网络传输机制实验二

孙佳钰 2015K8009929051

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1 实验内容

TCP 协议是传输层中面向连接的通用协议。本次实验需要实现部分 TCP 协议，内容有：

- 为收发数据包更新状态机。
- 实现对端口数据结构中环形缓冲区的读写操作，并根据缓冲区设置接收窗口。
- 实现将字符串封装到 tcp 数据包中并发送。

2 实验流程

由于代码太多，故报告中没有加入完整代码，完整代码可见附件。

2.1 更新状态机

增加了 *TCP_PSH* 包，用于发送数据。在收到置有该标志位的数据包后要将数据写入相应端口数据结构的环形缓冲区中，并用更新后的缓冲区大小作为接收窗口回复确认数据包。

```
case TCP_PSH | TCP_ACK:
  if (TCP_ESTABLISHED == tsk->state) {
    pthread_mutex_lock(&tsk->rcv_buf->lock);
    write_ring_buffer(tsk->rcv_buf, cb->payload, cb->pl_len);
    pthread_mutex_unlock(&tsk->rcv_buf->lock);
    tsk->rcv_wnd = ring_buffer_free(tsk->rcv_buf);
    tcp_send_control_packet(tsk, TCP_ACK);
  }
break;
```

2.2 缓冲区的读操作

对缓冲区的读写都要进行加锁。读出部分缓冲区内容后要更新端口数据结构的接收窗口值。在已处于 *TCP_CLOSE_WAIT* 状态且缓冲区中没有未处理数据时应返回-1，由调用函数断开连接。

```c
int tcp_sock_read(struct tcp_sock *tsk, char *buf, int len) {
  pthread_mutex_lock(&tsk->rcv_buf->lock);
  int res = read_ring_buffer(tsk->rcv_buf, buf, len);
  pthread_mutex_unlock(&tsk->rcv_buf->lock);
  tsk->rcv_wnd = ring_buffer_free(tsk->rcv_buf);
  if (0 == res && TCP_CLOSE_WAIT == tsk->state) return -1;
  return res;
}
```

