

- 1.
2. Identify the sockets that belong to the connection and their TCP state.

```
sakura
Terminal 1 Terminal 2 Terminal 3 Terminal 4
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 0.0.0.0:37             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:7              0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:9              0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:13             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:80             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:6000           0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:19             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:21             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:22             0.0.0.0:*               LISTEN
tcp        0      0 10.0.0.2:46349         10.0.1.2:21            ESTABLISHED
tcp        0      0 0.0.0.0:6000           0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:82             0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:22             0.0.0.0:*               LISTEN
```

3. Identify the *three-way-handshaking* and the termination of the tcp connection.

```
root@home:~# tcpdump -s 1500 -lnXi e1 port ftp -X
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on e1, link-type EN10MB (Ethernet), capture size 1500 bytes
18:56:00.265170 IP 10.0.0.2.46353 > 10.0.1.2.21: Flags [S], seq 140988995, win 14600, options [mss 1460,nop,nop,TS val 2500424 ecr 0], length 0
0x0000: 0800 272e 5e4e 0800 27da 1a7f 0800 4500  ..'.^N.....E.
0x0010: 0038 750b 4000 4006 b0b1 0a00 0002 0a00  .8u.@.....
0x0020: 0102 b511 0015 0867 5243 0000 0000 9002  .....gRC.....
0x0030: 3908 152e 0000 0204 05b4 0101 080a 0026  9.....&
0x0040: 2748 0000 0000 0000 0000 0000 0000 0000  'H.....
18:56:00.269502 IP 10.0.1.2.21 > 10.0.0.2.46353: Flags [S.], seq 1569384848, ack 140988996, win 14480, options [mss 1460,nop,nop,TS val 2488526 ecr 2500424], length 0
0x0000: 0800 27da 1a7f 0800 272e 5e4e 0800 4500  ..'.^N.....E.
0x0010: 0038 0000 4000 3f06 26bd 0a00 0102 0a00  .8..@.?.&.....
0x0020: 0002 0015 b511 5d8a e990 0867 5244 9012  .....]....gRD..
0x0030: 3890 9a1c 0000 0204 05b4 0101 080a 0025  8.....%
0x0040: f8ce 0026 2748 0000 0000 0000 0000 0000  ...&'H.....
18:56:00.269561 IP 10.0.0.2.46353 > 10.0.1.2.21: Flags [.], ack 1, win 14600, options [nop,nop,TS val 2500424 ecr 2488526], length 0
0x0000: 0800 272e 5e4e 0800 27da 1a7f 0800 4500  ..'.^N.....E.
0x0010: 0038 750b 4000 4006 b0b1 0a00 0002 0a00  .8u.@.....
0x0020: 0102 b511 0015 0867 5244 5d8a ea84 8018  .....gRM]....
0x0030: 3908 152e 0000 0101 080a 0026 274c 0025  9..*.....&'L.%
0x0040: f8ce 0026 2748 0000 0000 0000 0000 0000  ...&'H.....
18:56:00.275999 IP 10.0.1.2.21 > 10.0.0.2.46353: Flags [P.], seq 1:209, ack 1, win 15544, options [nop,nop,TS val 2507664 ecr 2494864], length 9
0x0000: 0800 272e 5e4e 0800 27da 1a7f 0800 4510  ..'.^N.....E.
0x0010: 003d 7510 4000 4006 b097 0a00 0002 0a00  .=u.@.....
0x0020: 0102 b511 0015 0867 524d 5d8a ea84 8018  .....gRM]....
0x0030: 3cbb 4680 0000 0101 080a 0026 4390 0026  <.F.....&C..&
0x0040: 1190 5041 5353 2078 630d 0a00 0000 0000  ..PASS.xc...
```

4. Look for the segment where the password has been sent, and where the command “dir” has been executed.

a. Password:

