

路由器转发实验报告

张磊 2017K8009922027

一、实验题目

路由器转发实验

二、实验内容

1. 基于已有代码，实现实现路由器转发功能，在 r1 上执行路由器程序，进行数据包处理，在 h1 上进行 ping 实验；
Ping 10.0.1.1(r1)，能够 ping 通；
Ping 10.0.2.22(h2)，能够 ping 通；
Ping 10.0.3.33(h3)，能够 ping 通；
Ping 10.0.3.11，返回 ICMP Destination Host Unreachable；
Ping 10.0.4.1，返回 ICMP Destination Net Unreachable；
2. 构造一个包含多个多个路由器节点组成的网络；
手动配置每个路由器节点的路由表；
有两个终端节点，通过路由器节点相连，两节点之间的跳数不少于 3 跳，手动配置其默认路由表；
3. 连通性测试；
在终端节点 ping 每个路由器节点的入端口 IP 地址，能够 ping 通；
4. 路径测试；
在一个终端节点上 traceroute 另一个节点，能够正确输出路径上的每个节点的 IP 信息；

三、实验流程

1. 基于附件中的代码，完成 arp.c, arpcache.c, icmp.c, ip_base.c, ip.c 的编写，实现路由器对数据包的转发处理功能；
2. 运行 router_topo.py 拓扑，在 r1 节点上运行 router 程序，在 h1 上进行 ping 实验；
3. 自己编写包含多个路由器节点的 topo 文件，手动配置其默认路由表，完成连通性测试和路径测试；

四、 实验结果

1. 实验内容一：

```

Node: h1
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ./scripts/d
isable_offloading.sh
Disabling h1-eth0 ...
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ping 10.0.1.1
PING 10.0.1.1 (10.0.1.1) 56(84) bytes of data.
64 bytes from 10.0.1.1: icmp_seq=1 ttl=64 time=0.243 ms
64 bytes from 10.0.1.1: icmp_seq=2 ttl=64 time=0.083 ms
64 bytes from 10.0.1.1: icmp_seq=3 ttl=64 time=0.081 ms
64 bytes from 10.0.1.1: icmp_seq=4 ttl=64 time=0.054 ms
64 bytes from 10.0.1.1: icmp_seq=5 ttl=64 time=0.080 ms
64 bytes from 10.0.1.1: icmp_seq=6 ttl=64 time=0.063 ms
64 bytes from 10.0.1.1: icmp_seq=7 ttl=64 time=0.097 ms
64 bytes from 10.0.1.1: icmp_seq=8 ttl=64 time=0.116 ms
64 bytes from 10.0.1.1: icmp_seq=9 ttl=64 time=0.066 ms
64 bytes from 10.0.1.1: icmp_seq=10 ttl=64 time=0.242 ms
64 bytes from 10.0.1.1: icmp_seq=11 ttl=64 time=0.178 ms
64 bytes from 10.0.1.1: icmp_seq=12 ttl=64 time=0.098 ms
64 bytes from 10.0.1.1: icmp_seq=13 ttl=64 time=0.099 ms
64 bytes from 10.0.1.1: icmp_seq=14 ttl=64 time=0.099 ms
64 bytes from 10.0.1.1: icmp_seq=15 ttl=64 time=0.101 ms
64 bytes from 10.0.1.1: icmp_seq=16 ttl=64 time=0.099 ms
64 bytes from 10.0.1.1: icmp_seq=17 ttl=64 time=0.098 ms
64 bytes from 10.0.1.1: icmp_seq=18 ttl=64 time=0.128 ms
64 bytes from 10.0.1.1: icmp_seq=19 ttl=64 time=0.099 ms

```

H1 ping 10.0.1.1

```

Node: h1
19 packets transmitted, 19 received, 0% packet loss, time 18431ms
rtt min/avg/max/mdev = 0.054/0.111/0.243/0.053 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ping 10.0.2.22
PING 10.0.2.22 (10.0.2.22) 56(84) bytes of data.
64 bytes from 10.0.2.22: icmp_seq=1 ttl=63 time=0.336 ms
64 bytes from 10.0.2.22: icmp_seq=2 ttl=63 time=0.124 ms
64 bytes from 10.0.2.22: icmp_seq=3 ttl=63 time=0.123 ms
64 bytes from 10.0.2.22: icmp_seq=4 ttl=63 time=0.121 ms
64 bytes from 10.0.2.22: icmp_seq=5 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=6 ttl=63 time=0.126 ms
64 bytes from 10.0.2.22: icmp_seq=7 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=8 ttl=63 time=0.126 ms
64 bytes from 10.0.2.22: icmp_seq=9 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=10 ttl=63 time=0.124 ms
64 bytes from 10.0.2.22: icmp_seq=11 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=12 ttl=63 time=0.124 ms
64 bytes from 10.0.2.22: icmp_seq=13 ttl=63 time=0.120 ms
64 bytes from 10.0.2.22: icmp_seq=14 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=15 ttl=63 time=0.135 ms
64 bytes from 10.0.2.22: icmp_seq=16 ttl=63 time=0.123 ms
64 bytes from 10.0.2.22: icmp_seq=17 ttl=63 time=0.125 ms
64 bytes from 10.0.2.22: icmp_seq=18 ttl=63 time=0.128 ms
64 bytes from 10.0.2.22: icmp_seq=19 ttl=63 time=0.123 ms
64 bytes from 10.0.2.22: icmp_seq=20 ttl=63 time=0.125 ms

