实验名称	OSPF 实验		
姓名		学号	

<table>
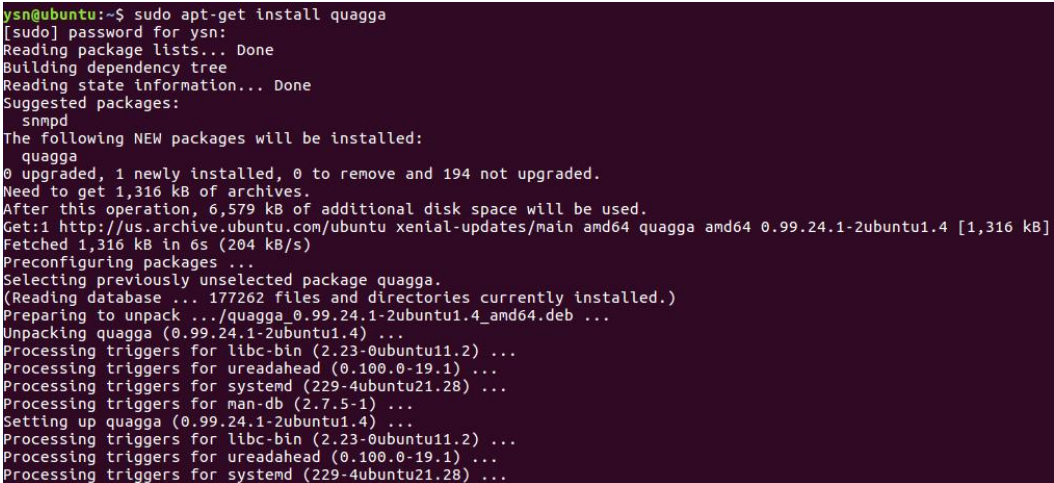<tr><td rowspan="1">实验步骤</td><td colspan="3">