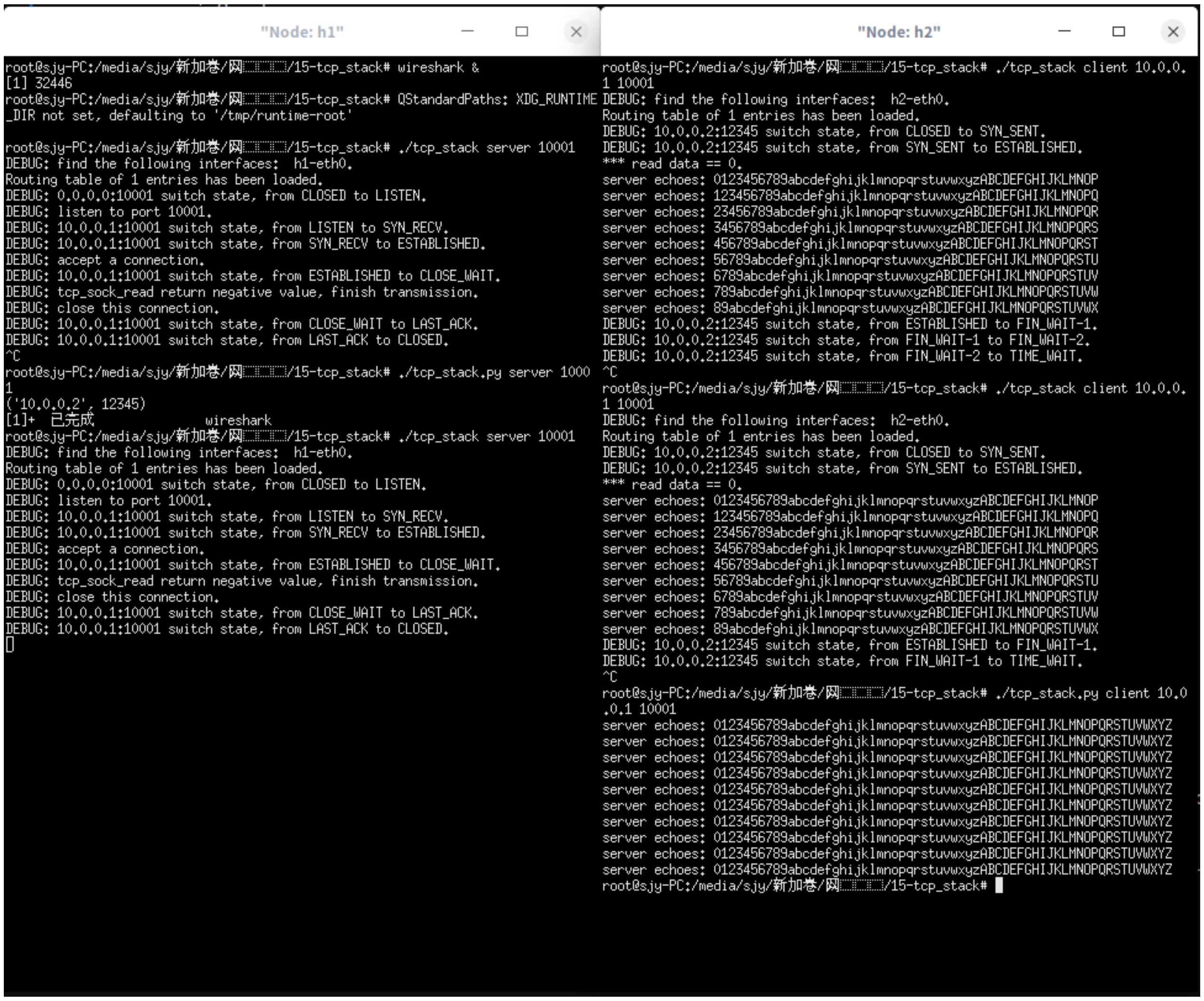
2.3 以 tcp 数据包发送字符串

由于 *tcp_send_packet* 函数中会处理所有的首部，故该函数中只需给数据包分配空间，然后将要发送的字符串复制到对应位置即可。

该函数未判断传入字符串长度是否超过该链路下允许发送的最长 tcp 字节长度，显然本次实验所有报文均未超过。

```c
int tcp_sock_write(struct tcp_sock *tsk, char *buf, int len) {
  int tot_len = ETHER_HDR_SIZE + IP_BASE_HDR_SIZE + TCP_BASE_HDR_SIZE + len;
  char *packet = malloc(tot_len);
  memset(packet, 0, tot_len);
  memcpy(packet + tot_len - len, buf, len);
  tcp_send_packet(tsk, packet, tot_len);
  return 0;
}
```

3 实验结果及分析



"Node: h1"