```

H1 ping 10.0.2.22

```
"Node: h1"
rtt min/avg/max/mdev = 0.120/0.135/0.336/0.047 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ping 10.0.3.33
PING 10.0.3.33 (10.0.3.33) 56(84) bytes of data.
64 bytes from 10.0.3.33: icmp_seq=1 ttl=63 time=0.230 ms
64 bytes from 10.0.3.33: icmp_seq=2 ttl=63 time=0.122 ms
64 bytes from 10.0.3.33: icmp_seq=3 ttl=63 time=0.136 ms
64 bytes from 10.0.3.33: icmp_seq=4 ttl=63 time=0.123 ms
64 bytes from 10.0.3.33: icmp_seq=5 ttl=63 time=0.124 ms
64 bytes from 10.0.3.33: icmp_seq=6 ttl=63 time=0.139 ms
64 bytes from 10.0.3.33: icmp_seq=7 ttl=63 time=0.124 ms
64 bytes from 10.0.3.33: icmp_seq=8 ttl=63 time=0.215 ms
64 bytes from 10.0.3.33: icmp_seq=9 ttl=63 time=0.122 ms
64 bytes from 10.0.3.33: icmp_seq=10 ttl=63 time=0.124 ms
64 bytes from 10.0.3.33: icmp_seq=11 ttl=63 time=0.123 ms
64 bytes from 10.0.3.33: icmp_seq=12 ttl=63 time=0.124 ms
64 bytes from 10.0.3.33: icmp_seq=13 ttl=63 time=0.148 ms
64 bytes from 10.0.3.33: icmp_seq=14 ttl=63 time=0.124 ms
64 bytes from 10.0.3.33: icmp_seq=15 ttl=63 time=0.122 ms
64 bytes from 10.0.3.33: icmp_seq=16 ttl=63 time=0.123 ms
^C
--- 10.0.3.33 ping statistics ---
16 packets transmitted, 16 received, 0% packet loss, time 15351ms
rtt min/avg/max/mdev = 0.122/0.138/0.230/0.036 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1#
```

H1 ping 10.0.3.33

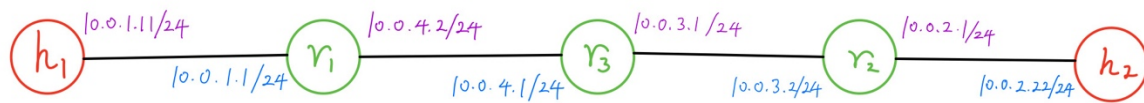
```
"Node: h1"
rtt min/avg/max/mdev = 0.122/0.138/0.230/0.036 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ping 10.0.3.11
PING 10.0.3.11 (10.0.3.11) 56(84) bytes of data.
From 10.0.1.1 icmp_seq=1 Destination Host Unreachable
From 10.0.1.1 icmp_seq=2 Destination Host Unreachable
From 10.0.1.1 icmp_seq=3 Destination Host Unreachable
From 10.0.1.1 icmp_seq=4 Destination Host Unreachable
From 10.0.1.1 icmp_seq=5 Destination Host Unreachable
From 10.0.1.1 icmp_seq=6 Destination Host Unreachable
From 10.0.1.1 icmp_seq=7 Destination Host Unreachable
From 10.0.1.1 icmp_seq=8 Destination Host Unreachable
From 10.0.1.1 icmp_seq=9 Destination Host Unreachable
From 10.0.1.1 icmp_seq=10 Destination Host Unreachable
From 10.0.1.1 icmp_seq=11 Destination Host Unreachable
From 10.0.1.1 icmp_seq=12 Destination Host Unreachable
From 10.0.1.1 icmp_seq=13 Destination Host Unreachable
From 10.0.1.1 icmp_seq=14 Destination Host Unreachable
From 10.0.1.1 icmp_seq=15 Destination Host Unreachable
From 10.0.1.1 icmp_seq=16 Destination Host Unreachable
From 10.0.1.1 icmp_seq=17 Destination Host Unreachable
From 10.0.1.1 icmp_seq=18 Destination Host Unreachable
From 10.0.1.1 icmp_seq=19 Destination Host Unreachable
From 10.0.1.1 icmp_seq=20 Destination Host Unreachable
From 10.0.1.1 icmp_seq=21 Destination Host Unreachable
```

