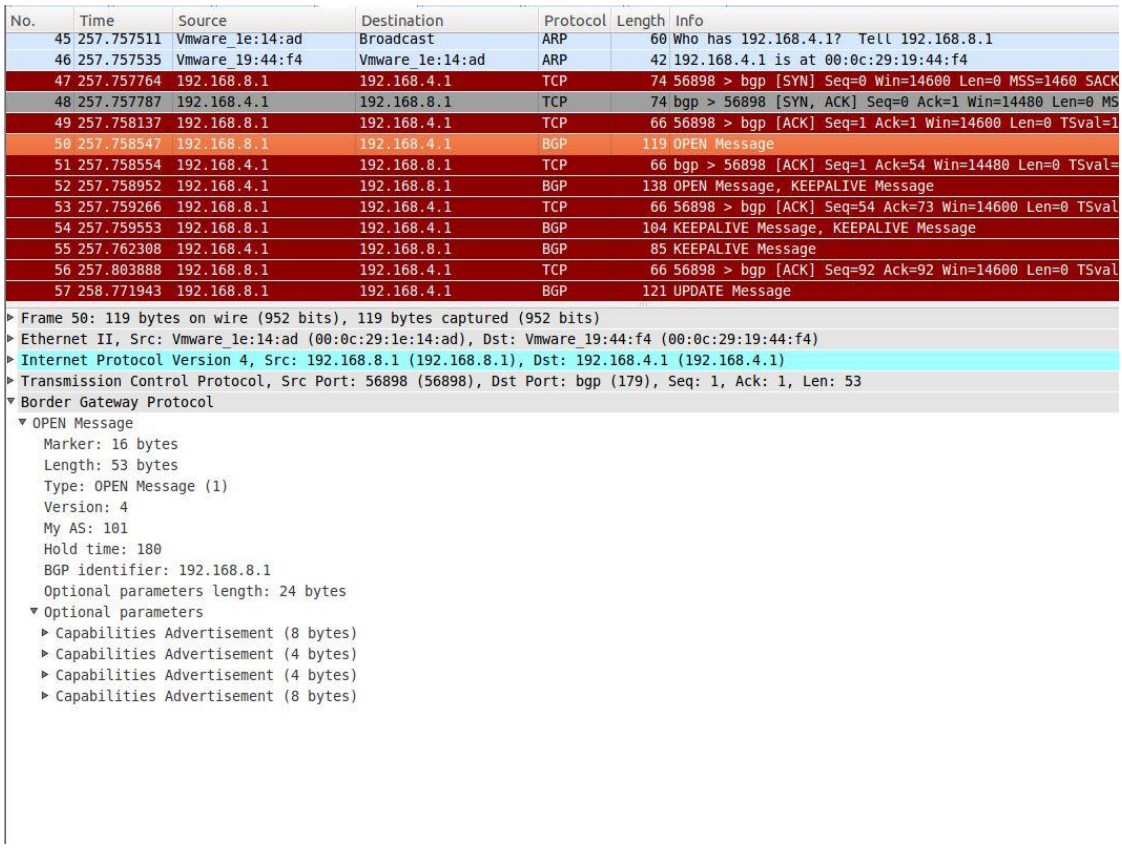
No.	Time	Source	Destination	Protocol	Length	Info
10	21.704638	192.168.9.2	224.0.0.5	OSPF	82	Hello Packet
11	21.909632	Vmware_1e:14:b7	Broadcast	ARP	42	Who has 192.168.9.2? Tell 192.168.9.1
12	21.909846	Vmware_98:37:14	Vmware_1e:14:b7	ARP	60	192.168.9.2 is at 00:0c:29:98:37:14
13	21.909849	192.168.9.1	192.168.9.2	OSPF	66	DB Description
14	21.910344	192.168.9.2	192.168.9.1	OSPF	66	DB Description
15	21.910410	192.168.9.1	192.168.9.2	OSPF	86	DB Description
16	21.910688	192.168.9.2	192.168.9.1	OSPF	146	DB Description
17	21.910747	192.168.9.1	192.168.9.2	OSPF	66	DB Description
18	21.910841	192.168.9.1	192.168.9.2	OSPF	106	LS Request
19	21.911048	192.168.9.2	224.0.0.5	OSPF	142	LS Update
20	21.911744	192.168.9.2	224.0.0.5	OSPF	214	LS Update
21	21.911827	192.168.9.1	192.168.9.2	OSPF	78	LS Acknowledge
22	21.911935	192.168.9.1	192.168.9.2	OSPF	70	LS Request

```
▸ Frame 13: 66 bytes on wire (528 bits), 66 bytes captured (528 bits)
▸ Ethernet II, Src: Vmware_1e:14:b7 (00:0c:29:1e:14:b7), Dst: Vmware_98:37:14 (00:0c:29:98:37:14)
▸ Internet Protocol Version 4, Src: 192.168.9.1 (192.168.9.1), Dst: 192.168.9.2 (192.168.9.2)
▾ Open Shortest Path First
  ▾ OSPF Header
      OSPF Version: 2
      Message Type: DB Description (2)
      Packet Length: 32
      Source OSPF Router: 192.168.9.1 (192.168.9.1)
      Area ID: 0.0.0.0 (Backbone)
      Packet Checksum: 0x9c93 [correct]
      Auth Type: Null
      Auth Data (none)
  ▾ OSPF DB Description
      Interface MTU: 1500
    ▸ Options: 0x02 (E)
    ▸ DB Description: 0x07 (I, M, MS)
      DD Sequence: 1462974602
```