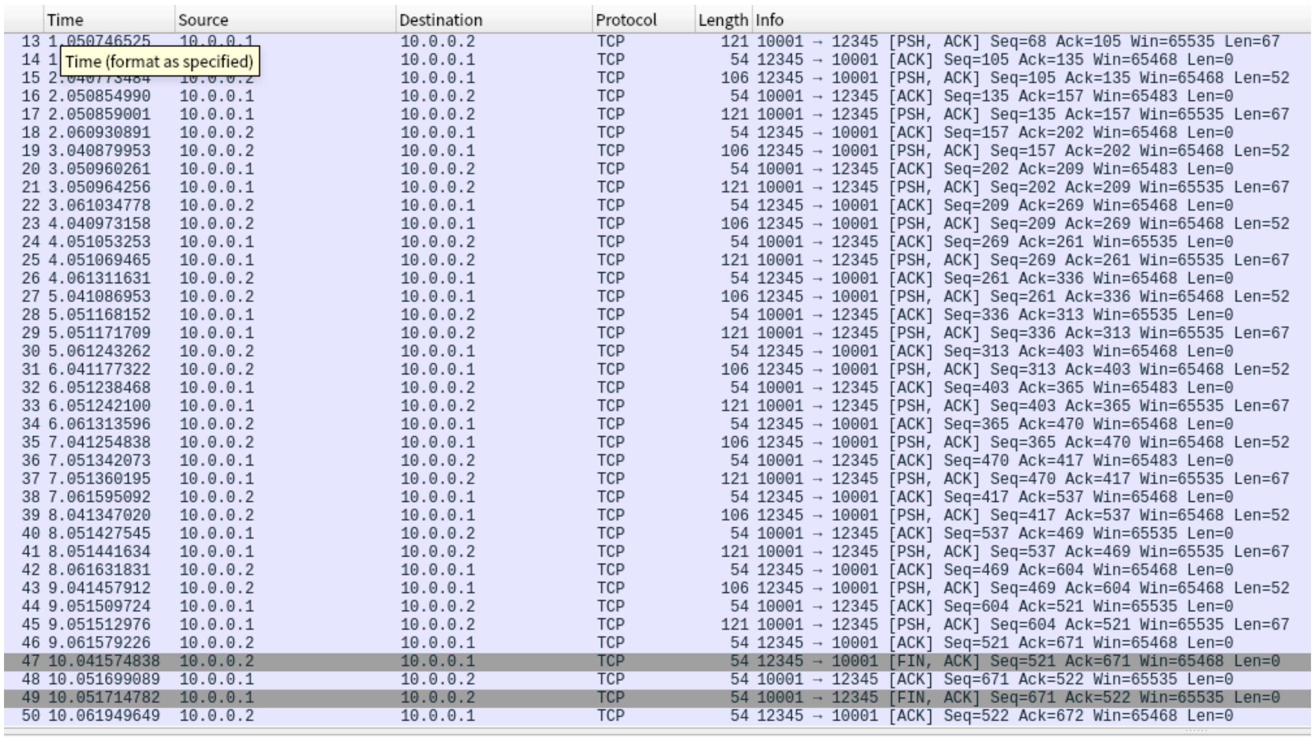
```
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# wireshark &
[1] 32446
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# QStandardPaths: XDG_RUNTIME
_DIR not set, defaulting to '/tmp/runtime-root'

root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack server 10001
DEBUG: find the following interfaces:  h1-eth0.
Routing table of 1 entries has been loaded.
DEBUG: 0.0.0.0:10001 switch state, from CLOSED to LISTEN.
DEBUG: listen to port 10001.
DEBUG: 10.0.0.1:10001 switch state, from LISTEN to SYN_RECV.
DEBUG: 10.0.0.1:10001 switch state, from SYN_RECV to ESTABLISHED.
DEBUG: accept a connection.
DEBUG: 10.0.0.1:10001 switch state, from ESTABLISHED to CLOSE_WAIT.
DEBUG: tcp_sock_read return negative value, finish transmission.
DEBUG: close this connection.
DEBUG: 10.0.0.1:10001 switch state, from CLOSE_WAIT to LAST_ACK.
DEBUG: 10.0.0.1:10001 switch state, from LAST_ACK to CLOSED.
^C
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack.py server 1000
1
('10.0.0.2', 12345)
[1]+  已完成               wireshark
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack server 10001
DEBUG: find the following interfaces:  h1-eth0.
Routing table of 1 entries has been loaded.
DEBUG: 0.0.0.0:10001 switch state, from CLOSED to LISTEN.
DEBUG: listen to port 10001.
DEBUG: 10.0.0.1:10001 switch state, from LISTEN to SYN_RECV.
DEBUG: 10.0.0.1:10001 switch state, from SYN_RECV to ESTABLISHED.
DEBUG: accept a connection.
DEBUG: 10.0.0.1:10001 switch state, from ESTABLISHED to CLOSE_WAIT.
DEBUG: tcp_sock_read return negative value, finish transmission.
DEBUG: close this connection.
DEBUG: 10.0.0.1:10001 switch state, from CLOSE_WAIT to LAST_ACK.
DEBUG: 10.0.0.1:10001 switch state, from LAST_ACK to CLOSED.
```

"Node: h2"

```
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack client 10.0.0.
1 10001
DEBUG: find the following interfaces:  h2-eth0.
Routing table of 1 entries has been loaded.
DEBUG: 10.0.0.2:12345 switch state, from CLOSED to SYN_SENT.
DEBUG: 10.0.0.2:12345 switch state, from SYN_SENT to ESTABLISHED.
*** read data == 0.
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOP
server echoes: 123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQ
server echoes: 23456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQR
server echoes: 3456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRS
server echoes: 456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRST
server echoes: 56789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTU
server echoes: 6789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUV
server echoes: 789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVW
server echoes: 89abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWX
DEBUG: 10.0.0.2:12345 switch state, from ESTABLISHED to FIN_WAIT-1.
DEBUG: 10.0.0.2:12345 switch state, from FIN_WAIT-1 to FIN_WAIT-2.
DEBUG: 10.0.0.2:12345 switch state, from FIN_WAIT-2 to TIME_WAIT.
^C
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack client 10.0.0.
1 10001
DEBUG: find the following interfaces:  h2-eth0.
Routing table of 1 entries has been loaded.
DEBUG: 10.0.0.2:12345 switch state, from CLOSED to SYN_SENT.
DEBUG: 10.0.0.2:12345 switch state, from SYN_SENT to ESTABLISHED.
*** read data == 0.
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOP
server echoes: 123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQ
server echoes: 23456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQR
server echoes: 3456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRS
server echoes: 456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRST
server echoes: 56789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTU
server echoes: 6789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUV
server echoes: 789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVW
server echoes: 89abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWX
DEBUG: 10.0.0.2:12345 switch state, from ESTABLISHED to FIN_WAIT-1.
DEBUG: 10.0.0.2:12345 switch state, from FIN_WAIT-1 to TIME_WAIT.
^C
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# ./tcp_stack.py client 10.0
.0.1 10001
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
server echoes: 0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ
root@sjy-PC:/media/sjy/新加卷/网□□□/15-tcp_stack# 
```

