

# LTE链路 IP隧道实现

lzy

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## 路由表信息

C端路由表和IP地址信息如下所示：

```

1 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ route
2 Kernel IP routing table
3 Destination      Gateway            Genmask           Flags Metric Ref    Use Iface
4 default          _gateway          0.0.0.0           UG        20100 0      0 enp45s0f0
5 default          _gateway          0.0.0.0           UG        20104 0      0 enp39s0
6 link-local       0.0.0.0           255.255.0.0       U         1000 0      0 enp45s0f0
7 172.16.1.0       0.0.0.0           255.255.255.0     U         101 0      0 enp45s0f1
8 172.16.2.0       0.0.0.0           255.255.255.0     U         102 0      0 enp45s0f2
9 172.16.3.0       0.0.0.0           255.255.255.0     U         103 0      0 enp45s0f3
10 192.168.0.0      0.0.0.0           255.255.255.0     U         104 0      0 enp39s0
11 192.168.1.0      0.0.0.0           255.255.255.0     U         100 0      0 enp45s0f0
12 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ sudo route del -net default netmask 0.0.0.0 dev
   enp45s0f0
13 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ sudo route add -net 192.168.2.0 netmask
   255.255.255.0 dev enp45s0f0 gw 192.168.1.1
14 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ ping 192.168.2.2
15 PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
16 64 bytes from 192.168.2.2: icmp_seq=1 ttl=63 time=2.14 ms
17 ^C
18 --- 192.168.2.2 ping statistics ---
19 1 packets transmitted, 1 received, 0% packet loss, time 0ms
20 rtt min/avg/max/mdev = 2.143/2.143/2.143/0.000 ms
21 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ route
22 Kernel IP routing table
23 Destination      Gateway            Genmask           Flags Metric Ref    Use Iface
24 default          _gateway          0.0.0.0           UG        20104 0      0 enp39s0
25 link-local       0.0.0.0           255.255.0.0       U         1000 0      0 enp45s0f0
26 172.16.1.0       0.0.0.0           255.255.255.0     U         101 0      0 enp45s0f1
27 172.16.2.0       0.0.0.0           255.255.255.0     U         102 0      0 enp45s0f2
28 172.16.3.0       0.0.0.0           255.255.255.0     U         103 0      0 enp45s0f3
29 192.168.0.0      0.0.0.0           255.255.255.0     U         104 0      0 enp39s0
30 192.168.1.0      0.0.0.0           255.255.255.0     U         100 0      0 enp45s0f0
31 192.168.2.0      192.168.1.1       255.255.255.0     UG        0      0      0 enp45s0f0
32 f410-client@f410client-MS-7C37:~/lzy/408_client_lte$ ifconfig enp45s0f0
33 enp45s0f0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
34     inet 192.168.1.2 netmask 255.255.255.0 broadcast 192.168.1.255
35     inet6 fe80::b083:44b4:4513:9631 prefixlen 64 scopeid 0x20<link>
36     ether 9c:69:b4:61:69:08 txqueuelen 1000 (Ethernet)
37     RX packets 27 bytes 1798 (1.7 KB)
38     RX errors 0 dropped 0 overruns 0 frame 0
39     TX packets 409 bytes 39072 (39.0 KB)
40     TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

```

S端路由表和IP地址信息如下所示：

```

1 f410-server@:408_server_lte$ route
2 内核 IP 路由表
3 目标          网关            子网掩码          标志  跃点  引用  使用  接口
4 default      _gateway        0.0.0.0           UG    100  0      0 enp45s0f0
5 default      _gateway        0.0.0.0           UG    104  0      0 enp39s0
6 link-local   0.0.0.0         255.255.0.0       U     1000 0      0 enp45s0f0
7 172.16.1.0   0.0.0.0         255.255.255.0     U     105  0      0 enp45s0f1
8 172.16.2.0   0.0.0.0         255.255.255.0     U     106  0      0 enp45s0f2
9 172.16.3.0   0.0.0.0         255.255.255.0     U     107  0      0 enp45s0f3
10 192.168.0.0  0.0.0.0         255.255.255.0     U     104  0      0 enp39s0

