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:

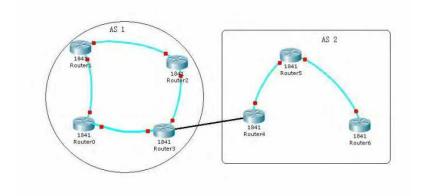
ubuntu-12.04 (机房环境)

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):



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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
	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		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
	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	e 9: 86 bytes	on wire (688 bits),	86 bytes captured (68	88 bits)	
Ethe	rnet II. Src:	Vmware 92:3e:1d (00	:0c:29:92:3e:1d). Dst:	IPv4mcast	00:00:09 (01:00:5e:00:00:09)
			.168.1.2 (192.168.1.2)	_	
			iter (520), Dst Port: i	U.D. and Control of the Control of t	11111
	ing Informati		(525), 551	(525)	
	mand: Respons				
	sion: RIPv2 (
		168.2.0, Metric: 1			
	dress Family:				
	oute Tag: 0	. 11 (2)			
		2.168.2.0 (192.168.2	A)		
		55.255.0 (255.255.25	10.00 (A)		
	ext Hop: 0.0.0		3.07		
	etric: 1	9.0 (0.0.0.0)			
		168.3.0, Metric: 2			
	Idress Family:	STANDARD CONT. THE RESERVE AND SERVE			
	-	(Z)			
	oute Tag: 0	160 2 0 (102 160 2	0)		
		2.168.3.0 (192.168.3			
		55.255.0 (255.255.25	5.0)		
	ext Hop: 0.0.0	0.0 (0.0.0.0)			
Me	etric: 2				

2. ospf 协议:

我在 router4 的 eth1 网卡上进行抓帧: ospf 协议截图如下:

- 11	Time	Source	Destination	Protocol L	
	25.218456	Vmware_1e:14:b7	Vmware_98:37:14	ARP	42 192.168.9.1 is at 00:0c:29:1e:14:b7
	2 25.219543	192.168.9.1	224.0.0.5	OSPF	134 LS Update
	3 25.224124	192.168.9.1	224.0.0.5	OSPF	78 LS Acknowledge
	25.784191	192.168.9.2	224.0.0.5	OSPF	78 LS Acknowledge
	27.616634	192.168.9.1	224.0.0.5	OSPF	82 Hello Packet
	5 29.891470	192.168.9.1	224.0.0.22	IGMP	54 V3 Membership Report / Join group 224.0.0.6 for any
- 15	30.062531	192.168.9.2	224.0.0.5	OSPF	82 Hello Packet
		192.168.9.1	192.168.9.2	OSPF	98 LS Update
-	35.894016	192.168.9.2	224.0.0.5	OSPF	78 LS Acknowledge
8415	37.629227	192.168.9.1	224.0.0.5	OSPF	82 Hello Packet
	40.018401	192.168.9.2	224.0.0.5	0SPF	82 Hello Packet
	47.630581	192.168.9.1	224.0.0.5	OSPF	82 Hello Packet
43	3 50.021115	192.168.9.2	224.0.0.5	OSPF	82 Hello Packet
pen S	Shortest Path Header		2.168.9.1 (192.168.9.1)		
Mes Pac	ket Length:	Hello Packet (1) 48			
Mes Pac Sou Are	sage Type: H ket Length: urce OSPF Rou a ID: 0.0.0.	Hello Packet (1) 48 uter: 192.168.9.1 (1 0 (Backbone) n: 0xd4f2 [correct]	92.168.9.1)		
Mes Pac Sou Are Pac Aut	ssage Type: F ket Length: Irce OSPF Rou ea ID: 0.0.0. ket Checksun	dello Packet (1) 48 der: 192.168.9.1 (1 0 (Backbone) n: 0xd4f2 [correct]	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut	sage Type: F ket Length: Irce OSPF Rou a ID: 0.0.0. ket Checksun h Type: Null	dello Packet (1) 48 uter: 192.168.9.1 (1 0 (Backbone) 0: 0xd4f2 [correct]	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF	sage Type: h ket Length: drce OSPF Rou a ID: 0.0.0. ket Checksum h Type: Null h Data (none Hello Packe	dello Packet (1) 48 uter: 192.168.9.1 (1 0 (Backbone) 0: 0xd4f2 [correct]	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net	sage Type: h ket Length: drce OSPF Rou a ID: 0.0.0. ket Checksum h Type: Null h Data (none Hello Packe	dello Packet (1) 48 iter: 192.168.9.1 (1 0 (Backbone) i: 0xd4f2 [correct] :) t	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel	sage Type: h ket Length: arce OSPF Rou a ID: 0.0.0. ket Checksum h Type: Null h Data (none Hello Packe work Mask: 2	dello Packet (1) 48 iter: 192.168.9.1 (1 0 (Backbone) 1: 0xd4f2 [correct] 2: 1: 0xd4f2 [correct] 1: 0xd4f2 [correct] 1: 0xd4f2 [correct]	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel	sage Type: he ket Length: lece OSPF Rouse ID: 0.0.0. ket Checksum th Type: Null hotal Packe Hello Packe work Mask: 2 lo Interval:	tello Packet (1) 48 vter: 192.168.9.1 (1 0 (Backbone) 1: 0xd4f2 [correct] 2: t t:555.255.255.0 10 seconds E)	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel Popt	sage Type: he ket Length: lirce OSPF Rouse ID: 0.0.0. ket Checksun th Type: Null th Data (none Hello Packe Lwork Mask: 2 lo Interval: cions: 0x02 (tter Priority	tello Packet (1) 48 vter: 192.168.9.1 (1 0 (Backbone) 1: 0xd4f2 [correct] 2: t t:555.255.255.0 10 seconds E)	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel Popt Rou Rou	sage Type: he ket Length: Irce OSPF Ro. as ID: 0.0.0. he ket Checksum th Type: Null he Data (none Hello Packe work Mask: 2.10 Interval: iions: 0x02 (tter Priority ter Dead Interval:	tello Packet (1) 48 iter: 192.168.9.1 (1 0 (Backbone) 1: 0xd4f2 [correct] 2: t t:55.255.255.0 10 seconds EE)	92.168.9.1)		
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel Dopt Rou Des	sage Type: he ket Length: irce OSPF Ro. ia ID: 0.0.0. ket Checksum th Type: Null th Data (none Hello Packe work Mask: 2. lo Interval: icions: 0x02 (iter Priority iter Pead Intignated Rout	Hello Packet (1) 48 Horer: 192.168.9.1 (1 0 (Backbone) Horerct] Horerct Horerc			
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel Popt Rou Rou Des Bac	sage Type: Heket Length: Irce OSPF Rota Isa ID: 0.0.0. Iket Checksum In Type: Null In Data (none Hello Packe Iwork Mask: 2 Io Interval: Iter Pead Int Ingnated Rout Ikek Designate Ikek Designate	tello Packet (1) 48 tter: 192.168.9.1 (1 0 (Backbone) 0: 0xd4f2 [correct] t 255.255.255.0 10 seconds (E) (: 1 terval: 40 seconds ter: 192.168.9.2			
Mes Pac Sou Are Pac Aut Aut OSPF Net Hel Popt Rou Rou Des Bac	sage Type: Heket Length: Irce OSPF Rota Isa ID: 0.0.0. Iket Checksum In Type: Null In Data (none Hello Packe Iwork Mask: 2 Io Interval: Iter Pead Int Ingnated Rout Ikek Designate Ikek Designate	tello Packet (1) 48 tter: 192.168.9.1 (1 0 (Backbone) 10 0xd4f2 [correct] 11 0xd4f2 [correct] 12 0xd4f2 [correct] 13 0xd4f2 [correct] 14 0xd4f2 [correct] 15 0xd4f2 [correct] 16 0xd4f2 [correct] 17 0xd4f2 [correct] 18 0xd4f2 [correct] 19 0xd4f2 [correct] 10 0xd4f2 [c			

3. bgp 协议:

我在 router3 的 eth2 网卡上进行抓帧: bgp 协议截图如下:

Vo.	Time	Source	Destination	Protocol	Length Info
	45 257.757511	Vmware_le:14:ad	Broadcast	ARP	60 Who has 192.168.4.1? Tell 192.168.8.1
	46 257.757535	Vmware_19:44:f4	Vmware_le: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 SAC
	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 M
	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=
	50 257.758547				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 TSva
	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 TSva
	57 258.771943	192.168.8.1	192.168.4.1	BGP	121 UPDATE Message

- ▶ 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)

					I Albania I anno A
No.	Time	Source	Destination	Protocol	Length Info
	45 257.757511	Vmware_le:14:ad	Broadcast	ARP	60 Who has 192.168.4.1? Tell 192.168.8.1
	46 257.757535	Vmware_19:44:f4	Vmware_le: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=
					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:

1 0.000000 192	rce	Destination	Protocol	Length Info
	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
6 4.894946 192	168.1.1	224.0.0.9	RIPv2	86 Response
7 9.324580 Vmwa	are_92:3e:1d	Vmware_1b:59:ed	ARP	60 Who has 192.168.1.1? Tell 192.168.1.2
8 9.324633 Vmwa	re_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
0 14.169075 192	168.1.1	224.0.0.22	IGMP	54 V3 Membership Report / Join group 224.0.0.9 for any
1 31.914362 192	168.1.1	224.0.0.9	RIPv2	86 Response
2 46.884824 192	168.1.2	224.0.0.9	RIPv2	86 Response
3 63.934732 192.	168.1.1	224.0.0.9	RIPv2	86 Response
	(2) .2.0 (192.168.2.0)			
tmask: 255.255.25 kt Hop: 0.0.0.0 (tric: 1	5.0 (255.255.255.0 9.0.0.0))		
ddress: 192.168.3 dress Family: IP ute Tag: 0				
ice iug. U	.3.0 (192.168.3.0)			
ite Tag: A			(255.255.255.0)	

