

计算机网络实验报告

实验一

基本网络工具集使用和协议数据单元（PDU）观测

学号：1412200065

姓名：刘博

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1.实验目的

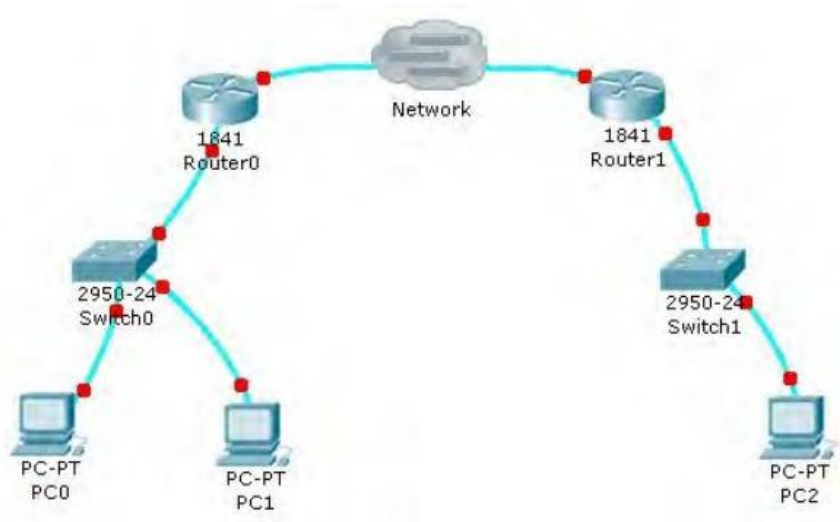
- 1. 熟悉 UNIX/Linux 系统下基本的网络工具集合，如 ifconfig、route、wireshark 等
- 2. 观察和初步分析协议 PDU 的内容
- 3. 通过实验学习基本的网络知识，体验网络拓扑的搭建，对网关、路由等知识形成初步的认识，为将来的实验打下基础。

2.网络拓扑配置

ip 分配表（仅方法 1）：

节点名	虚拟设备名	IP	子网掩码	虚拟交换机
Router 0	U-572	eth0 192.168.2.1	255.255.255.0	Vnet0
		eth1 192.168.3.1	255.255.255.0	Vnet1
Router 1	U-571	eth0 192.168.3.2	255.255.255.0	Vnet1
		eth1 192.168.4.2	255.255.255.0	Vnet2
PC 0	U-573	eth0 192.168.2.2	255.255.255.0	Vnet0
PC 1	U-574	eth0 192.168.2.3	255.255.255.0	Vnet0
PC 2	U-575	eth0 192.168.4.1	255.255.255.0	Vnet2

网络拓扑图如下：



3.路由规则配置

方法 1 ： 关闭 network-mananger

首先，必须关闭 network-manager，以免 IP 地址自动变更。

命令为： `sudo service network-manager stop`

之后依次为五个虚拟机分配 IP 地址，设置默认网关路由规则，并开启转发。

具体过程如下：

Router 0

设置 IP 地址：

```
sudo ifconfig eth0 192.168.2.1 netmask 255.255.255.0
```

```
sudo ifconfig eth1 192.168.3.1 netmask 255.255.255.0
```

设置转发规则：

```
sudo ip route add 192.168.2.0/24 via 192.168.2.1
```

```
sudo ip route add 192.168.3.0/24 via 192.168.3.1
```

```
sudo ip route add 192.168.4.0/24 via 192.168.4.1
```

启动转发：

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

Router 1

设置 IP 地址：

```
sudo ifconfig eth0 192.168.3.2 netmask 255.255.255.0
```

```
sudo ifconfig eth1 192.168.4.2 netmask 255.255.255.0
```

设置转发规则：

```
sudo ip route add 192.168.2.0/24 via 192.168.3.1
```

```
sudo ip route add 192.168.3.0/24 via 192.168.3.2
```

```
sudo ip route add 192.168.4.0/24 via 192.168.4.2
```