其中 DB description 就是路由信息的描述。

3. bgp 协议报文分析：

最后进行 bgp 报文的分析：

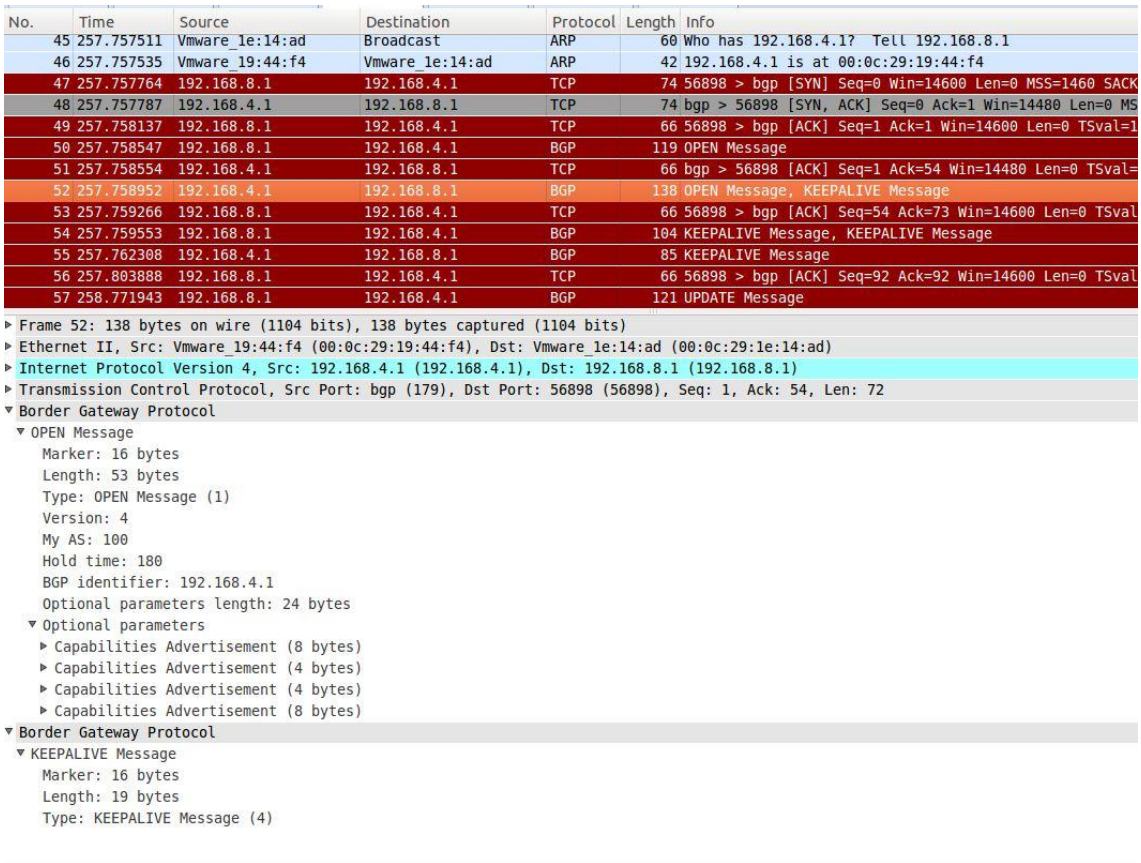


No.	Time	Source	Destination	Protocol	Length	Info
45	257.757511	Vmware_1e:14:ad	Broadcast	ARP	60	Who has 192.168.4.1? Tell 192.168.8.1
46	257.757535	Vmware_19:44:f4	Vmware_1e:14:ad	ARP	42	192.168.4.1 is at 00:0c:29:19:44:f4
47	257.757764	192.168.8.1	192.168.4.1	TCP	74	56898 > bgp [SYN] Seq=0 Win=14600 Len=0 MSS=1460 SACK
48	257.757787	192.168.4.1	192.168.8.1	TCP	74	bgp > 56898 [SYN, ACK] Seq=0 Ack=1 Win=14480 Len=0 MS
49	257.758137	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=1 Ack=1 Win=14600 Len=0 TSval=1
50	257.758547	192.168.8.1	192.168.4.1	BGP	119	OPEN Message
51	257.758554	192.168.4.1	192.168.8.1	TCP	66	bgp > 56898 [ACK] Seq=1 Ack=54 Win=14480 Len=0 TSval=
52	257.758952	192.168.4.1	192.168.8.1	BGP	138	OPEN Message, KEEPALIVE Message
53	257.759266	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=54 Ack=73 Win=14600 Len=0 TSval
54	257.759553	192.168.8.1	192.168.4.1	BGP	104	KEEPALIVE Message, KEEPALIVE Message
55	257.762308	192.168.4.1	192.168.8.1	BGP	85	KEEPALIVE Message
56	257.803888	192.168.8.1	192.168.4.1	TCP	66	56898 > bgp [ACK] Seq=92 Ack=92 Win=14600 Len=0 TSval
57	258.771943	192.168.8.1	192.168.4.1	BGP	121	UPDATE Message

```
▸ Frame 50: 119 bytes on wire (952 bits), 119 bytes captured (952 bits)
▸ Ethernet II, Src: Vmware_1e:14:ad (00:0c:29:1e:14:ad), Dst: Vmware_19:44:f4 (00:0c:29:19:44:f4)
▸ Internet Protocol Version 4, Src: 192.168.8.1 (192.168.8.1), Dst: 192.168.4.1 (192.168.4.1)
▸ Transmission Control Protocol, Src Port: 56898 (56898), Dst Port: bgp (179), Seq: 1, Ack: 1, Len: 53
▾ Border Gateway Protocol
  ▾ OPEN Message
      Marker: 16 bytes
      Length: 53 bytes
      Type: OPEN Message (1)
      Version: 4
      My AS: 101
      Hold time: 180
      BGP identifier: 192.168.8.1
      Optional parameters length: 24 bytes
    ▾ Optional parameters
      ▸ Capabilities Advertisement (8 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (4 bytes)
      ▸ Capabilities Advertisement (8 bytes)
```