如图,在执行了第一帧 request 之后,第二帧受到了来自 routerl 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_le: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	0SPF	78 LS Acknowledge
	40 37.629227			OSPF	82 Hello Packet
	41 40.018401	192.168.9.2	224.0.0.5	0SPF	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
▶ Fra	ne 40: 82 byte	s on wire (656 bits), 82 bytes captured (6	656 bits)	
. 10000000000					00:00:05 (01:00:5e:00:00:05)
			2.168.9.1 (192.168.9.1)		
III CALIFICA	n Shortest Pat			,,	TOTAL ATTENDED TO
	PF Header				
440	SPF Version: 2)			
		Hello Packet (1)			
950	Packet Length:				
		uter: 192.168.9.1 (192 168 9 1)		
5.9	Area ID: 0.0.0		132.100.3.17		
		n: 0xd4f2 [correct]			
10.1	Auth Type: Nul				
	Auth Data (none				
100000000000000000000000000000000000000	PF Hello Packe				
	letwork Mask: 2				
188	Hello Interval				
	options: 0x02				
2.330	Router Priority				
		terval: 40 seconds			
933		ter: 192.168.9.2			
	3	ted Router: 192.168	0 1		
100		r: 192.168.10.1	. 5.1		
1	active weighbor	. 152.100.10.1			

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:

	Time		Source	Destination	Protocol	Length Info
	10 21.70	94638	192.168.9.2	224.0.0.5	OSPF	82 Hello Packet
	11 21.90	99632	Vmware 1e:14:b7	Broadcast	ARP	42 Who has 192.168.9.2? Tell 192.168.9.1
	12 21.90	99846	Vmware 98:37:14	Vmware_1e:14:b7	ARP	60 192.168.9.2 is at 00:0c:29:98:37:14
	13 21.96	99849	192.168.9.1	192.168.9.2	OSPF	66 DB Description
	14 21.9	10344	192.168.9.2	192.168.9.1	OSPF	66 DB Description
	15 21.9	10410	192.168.9.1	192.168.9.2	OSPF	86 DB Description
	16 21.9	10688	192.168.9.2	192.168.9.1	OSPF	146 DB Description
	17 21.9	10747	192.168.9.1	192.168.9.2	0SPF	66 DB Description
	18 21.9	10841	192.168.9.1	192.168.9.2	OSPF	106 LS Request
	19 21.9	11048	192.168.9.2	224.0.0.5	OSPF	142 LS Update
	20 21.9		192.168.9.2	224.0.0.5	OSPF	214 LS Update
	21 21.9		192.168.9.1	192.168.9.2	OSPF	78 LS Acknowledge
	22 21.9	11935	192.168.9.1	192.168.9.2	OSPF	70 LS Request
Fra	me 13: 6	6 bytes	on wire (528 bits)	, 66 bytes captured (528 bits)	110 00000000000000000000000000000000000
						37:14 (00:0c:29:98:37:14)
				.168.9.1 (192.168.9.1		
	n Shorte		**			and the contract of the contra
₩ 05	PF Heade	er				
	SPE Ver	sion: 2				
31						
1	Message 1	Type: D	B Description (2)			
1	Message T Packet Le	Type: D ength:	B Description (2) 32	92.168.9.1)		
1	Message T Packet Le Source Os	Type: D ength: SPF Rou	B Description (2) 32 ter: 192.168.9.1 (1	92.168.9.1)		
1	Message T Packet Le Source OS Area ID:	Type: D ength: SPF Rou 0.0.0.	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone)	92.168.9.1)		
	Message T Packet Le Source OS Area ID: Packet Ch	Type: D ength: SPF Rou 0.0.0. hecksum	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]	92.168.9.1)		
	Message Tecket Le Source Os Area ID: Packet Ch	Type: D ength: SPF Rou 0.0.0. hecksum e: Null	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]	92.168.9.1)		
	Message Tecket Le Source Os Area ID: Packet Ch Auth Type Auth Data	Type: Dength: SPF Rou 0.0.0. hecksume: Null	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]	92.168.9.1)		
▼ 05	Message T Packet Le Source OS Area ID: Packet Ch Auth Type Auth Data PF DB De	Type: Dength: SPF Rou 0.0.0. hecksume: Null a (none	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion	92.168.9.1)		
▼ 05	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data PF DB De	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500	92.168.9.1)		
▼ 05	Message Teacket Le Fource OS Area ID: Packet Ch Auth Type Auth Data IPF DB De Interface Options:	Type: D ength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OFF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		
▶	Message Teacket Le Gource OS Area ID: Packet Ch Auth Type Auth Data OPF DB De Interface Options:	Type: Dength: SPF Rou 0.0.0. hecksum e: Null a (none escript: e MTU: 0x02 (iption:	B Description (2) 32 ter: 192.168.9.1 (1 0 (Backbone) : 0x9c93 [correct]) ion 1500 E) 0x07 (I, M, MS)	92.168.9.1)		