可以看出使用 python 文件替换后结果也是正确的。



```
   Time          Source          Destination     Protocol  Length Info
13 1.050746525   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=68 Ack=105 Win=65535 Len=67
14 1[illegible]                  10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=105 Ack=135 Win=65468 Len=0
15 2.040773484   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=105 Ack=135 Win=65468 Len=52
16 2.050854990   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=135 Ack=157 Win=65483 Len=0
17 2.050859001   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=135 Ack=157 Win=65535 Len=67
18 2.060930891   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=157 Ack=202 Win=65468 Len=0
19 3.040879953   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=157 Ack=202 Win=65468 Len=52
20 3.050960261   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=202 Ack=209 Win=65483 Len=0
21 3.050964256   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=202 Ack=209 Win=65535 Len=67
22 3.061034778   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=209 Ack=269 Win=65468 Len=0
23 4.040973158   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=209 Ack=269 Win=65468 Len=52
24 4.051053253   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=269 Ack=261 Win=65535 Len=0
25 4.051069465   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=269 Ack=261 Win=65535 Len=67
26 4.061311631   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=261 Ack=336 Win=65468 Len=0
27 5.041086953   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=261 Ack=336 Win=65468 Len=52
28 5.051168152   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=336 Ack=313 Win=65535 Len=0
29 5.051171709   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=336 Ack=313 Win=65535 Len=67
30 5.061243262   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=313 Ack=403 Win=65468 Len=0
31 6.041177322   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=313 Ack=403 Win=65468 Len=52
32 6.051238468   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=403 Ack=365 Win=65483 Len=0
33 6.051242100   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=403 Ack=365 Win=65535 Len=67
34 6.061313596   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=365 Ack=470 Win=65468 Len=0
35 7.041254838   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=365 Ack=470 Win=65468 Len=52
36 7.051342073   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=470 Ack=417 Win=65483 Len=0
37 7.051360195   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=470 Ack=417 Win=65535 Len=67
38 7.061595092   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=417 Ack=537 Win=65468 Len=0
39 8.041347020   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=417 Ack=537 Win=65468 Len=52
40 8.051427545   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=537 Ack=469 Win=65535 Len=0
41 8.051441634   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=537 Ack=469 Win=65535 Len=67
42 8.061631831   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=469 Ack=604 Win=65468 Len=0
43 9.041457912   10.0.0.2        10.0.0.1        TCP       106 12345 → 10001 [PSH, ACK] Seq=469 Ack=604 Win=65468 Len=52
44 9.051509724   10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=604 Ack=521 Win=65535 Len=0
45 9.051512976   10.0.0.1        10.0.0.2        TCP       121 10001 → 12345 [PSH, ACK] Seq=604 Ack=521 Win=65535 Len=67
46 9.061579226   10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=521 Ack=671 Win=65468 Len=0
47 10.041574838  10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [FIN, ACK] Seq=521 Ack=671 Win=65468 Len=0
48 10.051699089  10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [ACK] Seq=671 Ack=522 Win=65535 Len=0
49 10.051714782  10.0.0.1        10.0.0.2        TCP        54 10001 → 12345 [FIN, ACK] Seq=671 Ack=522 Win=65535 Len=0
50 10.061949649  10.0.0.2        10.0.0.1        TCP        54 12345 → 10001 [ACK] Seq=522 Ack=672 Win=65468 Len=0
```

可以看出接收窗口也发生了改变。