所有实验均在 VMware 17.6.1 虚拟机环境下的 Ubuntu 16.04.7 系统中完成。

一、Host1 设置

　　1、网卡编辑

　　2、安装 quagga

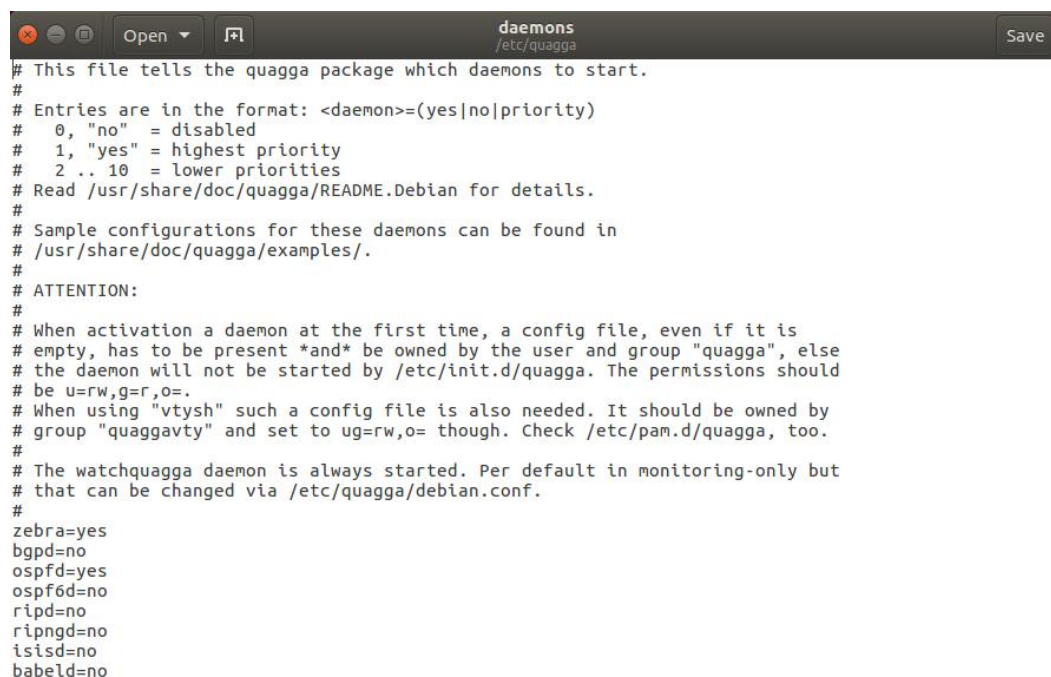　　3、设置 IP 地址

</td></tr>
</table>

```
ysn@ubuntu:~$ sudo ifconfig ens33 192.168.0.1
ysn@ubuntu:~$ sudo ifconfig ens37 192.168.1.1
ysn@ubuntu:~$ ifconfig
ens33     Link encap:Ethernet  HWaddr 00:0c:29:cb:9e:cf
          inet addr:192.168.0.1  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: fe80::3539:ee17:56fb:8f24/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1877 errors:0 dropped:0 overruns:0 frame:0
          TX packets:617 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:2451022 (2.4 MB)  TX bytes:47130 (47.1 KB)

ens37     Link encap:Ethernet  HWaddr 00:0c:29:cb:9e:d9
          inet addr:192.168.1.1  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::80aa:6e36:12d9:6fdf/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:21 errors:0 dropped:0 overruns:0 frame:0
          TX packets:36 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:3026 (3.0 KB)  TX bytes:5985 (5.9 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:226 errors:0 dropped:0 overruns:0 frame:0
          TX packets:226 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:19718 (19.7 KB)  TX bytes:19718 (19.7 KB)
```

4、修改 daemons 文件

```
daemons
/etc/quagga                                                    Save

# This file tells the quagga package which daemons to start.
#
# Entries are in the format: <daemon>=(yes|no|priority)
#   0, "no"  = disabled
#   1, "yes" = highest priority
#   2 .. 10  = lower priorities
# Read /usr/share/doc/quagga/README.Debian for details.
#
# Sample configurations for these daemons can be found in
# /usr/share/doc/quagga/examples/.
#
# ATTENTION:
#
# When activation a daemon at the first time, a config file, even if it is
# empty, has to be present *and* be owned by the user and group "quagga", else
# the daemon will not be started by /etc/init.d/quagga. The permissions should
# be u=rw,g=r,o=.
# When using "vtysh" such a config file is also needed. It should be owned by
# group "quaggavty" and set to ug=rw,o= though. Check /etc/pam.d/quagga, too.
#
# The watchquagga daemon is always started. Per default in monitoring-only but
# that can be changed via /etc/quagga/debian.conf.
#
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no
isisd=no
babeld=no
```

5、生成 zebra 和 ospfd 配置文件并初始化

```
ysn@ubuntu:~$ cd /etc/quagga/
ysn@ubuntu:/etc/quagga$ sudo touch zebra.conf ospfd.conf
ysn@ubuntu:/etc/quagga$ sudo chown quagga.quagga zebra.conf ospfd.conf
ysn@ubuntu:/etc/quagga$ sudo gedit zebra.conf

(gedit:3640): IBUS-WARNING **: The owner of /home/ysn/.config/ibus/bus is not root!

(gedit:3640): IBUS-WARNING **: Unable to connect to ibus: Unexpected lack of content trying to re
ad a line

(gedit:3640): Gtk-WARNING **: Calling Inhibit failed: GDBus.Error:org.freedesktop.DBus.Error.Serv
iceUnknown: The name org.gnome.SessionManager was not provided by any .service files

** (gedit:3640): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-spel
l-enabled not supported

** (gedit:3640): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-enco
ding not supported

** (gedit:3640): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-spel
l-enabled not supported

** (gedit:3640): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-enco
ding not supported

** (gedit:3640): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-posi
tion not supported
ysn@ubuntu:/etc/quagga$ sudo gedit ospfd.conf

(gedit:3654): IBUS-WARNING **: The owner of /home/ysn/.config/ibus/bus is not root!

(gedit:3654): IBUS-WARNING **: Unable to connect to ibus: Unexpected lack of content trying to re
ad a line

(gedit:3654): Gtk-WARNING **: Calling Inhibit failed: GDBus.Error:org.freedesktop.DBus.Error.Serv
iceUnknown: The name org.gnome.SessionManager was not provided by any .service files

** (gedit:3654): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-spel
l-enabled not supported

** (gedit:3654): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-enco
ding not supported

** (gedit:3654): WARNING **: Set document metadata failed: Setting attribute metadata::gedit-posi
tion not supported
```