H1 ping 10.0.3.11

```
^C
--- 10.0.3.11 ping statistics ---
27 packets transmitted, 0 received, +26 errors, 100% packet loss, time 26571ms
pipe 13
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-1# ping 10.0.4.1
PING 10.0.4.1 (10.0.4.1) 56(84) bytes of data:
From 10.0.1.1 icmp_seq=1 Destination Net Unreachable
From 10.0.1.1 icmp_seq=2 Destination Net Unreachable
From 10.0.1.1 icmp_seq=3 Destination Net Unreachable
From 10.0.1.1 icmp_seq=4 Destination Net Unreachable
From 10.0.1.1 icmp_seq=5 Destination Net Unreachable
From 10.0.1.1 icmp_seq=6 Destination Net Unreachable
From 10.0.1.1 icmp_seq=7 Destination Net Unreachable
From 10.0.1.1 icmp_seq=8 Destination Net Unreachable
From 10.0.1.1 icmp_seq=9 Destination Net Unreachable
From 10.0.1.1 icmp_seq=10 Destination Net Unreachable
From 10.0.1.1 icmp_seq=11 Destination Net Unreachable
From 10.0.1.1 icmp_seq=12 Destination Net Unreachable
From 10.0.1.1 icmp_seq=13 Destination Net Unreachable
From 10.0.1.1 icmp_seq=14 Destination Net Unreachable
From 10.0.1.1 icmp_seq=15 Destination Net Unreachable
From 10.0.1.1 icmp_seq=16 Destination Net Unreachable
From 10.0.1.1 icmp_seq=17 Destination Net Unreachable
From 10.0.1.1 icmp_seq=18 Destination Net Unreachable
```

H1 ping 10.0.4.1

2. 实验内容二:



3router_topo

```
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-2# ping 10.0.2.22
PING 10.0.2.22 (10.0.2.22) 56(84) bytes of data.
64 bytes from 10.0.2.22: icmp_seq=1 ttl=61 time=0.301 ms
64 bytes from 10.0.2.22: icmp_seq=2 ttl=61 time=0.199 ms
64 bytes from 10.0.2.22: icmp_seq=3 ttl=61 time=0.738 ms
64 bytes from 10.0.2.22: icmp_seq=4 ttl=61 time=0.209 ms
64 bytes from 10.0.2.22: icmp_seq=5 ttl=61 time=0.195 ms
64 bytes from 10.0.2.22: icmp_seq=6 ttl=61 time=0.216 ms
64 bytes from 10.0.2.22: icmp_seq=7 ttl=61 time=0.204 ms
64 bytes from 10.0.2.22: icmp_seq=8 ttl=61 time=0.248 ms
64 bytes from 10.0.2.22: icmp_seq=9 ttl=61 time=0.155 ms
64 bytes from 10.0.2.22: icmp_seq=10 ttl=61 time=0.193 ms
64 bytes from 10.0.2.22: icmp_seq=11 ttl=61 time=0.145 ms
64 bytes from 10.0.2.22: icmp_seq=12 ttl=61 time=0.401 ms
64 bytes from 10.0.2.22: icmp_seq=13 ttl=61 time=0.208 ms
64 bytes from 10.0.2.22: icmp_seq=14 ttl=61 time=0.200 ms
64 bytes from 10.0.2.22: icmp_seq=15 ttl=61 time=0.146 ms
^C
--- 10.0.2.22 ping statistics ---
15 packets transmitted, 15 received, 0% packet loss, time 14314ms
rtt min/avg/max/mdev = 0.145/0.250/0.738/0.145 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-2#
```

H1 ping 10.0.2.22

```
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router# ping 10.0.1.1
PING 10.0.1.1 (10.0.1.1) 56(84) bytes of data.
64 bytes from 10.0.1.1: icmp_seq=1 ttl=64 time=0.135 ms
64 bytes from 10.0.1.1: icmp_seq=2 ttl=64 time=0.093 ms
64 bytes from 10.0.1.1: icmp_seq=3 ttl=64 time=0.094 ms
64 bytes from 10.0.1.1: icmp_seq=4 ttl=64 time=0.094 ms
64 bytes from 10.0.1.1: icmp_seq=5 ttl=64 time=0.094 ms
64 bytes from 10.0.1.1: icmp_seq=6 ttl=64 time=0.094 ms
64 bytes from 10.0.1.1: icmp_seq=7 ttl=64 time=0.094 ms
^C
--- 10.0.1.1 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6106ms
rtt min/avg/max/mdev = 0.093/0.099/0.135/0.018 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router#
```