启动转发：

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

PC 0

设置 IP 地址：

```
sudo ifconfig eth0 192.168.2.2
```

设置默认网关：

```
sudo add default gw 192.168.2.1
```

PC 1

设置 IP 地址：

```
sudo ifconfig eth0 192.168.2.3
```

设置默认网关：

```
sudo add default gw 192.168.2.1
```

PC 2

设置 IP 地址:

sudo ifconfig eth0 192.168.4.1

设置默认网关:

sudo add default gw 192.168.4.2

4.数据包截图:

PC0 (192.168.2.2) ping PC1 (192.168.2.3)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.2.2	192.168.2.3	ICMP	98	Echo (ping) request id=0x1045, seq=1/256, ttl=64 (reply in 2)
2	0.001283000	192.168.2.3	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1045, seq=1/256, ttl=64 (request in 1)
3	1.001558000	192.168.2.2	192.168.2.3	ICMP	98	Echo (ping) request id=0x1045, seq=2/512, ttl=64 (reply in 4)
4	1.002203000	192.168.2.3	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1045, seq=2/512, ttl=64 (request in 3)
5	2.002970000	192.168.2.2	192.168.2.3	ICMP	98	Echo (ping) request id=0x1045, seq=3/768, ttl=64
6	2.004056000	192.168.2.3	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1045, seq=3/768, ttl=64 (request in 5)
7	3.004763000	192.168.2.2	192.168.2.3	ICMP	98	Echo (ping) request id=0x1045, seq=4/1024, ttl=64
8	3.005585000	192.168.2.3	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1045, seq=4/1024, ttl=64 (request in 7)
9	4.006307000	192.168.2.2	192.168.2.3	ICMP	98	Echo (ping) request id=0x1045, seq=5/1280, ttl=64
10	4.007358000	192.168.2.3	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1045, seq=5/1280, ttl=64 (request in 9)
11	5.003224000	CadmusCo_6a:d6:0c	CadmusCo_b7:cf:a8	ARP	60	Who has 192.168.2.2? Tell 192.168.2.3
12	5.003323000	CadmusCo_b7:cf:a8	CadmusCo_6a:d6:0c	ARP	42	192.168.2.2 is at 08:00:27:b7:cf:a8

▶ Frame 16: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

▶ Ethernet II, Src: CadmusCo_6a:d6:0c (08:00:27:6a:d6:0c), Dst: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8)

▶ Internet Protocol Version 4, Src: 192.168.2.3 (192.168.2.3), Dst: 192.168.2.2 (192.168.2.2)

▶ Internet Control Message Protocol

0000 08 00 27 b7 cf a8 08 00 27 6a d6 0c 08 00 45 00 ..'.....'j....E.

0010 00 54 09 0d 00 00 40 01 ec 46 c0 a8 02 03 c0 a8 .T....@. .F.....

0020 02 02 00 00 a7 11 10 45 00 07 83 a7 1d 54 00 00E.....T..

0030 00 00 dc d3 0c 00 00 00 00 00 10 11 12 13 14 15T.....

0040 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 !"#%\$

0050 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 &'()*+,-./012345

0060 36 37 67

eth0: <live capture in progress> File: ... Packets: 18 • Displayed: 18 (100.0%)

Profile: Default

PC0 ping PC1

PC0 (192.168.2.2) ping PC2 (192.168.4.1)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=1/256, ttl=64
2	0.003345000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=1/256, ttl=62 (request in 1)
3	1.002470000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=2/512, ttl=64
4	1.006470000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=2/512, ttl=62 (request in 3)
5	2.004074000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=3/768, ttl=64 (reply in 6)
6	2.007346000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=3/768, ttl=62 (request in 5)
7	3.006412000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=4/1024, ttl=64 (reply in 8)
8	3.009961000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=4/1024, ttl=62 (request in 7)
9	4.007591000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=5/1280, ttl=64
10	4.011406000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=5/1280, ttl=62 (request in 9)
11	5.009080000	192.168.2.2	192.168.4.1	ICMP	98	Echo (ping) request id=0x1198, seq=6/1536, ttl=64 (reply in 12)
12	5.011663000	192.168.4.1	192.168.2.2	ICMP	98	Echo (ping) reply id=0x1198, seq=6/1536, ttl=62 (request in 11)

▶ Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

▶ Ethernet II, Src: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8), Dst: CadmusCo_7b:3e:74 (08:00:27:7b:3e:74)

▶ Internet Protocol Version 4, Src: 192.168.2.2 (192.168.2.2), Dst: 192.168.4.1 (192.168.4.1)

▶ Internet Control Message Protocol

0000 08 00 27 7b 3e 74 08 00 27 b7 cf a8 08 00 45 00 ..'>t.. '.....E.