6、启动 quagga

```
ysn@ubuntu:/etc/quagga$ sudo /etc/init.d/quagga start
[ ok ] Starting quagga (via systemctl): quagga.service.
```

Ps：有可能还需要再 restart 一次才能跑通下一步

7、配置 zebra

```
ysn@ubuntu:/etc/quagga$ sudo telnet localhost 2601
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
ubuntu> enable
ubuntu# configure terminal
ubuntu(config)# interface ens33
ubuntu(config-if)# ip address 192.168.0.1/24
ubuntu(config-if)# no shutdown
ubuntu(config-if)# interface ens37
ubuntu(config-if)# ip address 192.168.1.1/24
ubuntu(config-if)# no shutdown
ubuntu(config-if)# write
Configuration saved to /etc/quagga/zebra.conf
ubuntu(config-if)# exit
ubuntu(config)# exit
ubuntu# exit
Connection closed by foreign host.
```

Ps：密码就是前面设的 zebra

8、配置 ospf

```
ysn@ubuntu:/etc/quagga$ sudo telnet localhost 2604
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
ubuntu> enable
ubuntu# configure terminal
ubuntu(config)# router ospf
ubuntu(config-router)# network 192.168.0.0/24 area 0.0.0.0
ubuntu(config-router)# network 192.168.1.0/24 area 0.0.0.1
ubuntu(config-router)# write
Configuration saved to /etc/quagga/ospfd.conf
ubuntu(config-router)# exit
ubuntu(config)# exit
ubuntu# exit
Connection closed by foreign host.
```

二、Host2 设置

与 Host1 基本一致，命令上的区别如下图所示：

```
ysn@ubuntu:~$ sudo ifconfig ens33 192.168.0.2
ysn@ubuntu:~$ sudo ifconfig ens37 192.168.2.1
```

```
ysn@ubuntu:/etc/quagga$ sudo telnet localhost 2601
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
Password:
ubuntu> enable
ubuntu# configure terminal
ubuntu(config)# interface ens33
ubuntu(config-if)# ip address 192.168.0.2/24
ubuntu(config-if)# no shutdown
ubuntu(config-if)# interface ens37
ubuntu(config-if)# ip address 192.168.2.1/24
ubuntu(config-if)# no shutdown
ubuntu(config-if)# write
Configuration saved to /etc/quagga/zebra.conf
ubuntu(config-if)# exit
ubuntu(config)# exit
ubuntu# exit
Connection closed by foreign host.
```

```
ysn@ubuntu:/etc/quagga$ sudo telnet localhost 2604
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
ubuntu> enable
ubuntu# configure terminal
ubuntu(config)# router ospf
ubuntu(config-router)# network 192.168.0.0/24 area 0.0.0.0
ubuntu(config-router)# network 192.168.2.0/24 area 0.0.0.1
ubuntu(config-router)# write
Configuration saved to /etc/quagga/ospfd.conf
ubuntu(config-router)# exit
ubuntu(config)# exit
ubuntu# exit
Connection closed by foreign host.
```

三、检查路由表

1、重启 quagga 服务

```
ysn@ubuntu:/etc/quagga$ sudo /etc/init.d/quagga restart
[ ok ] Restarting quagga (via systemctl): quagga.service.
```