H1 ping 10.0.1.1(r1)

```

x _ "Node: h1"
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router# ping 10.0.4.1
PING 10.0.4.1 (10.0.4.1) 56(84) bytes of data.
64 bytes from 10.0.4.1: icmp_seq=1 ttl=63 time=0.172 ms
64 bytes from 10.0.4.1: icmp_seq=2 ttl=63 time=0.141 ms
64 bytes from 10.0.4.1: icmp_seq=3 ttl=63 time=0.272 ms
64 bytes from 10.0.4.1: icmp_seq=4 ttl=63 time=0.135 ms
64 bytes from 10.0.4.1: icmp_seq=5 ttl=63 time=0.130 ms
64 bytes from 10.0.4.1: icmp_seq=6 ttl=63 time=0.143 ms
64 bytes from 10.0.4.1: icmp_seq=7 ttl=63 time=0.147 ms
64 bytes from 10.0.4.1: icmp_seq=8 ttl=63 time=0.180 ms
^C
--- 10.0.4.1 ping statistics ---
8 packets transmitted, 8 received, 0% packet loss, time 7152ms
rtt min/avg/max/mdev = 0.130/0.165/0.272/0.043 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router#
```

H1 ping 10.0.4.1(r3)

```

x _ "Node: h1"
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router# ping 10.0.3.2
PING 10.0.3.2 (10.0.3.2) 56(84) bytes of data.
64 bytes from 10.0.3.2: icmp_seq=1 ttl=62 time=0.270 ms
64 bytes from 10.0.3.2: icmp_seq=2 ttl=62 time=0.191 ms
64 bytes from 10.0.3.2: icmp_seq=3 ttl=62 time=0.191 ms
64 bytes from 10.0.3.2: icmp_seq=4 ttl=62 time=0.180 ms
64 bytes from 10.0.3.2: icmp_seq=5 ttl=62 time=0.098 ms
64 bytes from 10.0.3.2: icmp_seq=6 ttl=62 time=0.180 ms
64 bytes from 10.0.3.2: icmp_seq=7 ttl=62 time=0.364 ms
^C
--- 10.0.3.2 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6124ms
rtt min/avg/max/mdev = 0.098/0.210/0.364/0.079 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router#
```

H1 ping 10.0.3.2(r2)

```

x _ "Node: h1"
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-2# traceroute
10.0.2.22
traceroute to 10.0.2.22 (10.0.2.22), 30 hops max, 60 byte packets
 1 10.0.1.1 (10.0.1.1) 0.061 ms 0.011 ms 0.010 ms
 2 10.0.4.1 (10.0.4.1) 0.051 ms 0.023 ms 0.023 ms
 3 10.0.3.2 (10.0.3.2) 0.102 ms 0.037 ms 0.034 ms
 4 10.0.2.22 (10.0.2.22) 0.056 ms 0.042 ms 0.041 ms
root@zhanglei-VirtualBox:~/Workspace/Network/07-router/07-router-2#
```

路径测试

五、 实验分析

1. 实验一中成功在 h1 上 ping 通 r1, h2, h3; 并且在 ping 10.0.3.11 时, 如期返回 ICMP Destination Host Unreachable; 在 ping 10.0.4.1 时, 如期返回 ICMP Destination Net Unreachable;
2. 实验二中, 构造 TOPO 满足路由器节点数要求(3 个)和主机节点跳数要求(至少 3 跳), 并在 h1 上成功 ping 通 h2, ping 通 r1, r3, r2, 完成连通性测试, traceroute 成功显示路径节点 IP 信息, 完成路径测试;

六、 反思总结

1. 本次实验代码量较之前的实验有了巨大的提升, 所以耗费时间比较长, 但是通过编写代码和 DEBUG, 让我对路由器如何进行数据包的转发, 对 ICMP 报文的格式, ARP 报文的格式都有了更加深刻的记忆和理解;
2. 通过对 arp.c, arpcache.c 的编写, 让我对路由器如何利用 arp 协议进行数据包转发, 以及 IP 地址和 MAC 地址在网络传输中的作用有了更加深刻的认识, MAC 地址只在局域网内起作用, 而 IP 在整个网络中都起作用;
3. 在 ip.base.c, ip.c, icmp.c 的编写中, 加深了我对路由器在网络层是如何处理收到的各种数据包的理解;

七、 参考文献

i

ii

iii 关于 ARP 协议, IP 协议数据报的格式

ⁱ 中国科学院大学 2020 春计算机网络研讨课 07-路由器转发实验课件

ⁱⁱ 中国科学院大学 2020 春计算机网络研讨课 07-路由器转发实验附件代码

ⁱⁱⁱ <https://akaedu.github.io/book/ch36s03.html>