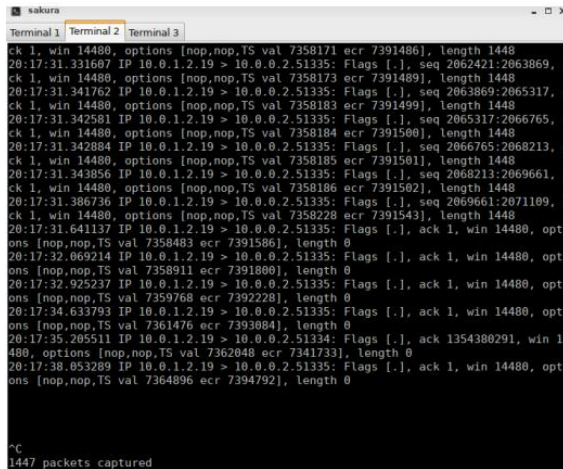
```
18:56:07.506024 IP 10.0.0.2.46353 > 10.0.1.2.21: Flags [P.], seq 10:19, ack 244, win 15544, options [nop,nop,TS val 2507664 ecr 2494864], length 9
0x0000: 0800 272e 5e4e 0800 27da 1a7f 0800 4510  ..'.^N.....E.
0x0010: 003d 7510 4000 4006 b097 0a00 0002 0a00  .=u.@.....
0x0020: 0102 b511 0015 0867 524d 5d8a ea84 8018  .....gRM]....
0x0030: 3cbb 4680 0000 0101 080a 0026 4390 0026  <.F.....&C..&
0x0040: 1190 5041 5353 2078 630d 0a00 0000 0000  ..PASS.xc...
```

b. Command “dir”:

```
18:56:07.512242 IP 10.0.1.2.21 > 10.0.0.2.46353: Flags [P.], seq 244:287, ack 19, win 14480, options [nop,nop,TS val 2495772 ecr 2507664], length 43
0x0000: 0800 27da 1a7f 0800 272e 5e4e 0800 4510  ..'.^N.....E.
0x0010: 005f 1145 4000 3f06 1541 0a00 0102 0a00  ._.E@.?.A.....
0x0020: 0002 0015 b511 5d8a ea84 0867 5256 8018  .....]....gRV..
0x0030: 3890 4500 0000 0101 080a 0026 151c 0026  8.E.....&...&
0x0040: 4390 3233 3020 4f4b 2e20 4375 7272 656e  C.230.OK..Curren
0x0050: 7420 7265 7374 7269 6374 6564 2064 6972  t.restricted.dir
0x0060: 6563 746f 7279 2069 7320 2f0d 0a00 0000  ectory.is/...
```

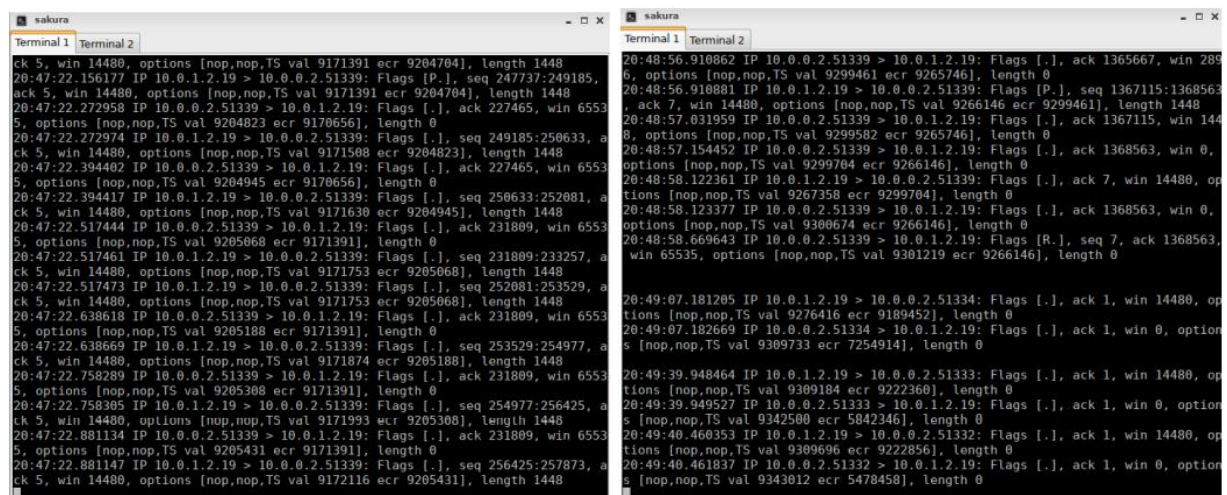
- 5.
6. Estimate the effective transmission speed of the connection:
Length = 1448
Time intervals from 19:31:52 to 19:31:54 (2 seconds)
Effective Transmission Speed = 724 bps
7. Check whether there are losses.
There are losses because of the limit of 200 packets to capture.
8. Why is that?
Because we are connecting to the chargen connection from the client.
9. Relate the evolution of the window with the slow start.
The difference between the sequence number in ack and the received next is the length of the information.
For example, if the ack number in a sequence is 146249 and the received next is 147697, the length is 147697-146249=1448 bytes.