2、Host1 路由表

```
ysn@ubuntu:/etc/quagga$ sudo route
[sudo] password for ysn:
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
link-local      *               255.255.0.0     U     1000   0        0 ens33
192.168.0.0     *               255.255.255.0   U     0      0        0 ens33
192.168.1.0     *               255.255.255.0   U     0      0        0 ens37
192.168.2.0     192.168.0.2     255.255.255.0   UG    20     0        0 ens33
```
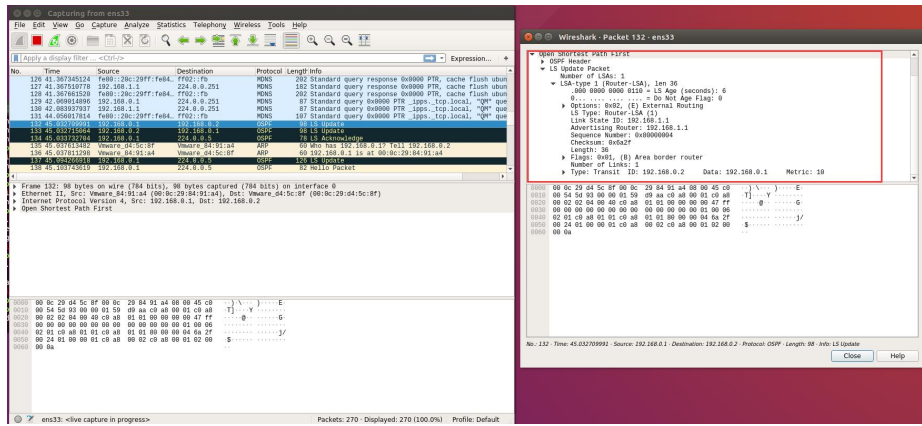
3、Host2 路由表

```
ysn@ubuntu:/etc/quagga$ sudo route
[sudo] password for ysn:
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
link-local      *               255.255.0.0     U     1000   0        0 ens33
192.168.0.0     *               255.255.255.0   U     0      0        0 ens33
192.168.1.0     192.168.0.1     255.255.255.0   UG    20     0        0 ens33
192.168.2.0     *               255.255.255.0   U     0      0        0 ens37
```
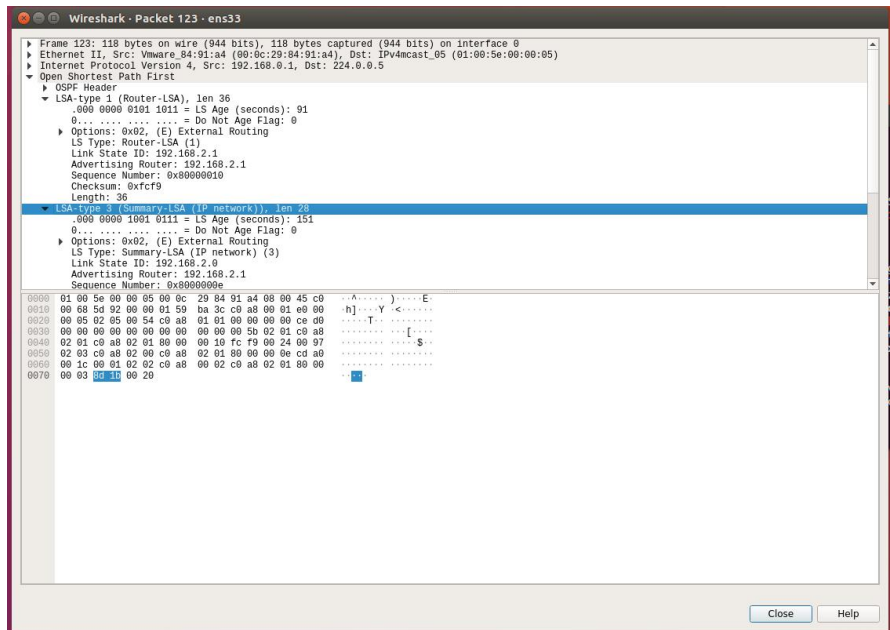
一、观察链路状态更新分组

在 Wireshark 中可以捕获 LSU 报文，即链路状态更新分组。由源地址可知，Host1 组播发送 LSU 报文，其中包括很多信息，如 Link State ID: 192.168.1.1, Advertising Router: 192.168.1.1, Sequence Number: 0x80000004, Checksum: 0x6a2f 等。