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
	Vmware 1e:14:ad	Broadcast	ARP	60 Who has 192.168.4.1? Tell 192.168.8.1
	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		192.168.4.1	TCP	74 56898 > bgp [SYN] Seg=0 Win=14600 Len=0 MSS=1460 SAC
48 257.757787	The state of the s	192,168,8,1	TCP	74 bgp > 56898 [SYN, ACK] Seg=0 Ack=1 Win=14480 Len=0 M
49 257.758137		192.168.4.1	TCP	66 56898 > bgp [ACK] Seg=1 Ack=1 Win=14600 Len=0 TSval=
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] Seg=54 Ack=73 Win=14600 Len=0 TSva
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] Seg=92 Ack=92 Win=14600 Len=0 TSva
57 258.771943	192.168.8.1	192.168.4.1	BGP	121 UPDATE Message
▼ OPEN Message Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 101	s			

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:

MyAS : 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:

	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_le: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=
					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
▶ Fra	me 52: 138 byte	es on wire (1104 bit	s), 138 bytes captured	d (1104 bits	
					14:ad (00:0c:29:1e:14:ad)
	CANADA AND AND AND AND AND AND AND AND AN	The state of the s	2.168.4.1 (192.168.4.1)	Charles and American Property of the Control of the	
					6898), Seq: 1, Ack: 54, Len: 72
▼ Bor	der Gateway Pro	otocol			100 to 160 to
▼ 0E	PEN Message				
OI.					
	Marker: 16 byte	S			
ì					
1	Marker: 16 byte	s			
1	Marker: 16 byte Length: 53 byte	s			
1	Marker: 16 byte Length: 53 byte Type: OPEN Mess	s			
1	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4	s			
1	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100	es age (1)			
1	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier:	es age (1)	es		
	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame	es age (1) 192.168.4.1 eters length: 24 byt	es		
 	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame Optional parame	192.168.4.1 ters length: 24 byt			
 	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame Optional parame	es age (1) 192.168.4.1 eters length: 24 byt	tes)		
V	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame Capabilities / Capabilities /	192.168.4.1 teers length: 24 byt ters Advertisement (8 byt	res)		
V	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame > Capabilities / Capabilities /	192.168.4.1 ters length: 24 byters devertisement (8 byterdevertisement (4 byterdevertise	ces) ces)		
V	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame > Capabilities / Capabilities /	192.168.4.1 hters length: 24 bythers ters Addvertisement (8 bythers) Advertisement (4 bythers) Advertisement (4 bythers)	ces) ces)		
▼ Bor	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 Wy AS: 100 Hold time: 180 BGP identifier: Optional parame Optional parame Capabilities Capabilities Capabilities Capabilities	192.168.4.1 ters length: 24 byt ters Advertisement (8 byt Advertisement (4 byt Advertisement (8 byt	ces) ces)		
▼ Bor	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame Optional parame Capabilities /	192.168.4.1 192.168.4.1 ters length: 24 byt ters Advertisement (8 byt Advertisement (4 byt Advertisement (4 byt Advertisement (8 byt tocol e	ces) ces)		
▼ Bor ▼ KE	Marker: 16 byte Length: 53 byte Type: OPEN Mess Version: 4 My AS: 100 Hold time: 180 BGP identifier: Optional parame Optional parame Capabilities / Capabilities / Capabilities / Capabilities /	192.168.4.1 teers length: 24 bytyteers Advertisement (8 bytytytytytytytytytytytytytytytytytytyt	ces) ces)		

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 rout	ting table				Head - Lan-		
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:

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
                                255.255.255.0
192.168.1.0
                                                U
                                                      0
                                                             0
                                                                      0 eth1
192.168.2.0
                192.168.1.2
                                255.255.255.0
                                                      2
                                                             0
                                                                      0 eth1
                                                UG
               ubuntu-2.local 255.255.255.0
192.168.3.0
                                                UG
                                                      2
                                                             0
                                                                      0 eth0
root@ubuntu:/etc/quagga#
```

同样输入 tracepath 指令后显示如下:

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。