```

```
11 192.168.1.0 0.0.0.0 255.255.255.0 U 100 0 0 enp45s0f0
12 192.168.2.0 0.0.0.0 255.255.255.0 U 100 0 0 enp45s0f0
13 f410-server@408_server_lte$ ifconfig enp45s0f0
14 enp45s0f0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
15     inet 192.168.2.2 netmask 255.255.255.0 broadcast 192.168.2.255
16     inet6 fe80::8e2f:f9c4:eaf8:244b prefixlen 64 scopeid 0x20<link>
17     ether 9c:69:b4:62:4c:54 txqueuelen 1000 (以太网)
18     RX packets 954 bytes 62143 (62.1 KB)
19     RX errors 0 dropped 0 overruns 0 frame 0
20     TX packets 1538 bytes 130549 (130.5 KB)
21     TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

路由表修改命令常用：

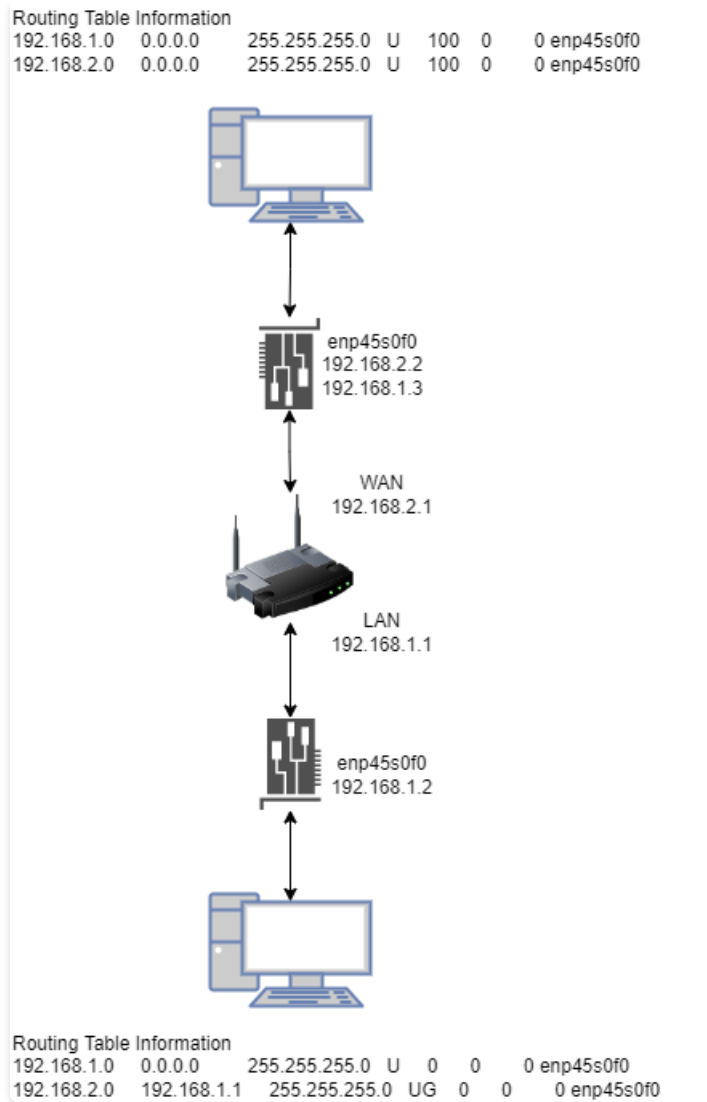
```
1 sudo route del -net default netmask 0.0.0.0 dev enp45s0f0
2 sudo route add -net 192.168.2.0 netmask 255.255.255.0 dev enp45s0f0 gw 192.168.1.1
```

iperf3打流测试命令：