如图，在 NO.50 号帧上，router3 受到了 router4 传来的 open 信息：其中包含了 router4 所在的 AS 的编号：
My AS ： 101
hole time：（保持时间）100
还有 4 个选项参数（optional parameters）

在双方建立了连接之后，可以看到双方每隔一段时间就会通过发送 keepalive 帧来确认对方的连接同时保持更新，其中 keepalive 帧的截图如下：



其中 keepalive 帧保证了两个 AS 之间的实时更新和互通。

7. 动态路由变化：

可以观察，在未加上 router0 和 router3 的直接连接之前路由表信息如下：

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.0.0     192.168.1.2     255.255.255.0   UG    4      0        0 eth1
192.168.1.0     *               255.255.255.0   U     0      0        0 eth1
192.168.2.0     192.168.1.2     255.255.255.0   UG    2      0        0 eth1
192.168.3.0     192.168.1.2     255.255.255.0   UG    3      0        0 eth1
```

输入 tracepath 指令后显示如下：

```
root@ubuntu:/etc/quagga# tracepath 192.168.3.2
 1:  ubuntu.local                                          0.655ms pmtu 1500
 1:  192.168.1.2                                           1.419ms
 1:  192.168.1.2                                           1.232ms
 2:  192.168.2.2                                           3.709ms
 3:  192.168.3.2                                           3.863ms reached
     Resume: pmtu 1500 hops 3 back 62
root@ubuntu:/etc/quagga#
```

可以看到 router0 要经过 router1，router2 的转发，通过 3 跳到达 router3。
然后我添加了 router0 到 router3 的连接，并且将其加入 rip 协议并更新了 rip，可以发现路由表信息如下：

```
root@ubuntu:/etc/quagga# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.0.0     *               255.255.255.0   U     0      0        0 eth0
192.168.1.0     *               255.255.255.0   U     0      0        0 eth1
192.168.2.0     192.168.1.2     255.255.255.0   UG    2      0        0 eth1
192.168.3.0     ubuntu-2.local  255.255.255.0   UG    2      0        0 eth0
root@ubuntu:/etc/quagga#
```

同样输入 tracepath 指令后显示如下：

```
root@ubuntu:/etc/quagga# tracepath 192.168.3.2
 1:  ubuntu.local                                          0.865ms pmtu 1500
 1:  192.168.3.2                                           2.476ms reached
 1:  192.168.3.2                                           1.161ms reached
     Resume: pmtu 1500 hops 1 back 64
root@ubuntu:/etc/quagga#
```

可以看到 router0 此时只通过一跳就可以到达 router3。可以看到 rip 协议更新以及动态路由的变化。