0010 00 54 d9 d1 40 00 40 01 d9 83 c0 a8 02 02 c0 a8 .T..@.@.

0020 04 01 08 00 66 10 11 98 00 01 b1 a9 1d 54 00 00f... ..T..

0030 00 00 f0 85 02 00 00 00 00 00 10 11 12 13 14 15T.....

0040 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 !"#%\$

0050 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 &'()*+,-./012345

0060 36 37 67

eth0: <live capture in progress> File: ... Packets: 42 • Displayed: 42 (100.0%)

Profile: Default

PC0 ping PC2

5.协议报文分析

由上图可以看出在 192.168.2.2 (PC0) 发送一个请求包之后, 192.168.4.1 (PC2) 接收

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到之后返回一个 reply 包。采用的协议为 ICMP 协议，其中请求包中包含类型码，0 表示回显应答，8 表示回显请求。下面详细分析每一个层次上的 PDU 头。

```

▶ Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
▶ Ethernet II, Src: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8), Dst: CadmusCo_7b:3e:74 (08:00:27:7b:3e:74)
▶ Internet Protocol Version 4, Src: 192.168.2.2 (192.168.2.2), Dst: 192.168.4.1 (192.168.4.1)
▶ Internet Control Message Protocol

0000  08 00 27 7b 3e 74 08 00 27 b7 cf a8 08 00 45 00  ..'>t.. '.....E.
0010  00 54 d9 d1 40 00 40 01 d9 83 c0 a8 02 02 c0 a8  .T..@.@. ....
0020  04 01 08 00 66 10 11 98 00 01 b1 a9 1d 54 00 00  ....f... ..T..
0030  00 00 f0 85 02 00 00 00 00 00 10 11 12 13 14 15  ....
0040  16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25  .... ..!"#$%
0050  26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35  &'()*+,-./012345
0060  36 37                                           67
    
```

协议报文共分为四层，分别是物理层帧、以太网帧及其首部、IP 协议数据报及其首部以及 Internet 控制报文协议。

物理层帧：

```

- Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
  Interface id: 0
  Encapsulation type: Ethernet (1)
  Arrival Time: Sep 21, 2014 00:22:09.165472000 CST
  [Time shift for this packet: 0.000000000 seconds]
  Epoch Time: 1411230129.165472000 seconds
  [Time delta from previous captured frame: 0.000000000 seconds]
  [Time delta from previous displayed frame: 0.000000000 seconds]
  [Time since reference or first frame: 0.000000000 seconds]
  Frame Number: 1
  Frame Length: 98 bytes (784 bits)
  Capture Length: 98 bytes (784 bits)
  [Frame is marked: False]
  [Frame is ignored: False]
  [Protocols in frame: eth:ip:icmp:data]
  [Coloring Rule Name: ICMP]
  [Coloring Rule String: icmp || icmpv6]

0000  08 00 27 7b 3e 74 08 00 27 b7 cf a8 08 00 45 00  ..'>t.. '.....E.
0010  00 54 d9 d1 40 00 40 01 d9 83 c0 a8 02 02 c0 a8  .T..@.@. ....
0020  04 01 08 00 66 10 11 98 00 01 b1 a9 1d 54 00 00  ....f... ..T..
0030  00 00 f0 85 02 00 00 00 00 00 10 11 12 13 14 15  ....
0040  16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25  .... ..!"#$%
0050  26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35  &'()*+,-./012345
0060  36 37                                           67
    
```