二、观察 LSA

在上面所示的 LSA 包中，可以找到类型为 Type 1, Type 3, Type 2 的 LSA，可以帮助其他 OSPF 路由器构建其链路状态数据库，告知区域内路由器的存在和网络拓扑，帮助计算最短路径等。源地址为 Host-1，即为 Host-1 组播发送的 LSA。

三、部分示例数据

数据分析

```
 99 40.026409556  Vmware_84:91:a4    Broadcast         ARP    60 Who has 192.168.0.2? Tell 192.168.0.1
100 40.027568780  Vmware_d4:5c:8f    Vmware_84:91:a4   ARP    60 192.168.0.2 is at 00:0c:29:d4:5c:8f
101 40.027606847  192.168.0.1        192.168.0.2       OSPF   66 DB Description
102 40.028351232  192.168.0.2        192.168.0.1       OSPF   66 DB Description
103 40.028618310  192.168.0.1        192.168.0.2       OSPF  106 DB Description
104 40.028811723  192.168.0.2        192.168.0.1       OSPF  106 DB Description
105 40.029058030  192.168.0.1        192.168.0.2       OSPF   66 DB Description
106 40.029071242  192.168.0.1        192.168.0.2       OSPF   82 LS Request
107 40.029212758  192.168.0.2        192.168.0.1       OSPF   82 LS Request
108 40.029214233  192.168.0.2        224.0.0.5         OSPF  126 LS Update
109 40.029426633  192.168.0.1        224.0.0.5         OSPF  126 LS Update
110 40.029529342  192.168.0.1        224.0.0.5         OSPF   98 LS Update
111 40.030659175  192.168.0.2        224.0.0.5         OSPF  130 LS Update
```

　　观察整个 OSPF 建立连接的过程，出来 LSU、LSA 报文外，还存在 Hello Packet, DB Description 等类型的报文。

思考题	**1、改变 OSPF Area 类型时，OSPF 的邻居关系会发生震荡么?** 当 OSPF 区域类型发生变化时，OSPF 的邻居关系会发生震荡。这是因为： ● 区域类型改变后，路由器的 LSA 传播方式、路由计算方式以及邻居关系会发生变化。 ● 需要重新计算网络拓扑结构、交换新的链路状态信息，并根据新区域类型进行路由调整。 ● 在某些情况下，邻居关系会被断开并重新建立，可能会导致短暂的网络不稳定。 因此，在进行 OSPF 区域类型的更改时，必须考虑对网络拓扑、路由计算、邻居关系的潜在影响，并做好相应的网络调优和监控。 **2、两条"等价"路径存在时，OSPF 如何处理在网络中建立几条路径?** 在 OSPF 中，处理两条"等价"路径时，OSPF 采用了等价路由（Equal-Cost Multi-Path, ECMP）的机制来建立多条路径。ECMP 机制基于以下原则： ● 代价相同：在 OSPF 中，所有等价路径的代价必须相同，才能被选为 ECMP 路径。 ● 负载均衡：OSPF 将使用这些等价路径进行负载均衡。负载均衡的方式通常是基于哈希算法，将流量分配到不同的路径上。这个哈希通常考虑的是源 IP、目的 IP、协议、端口等信息。 ● 交换更新：OSPF 会为每条等价路径都生成一个路由条目，并在路由表中同时保存这些路径。当路由器接收到数据包时，它会根据哈希算法选择一条路径来转发。 总而言之，当存在两条或多条等价路径时，OSPF 会根据 ECMP 机制将这些路径同时引入路由表，并通过哈希算法进行负载均衡。默认情况下，OSPF 最多支持 16 条等价路径，但这个数量可以根据需求进行调整。
经验总结	（实验过程中遇到的困难，试验中需要额外注意的事项，实验中激发的灵感等） 1、当按指导书跑不通命令时，问助教才得知需要 restart 一下 quagga。 2、虚拟机设置 ip 后需要用 ifconfig 检查一下 ip 设置是否生效。 3、在检查路由器时，restart quagga 后可能需要等待接近十分钟才能得到正确的 route 命令运行结果，需要有耐心。