```
1
2 iperf3 -u -c 10.0.0.1 -p10000 -l1400 -t100 -b100M -A2
3
4 iperf3 -s -p10000 -A2
5
```

## 网络环境

网络拓扑图如下所示, 注意S端的IP地址需要填写一个192.168.1.X的地址, 否则LINUX协议栈收到C端发送的报文头为192.168.1.X的报文, 不会对其进行上层提交。



Network topology diagram

## 代码修改

使用代码为408\_clientv2.0.0.zip

需要在C端和S端check.c中的 `do_lte` 函数中, 加入以下代码。链路0为LTE链路, 链路1-3为正常链路。

```
1 link[1].invalid = 0;
2 link[2].invalid = 0;
3 link[3].invalid = 0;
4 lte_on = lte_is_valid(link, link_count);
```

## client1\_conf.c

```
1
2 static struct nic_info nic_list[] = {
3     [0] = {
4         .name = "enp45s0f0",
```

```

5     .ip_str = "192.168.1.2",
6     .isvalid = 0,
7     },
8     [1] = {
9         .name = "enp45s0f1",
10        .ip_str = "172.16.1.10",
11        .isvalid = 0,
12    },
13    [2] = {
14        .name = "enp45s0f2",
15        .ip_str = "172.16.2.10",
16        .isvalid = 0,
17    },
18    [3] = {
19        .name = "enp45s0f3",
20        .ip_str = "172.16.3.10",
21        .isvalid = 0,
22    },
23 };
24
25 static struct link_info user0_link_list[] = {
26     [0] = {
27         .isvalid = 0,
28         .scale = 1,
29         .istosnd = 1,
30         .ip_str = "192.168.2.2",
31     },
32     [1] = {
33         .isvalid = 0,
34         .scale = 1,
35         .istosnd = 1,
36         .ip_str = "172.16.1.1",
37     },
38     [2] = {
39         .isvalid = 0,
40         .scale = 1,
41         .istosnd = 1,
42         .ip_str = "172.16.2.1",
43     },
44     [3] = {
45         .isvalid = 0,
46         .scale = 1,
47         .istosnd = 1,
48         .ip_str = "172.16.3.1",
49     },
50 };

```

## server\_conf.c

S端的用户链路信息中的IP地址, 为与其网卡对接的Wan口IP地址。

```

1
2 struct nic_info nic_list[] = {
3     [0] = {
4         .name = "enp45s0f0",
5         .ip_str = "192.168.2.2",
6         .isvalid = 0,
7     },
8     [1] = {
9         .name = "enp45s0f1",
10        .ip_str = "172.16.1.1",

```

```

11     .isvalid = 0,
12     },
13     [2] = {
14         .name = "enp45s0f2",
15         .ip_str = "172.16.2.1",
16         .isvalid = 0,
17     },
18     [3] = {
19         .name = "enp45s0f3",
20         .ip_str = "172.16.3.1",
21         .isvalid = 0,
22     },
23 };
24
25 struct link_info user0_link_list[] = {
26     [0] = {
27         .isvalid = 0,
28         .scale = 1,
29         .istosnd = 1,
30         .ip_str = "192.168.2.1",
31     },
32     [1] = {
33         .isvalid = 0,
34         .scale = 1,
35         .istosnd = 1,
36         .ip_str = "172.16.1.10",
37     },
38     [2] = {
39         .isvalid = 0,
40         .scale = 1,
41         .istosnd = 1,
42         .ip_str = "172.16.2.10",
43     },
44     [3] = {
45         .isvalid = 0,
46         .scale = 1,
47         .istosnd = 1,
48         .ip_str = "172.16.3.10",
49     },
50 };

```

## 测试

### ping测试