这是物理连接的接收的全部数据。

以太网帧：


```

▶ Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
- Ethernet II, Src: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8), Dst: CadmusCo_7b:3e:74 (08:00:27:7b:3e:74)
  ▼ Destination: CadmusCo_7b:3e:74 (08:00:27:7b:3e:74)
    Address: CadmusCo_7b:3e:74 (08:00:27:7b:3e:74)
    .... ..0. .... = LG bit: Globally unique address (factory default)
    .... ..0. .... = IG bit: Individual address (unicast)
  ▼ Source: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8)
    Address: CadmusCo_b7:cf:a8 (08:00:27:b7:cf:a8)
    .... ..0. .... = LG bit: Globally unique address (factory default)
    .... ..0. .... = IG bit: Individual address (unicast)
  Type: IP (0x0800)

0000  08 00 27 7b 3e 74 08 00 27 b7 cf a8 08 00 45 00  ..'{}>t.. '.....E.
0010  00 54 d9 d1 40 00 40 01 d9 83 c0 a8 02 02 c0 a8  .T..@.@. ....
0020  04 01 08 00 66 10 11 98 00 01 b1 a9 1d 54 00 00  ....f... ..T..
0030  00 00 f0 85 02 00 00 00 00 00 10 11 12 13 14 15  ....
0040  16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25  .... !"#$$%
0050  26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35  &'()*+,- ./012345
0060  36 37 67

```

该层中包含了源 MAC 以及目的 MAC, 该包中源 MAC 为: 08:00:27:b7:cf:a8, 目的 MAC 为: 08:00:27:7b:3e:74, 并有一个 Type 字段, 该字段表示该以太网帧的上层协议类型, 这里 Type 是 IP (0x0800) 表示, 该帧内容要递交给 IP 协议处理。