10. Which window do you think is limiting the transmission: the advertised (awnd) or the congestion (cwnd)?
The congestion (cwnd).
11. What does the server do when the window is 0?
12. With the charged connection established, try tcpdump using expressions.



```
Terminal 1 Terminal 2
ck 1, win 14480, options [nop,nop,TS val 7358171 ecr 7391486], length 1448
20:17:31.331687 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2062421:2063869, a
ck 1, win 14480, options [nop,nop,TS val 7358173 ecr 7391489], length 1448
20:17:31.341762 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2063869:2065317, a
ck 1, win 14480, options [nop,nop,TS val 7358183 ecr 7391499], length 1448
20:17:31.342581 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2065317:2066765, a
ck 1, win 14480, options [nop,nop,TS val 7358184 ecr 7391500], length 1448
20:17:31.342884 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2066765:2068213, a
ck 1, win 14480, options [nop,nop,TS val 7358185 ecr 7391501], length 1448
20:17:31.343856 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2068213:2069661, a
ck 1, win 14480, options [nop,nop,TS val 7358186 ecr 7391502], length 1448
20:17:31.386736 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], seq 2069661:2071109, a
ck 1, win 14480, options [nop,nop,TS val 7358228 ecr 7391543], length 1448
20:17:31.641137 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1, win 14480, opti
ons [nop,nop,TS val 7358483 ecr 7391586], length 0
20:17:32.069214 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1, win 14480, opti
ons [nop,nop,TS val 7358911 ecr 7391800], length 0
20:17:32.925237 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1, win 14480, opti
ons [nop,nop,TS val 7359768 ecr 7392228], length 0
20:17:34.633793 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1, win 14480, opti
ons [nop,nop,TS val 7361476 ecr 7393884], length 0
20:17:35.285511 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1354380291, win 14
480, options [nop,nop,TS val 7362048 ecr 7341733], length 0
20:17:38.053289 IP 10.0.1.2.19 > 10.0.0.2.51335: Flags [P], ack 1, win 14480, opti
ons [nop,nop,TS val 7364896 ecr 7394792], length 0
^C
1447 packets captured
```

13. Configure the queue and repeat the commands.
 - a. Look for the first duplicate ack and check that the server retransmits the lost packets afterwards.
Look at the trace captured by the client and check that effectively the packet was lost.