```

1 root@f410client-MS-7C37:/home/f410-client/lzy/408_client_lte# ping 192.168.2.2
2 PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
3 64 bytes from 192.168.2.2: icmp_seq=1 ttl=63 time=1.96 ms
4 64 bytes from 192.168.2.2: icmp_seq=2 ttl=63 time=2.71 ms
5 ^C
6 --- 192.168.2.2 ping statistics ---
7 2 packets transmitted, 2 received, 0% packet loss, time 1000ms
8 rtt min/avg/max/mdev = 1.963/2.338/2.714/0.378 ms
9 root@f410client-MS-7C37:/home/f410-client/lzy/408_client_lte# ping 10.0.0.1
10 PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
11 64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.671 ms
12 64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.776 ms
13 ^[[64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.899 ms
14 64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.730 ms
15 64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.841 ms

```

```

16 64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.702 ms
17 64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.825 ms
18 64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.671 ms
19 64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.810 ms
20 64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.927 ms
21 64 bytes from 10.0.0.1: icmp_seq=11 ttl=64 time=0.774 ms
22 64 bytes from 10.0.0.1: icmp_seq=12 ttl=64 time=0.902 ms
23 64 bytes from 10.0.0.1: icmp_seq=13 ttl=64 time=0.801 ms
24 64 bytes from 10.0.0.1: icmp_seq=14 ttl=64 time=0.883 ms
25 64 bytes from 10.0.0.1: icmp_seq=15 ttl=64 time=0.771 ms
26 64 bytes from 10.0.0.1: icmp_seq=16 ttl=64 time=0.778 ms
27 64 bytes from 10.0.0.1: icmp_seq=17 ttl=64 time=0.695 ms
28 64 bytes from 10.0.0.1: icmp_seq=18 ttl=64 time=0.809 ms
29 64 bytes from 10.0.0.1: icmp_seq=19 ttl=64 time=0.671 ms
30 64 bytes from 10.0.0.1: icmp_seq=20 ttl=64 time=0.791 ms
31 64 bytes from 10.0.0.1: icmp_seq=21 ttl=64 time=0.918 ms
32 64 bytes from 10.0.0.1: icmp_seq=22 ttl=64 time=0.781 ms
33 64 bytes from 10.0.0.1: icmp_seq=23 ttl=64 time=0.911 ms
34 ^C
35 --- 10.0.0.1 ping statistics ---
36 23 packets transmitted, 23 received, 0% packet loss, time 22498ms
37 rtt min/avg/max/mdev = 0.671/0.797/0.927/0.083 ms

```

## iperf3 打流测试(只保留LTE链路)

C端测试结果如下:

```

1 root@f410client-MS-7C37:/home/f410-client/lzy/408_client_lte# iperf3 -u -c 10.0.0.1 -p10000 -l1400 -
  t100 -b100M -A0
2 Connecting to host 10.0.0.1, port 10000
3 [ 4] local 10.0.0.10 port 47899 connected to 10.0.0.1 port 10000
4 [ ID] Interval           Transfer     Bandwidth       Total Datagrams
5 [ 4]  0.00-1.00    sec    10.8 MBytes   90.3 Mbits/sec    8066
6 [ 4]  1.00-2.00    sec    11.9 MBytes   100 Mbits/sec    8929
7 [ 4]  2.00-3.00    sec    11.9 MBytes   100 Mbits/sec    8929
8 [ 4]  3.00-4.00    sec    11.9 MBytes   100 Mbits/sec    8928
9 [ 4]  4.00-5.00    sec    11.9 MBytes   100 Mbits/sec    8929
10 [ 4]  5.00-6.00    sec    11.9 MBytes   100 Mbits/sec    8928
11 [ 4]  6.00-7.00    sec    11.9 MBytes   100 Mbits/sec    8929
12 [ 4]  7.00-8.00    sec    11.9 MBytes   100 Mbits/sec    8928
13 [ 4]  8.00-9.00    sec    11.9 MBytes   100 Mbits/sec    8929
14 [ 4]  9.00-10.00   sec    11.9 MBytes   100 Mbits/sec    8928
15 [ 4]  9.00-10.00   sec    11.9 MBytes   100 Mbits/sec    8928
16 - - - - -
17 [ ID] Interval           Transfer     Bandwidth       Jitter    Lost/Total Datagrams
18 [ 4]  0.00-10.00   sec    120 MBytes   101 Mbits/sec    0.000 ms   0/90208 (0%)
19 [ 4] Sent 90208 datagrams
20 iperf3: error - the server has terminated

```

S端测试结果如下:

```

1 root@:408_server_lte# iperf3 -s -p10000 -A0
2 -----
3 Server listening on 10000
4 -----
5 Accepted connection from 10.0.0.10, port 36586
6 [ 5] local 10.0.0.1 port 10000 connected to 10.0.0.10 port 47899
7 [ ID] Interval           Transfer     Bandwidth       Jitter    Lost/Total Datagrams

```



```

 8 [ 5] 0.00-1.00 sec 10.8 MBytes 90.3 Mbits/sec 0.011 ms 0/8065 (0%)
 9 [ 5] 1.00-2.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8929 (0%)
10 [ 5] 2.00-3.00 sec 11.9 MBytes 100 Mbits/sec 0.013 ms 0/8929 (0%)
11 [ 5] 3.00-4.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8928 (0%)
12 [ 5] 4.00-5.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8929 (0%)
13 [ 5] 5.00-6.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8928 (0%)
14 [ 5] 6.00-7.00 sec 11.9 MBytes 100 Mbits/sec 0.014 ms 0/8929 (0%)
15 [ 5] 7.00-8.00 sec 11.9 MBytes 100 Mbits/sec 0.014 ms 0/8928 (0%)
16 [ 5] 8.00-9.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8929 (0%)
17 [ 5] 9.00-10.00 sec 11.9 MBytes 100 Mbits/sec 0.012 ms 0/8928 (0%)
18 ^C[ 5] 10.00-10.23 sec 2.38 MBytes 87.1 Mbits/sec 0.012 ms 0/1786 (0%)
19 -----
20 [ ID] Interval          Transfer      Bandwidth      Jitter      Lost/Total Datagrams
21 [ 5] 0.00-10.23 sec 0.00 Bytes 0.00 bits/sec 0.012 ms 0/90208 (0%)
22 iperf3: interrupt - the server has terminated
23

```

## 内核打印信息

```

 1 [ 412.508711] USER0-0:[1.1]SND: 6651582 RCV: 282 DELAY: 0us Record:1
 2 DD:0
 3 [ 412.508713] USER0-1:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
 4 DD:0
 5 [ 412.508714] USER0-2:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
 6 DD:0
 7 [ 412.508714] USER0-3:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
 8 DD:0
 9 [ 413.020694] USER0-0:[1.1]SND: 6651582 RCV: 282 DELAY: 0us Record:1
10 DD:0
11 [ 413.020695] USER0-1:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
12 DD:0
13 [ 413.020696] USER0-2:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
14 DD:0
15 [ 413.020697] USER0-3:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
16 DD:0
17 [ 413.532680] USER0-0:[1.1]SND: 2661590 RCV: 439 DELAY: 0us Record:1
18 DD:0
19 [ 413.532682] USER0-1:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
20 DD:0
21 [ 413.532683] USER0-2:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
22 DD:0
23 [ 413.532684] USER0-3:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
24 DD:0
25 [ 414.044666] USER0-0:[1.1]SND: 222 RCV: 282 DELAY: 0us Record:1
26 DD:0
27 [ 414.044668] USER0-1:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
28 DD:0
29 [ 414.044669] USER0-2:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
30 DD:0
31 [ 414.044669] USER0-3:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
32 DD:0
33 [ 414.556652] USER0-0:[1.1]SND: 222 RCV: 282 DELAY: 0us Record:1
34 DD:0
35 [ 414.556654] USER0-1:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
36 DD:0
37 [ 414.556655] USER0-2:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
38 DD:0
39 [ 414.556656] USER0-3:[0.1]SND: 246 RCV: 0 DELAY: 0us Record:1
40 DD:0

```