IP 协议数据报:

```

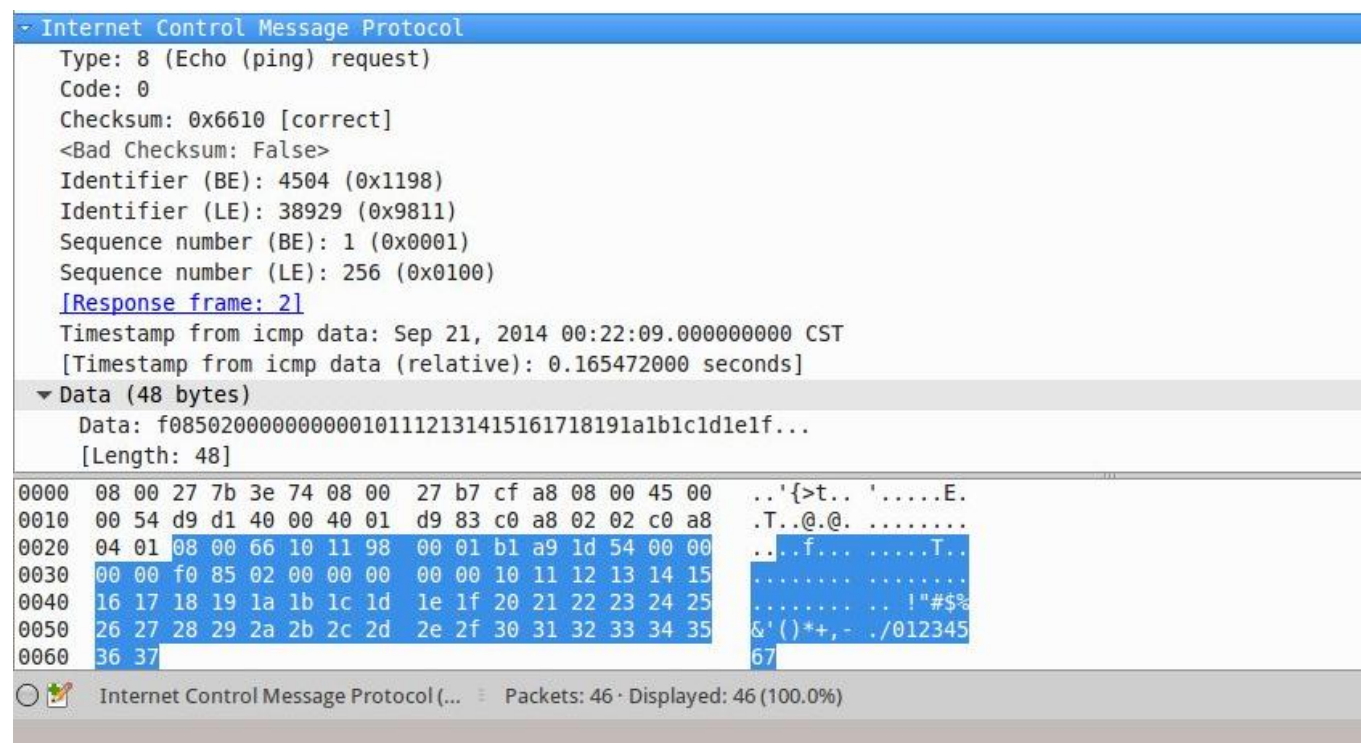
- Internet Protocol Version 4, Src: 192.168.2.2 (192.168.2.2), Dst: 192.168.4.1 (192.168.4.1)
  Version: 4
  Header length: 20 bytes
  ▶ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
  Total Length: 84
  Identification: 0xd9d1 (55761)
  ▶ Flags: 0x02 (Don't Fragment)
  Fragment offset: 0
  Time to live: 64
  Protocol: ICMP (1)
  ▶ Header checksum: 0xd983 [validation disabled]
  Source: 192.168.2.2 (192.168.2.2)
  <Source or Destination Address: 192.168.2.2 (192.168.2.2)>
  <[Source Host: 192.168.2.2]>
  <[Source or Destination Host: 192.168.2.2]>
  Destination: 192.168.4.1 (192.168.4.1)
  <Source or Destination Address: 192.168.4.1 (192.168.4.1)>
  <[Destination Host: 192.168.4.1]>
  <[Source or Destination Host: 192.168.4.1]>
  [Source GeoIP: Unknown]
  [Destination GeoIP: Unknown]

0000  08 00 27 7b 3e 74 08 00 27 b7 cf a8 08 00 45 00  ..'{}>t.. '.....E.
0010  00 54 d9 d1 40 00 40 01 d9 83 c0 a8 02 02 c0 a8  .T..@.@. ....
0020  04 01 08 00 66 10 11 98 00 01 b1 a9 1d 54 00 00  ....f... ..T..
0030  00 00 f0 85 02 00 00 00 00 00 10 11 12 13 14 15  ....

```

IP 协议 PDU 包含了 IP 版本, 头部长度, 服务类型, 总长度, 标志, 片偏移, 生存周期, 协议, 校验和, 源地址, 目的地址几项内容, 其中该包中 IP 版本为 4, 头部长度为 20bytes, 服务类型为 0x00, 总长度为 84, 标志位是 0x02, 片偏移是 0, 生存周期是 64, 首部校验和为 0xd983, 源地址是 192.168.2.2, 目的地址是 192.168.4.1。

Internet 控制报文协议 (此处是 ICMP 协议):



该字段中 Type 为 8，表示这是一个 ICMP 回显请求包，code 为 0，表示网络不可达，校验和为 0x6610，data 域长度为 48byte，这里面的内容是随机的。

6.实验中遇到的困难和解决办法

1. 无法设置 route 规则，提示 file exits

由于一开始设置时已经有了一部分规则，所以要先将默认的 route 规则删除掉，然后才能加入新的 route 规则。

2. 使用 sudo echo 1 > /proc/sys/net/ipv4/ip_forward 命令提示 permission denied

本条命令中实际包含了两个命令，分别是 echo 和>，然而 sudo 只能将 echo 提升至管理员权限，因而执行>命令时权限不够。解决方法大致有两种

1) sudo su 或者 su 进入超级用户模式（但是 su 模式好像直接无法进入）

2) sudo sh -c “echo 1 > /proc/sys/net/ipv4/ip_forward”

sh -c 是 bash 的命令，会将之后的字符串作为一个命令来执行。