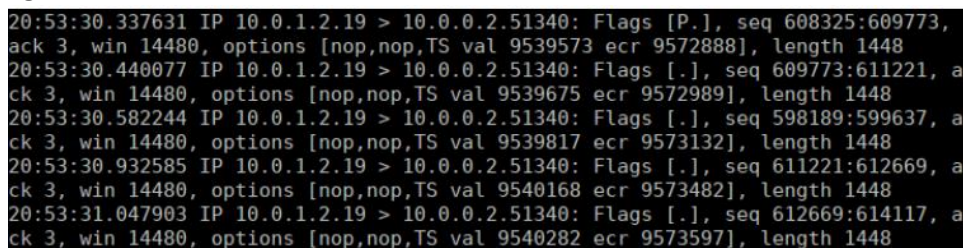
```
Terminal 1 Terminal 2
ck 5, win 14480, options [nop,nop,TS val 9171391 ecr 9204704], length 1448
20:47:22.156177 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 247737:249185,
ack 5, win 14480, options [nop,nop,TS val 9171391 ecr 9204704], length 1448
20:47:22.272958 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 227465, win 6553
5, options [nop,nop,TS val 9204823 ecr 9170656], length 0
20:47:22.272974 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 249185:250633, a
ck 5, win 14480, options [nop,nop,TS val 9171588 ecr 9204823], length 1448
20:47:22.394402 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 227465, win 6553
5, options [nop,nop,TS val 9204945 ecr 9170656], length 0
20:47:22.394417 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 250633:252081, a
ck 5, win 14480, options [nop,nop,TS val 9171638 ecr 9204945], length 1448
20:47:22.517444 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 231809, win 6553
5, options [nop,nop,TS val 9205068 ecr 9171391], length 0
20:47:22.517461 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 231809:233257, a
ck 5, win 14480, options [nop,nop,TS val 9171753 ecr 9205068], length 1448
20:47:22.517473 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 252081:253529, a
ck 5, win 14480, options [nop,nop,TS val 9171753 ecr 9205068], length 1448
20:47:22.638618 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 231809, win 6553
5, options [nop,nop,TS val 9205188 ecr 9171391], length 0
20:47:22.638659 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 253529:254977, a
ck 5, win 14480, options [nop,nop,TS val 9171874 ecr 9205188], length 1448
20:47:22.758289 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 231809, win 6553
5, options [nop,nop,TS val 9205388 ecr 9171391], length 0
20:47:22.758385 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 254977:256425, a
ck 5, win 14480, options [nop,nop,TS val 9171993 ecr 9205388], length 1448
20:47:22.881134 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 231809, win 6553
5, options [nop,nop,TS val 9205431 ecr 9171391], length 0
20:47:22.881147 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 256425:257873, a
ck 5, win 14480, options [nop,nop,TS val 9172116 ecr 9205431], length 1448

20:48:56.910862 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 1365667, win 289
6, options [nop,nop,TS val 9299461 ecr 9265746], length 0
20:48:56.910881 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], seq 1367115:1368563
, ack 7, win 14480, options [nop,nop,TS val 9266146 ecr 9299461], length 1448
20:48:57.031959 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 1367115, win 144
8, options [nop,nop,TS val 9299582 ecr 9265746], length 0
20:48:57.154452 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 1368563, win 0,
options [nop,nop,TS val 9299704 ecr 9266146], length 0
20:48:58.122361 IP 10.0.1.2.19 > 10.0.0.2.51339: Flags [P], ack 7, win 14480, op
tions [nop,nop,TS val 9267358 ecr 9299704], length 0
20:48:58.123377 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [P], ack 1368563, win 0,
options [nop,nop,TS val 9300674 ecr 9266146], length 0
20:48:58.669643 IP 10.0.0.2.51339 > 10.0.1.2.19: Flags [R], seq 7, ack 1368563,
win 65535, options [nop,nop,TS val 9301219 ecr 9266146], length 0

20:49:07.181205 IP 10.0.1.2.19 > 10.0.0.2.51334: Flags [P], ack 1, win 14480, op
tions [nop,nop,TS val 9276416 ecr 9189452], length 0
20:49:07.182669 IP 10.0.0.2.51334 > 10.0.1.2.19: Flags [P], ack 1, win 0, option
s [nop,nop,TS val 9309733 ecr 7254914], length 0

20:49:39.948464 IP 10.0.1.2.19 > 10.0.0.2.51333: Flags [P], ack 1, win 14480, op
tions [nop,nop,TS val 9309184 ecr 9222360], length 0
20:49:39.949527 IP 10.0.0.2.51333 > 10.0.1.2.19: Flags [P], ack 1, win 0, option
s [nop,nop,TS val 9342500 ecr 5842346], length 0
20:49:40.468353 IP 10.0.1.2.19 > 10.0.0.2.51332: Flags [P], ack 1, win 14480, op
tions [nop,nop,TS val 9309696 ecr 9222856], length 0
20:49:40.461837 IP 10.0.0.2.51332 > 10.0.1.2.19: Flags [P], ack 1, win 0, option
s [nop,nop,TS val 9343012 ecr 5478458], length 0
```

- b. Check that after the transmission the tcp window keep increasing slowly until there are losses again.



```
20:53:30.337631 IP 10.0.1.2.19 > 10.0.0.2.51340: Flags [P], seq 608325:609773,
ack 3, win 14480, options [nop,nop,TS val 9539573 ecr 9572888], length 1448
20:53:30.440077 IP 10.0.1.2.19 > 10.0.0.2.51340: Flags [P], seq 609773:611221, a
ck 3, win 14480, options [nop,nop,TS val 9539675 ecr 9572989], length 1448
20:53:30.582244 IP 10.0.1.2.19 > 10.0.0.2.51340: Flags [P], seq 598189:599637, a
ck 3, win 14480, options [nop,nop,TS val 9539817 ecr 9573132], length 1448
20:53:30.932585 IP 10.0.1.2.19 > 10.0.0.2.51340: Flags [P], seq 611221:612669, a
ck 3, win 14480, options [nop,nop,TS val 9540168 ecr 9573482], length 1448
20:53:31.047903 IP 10.0.1.2.19 > 10.0.0.2.51340: Flags [P], seq 612669:614117, a
ck 3, win 14480, options [nop,nop,TS val 9540282 ecr 9573597], length 1448
```

14. Estimate the value of RTT in the three-way-handshaking and when the losses are produced. Why is it different?

It is different because, when there are losses, we need to send the packets and their corresponding acks, so it is slower.