

CS305-2022 Fall Lab8 Report

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Practice8-1: TCP stream

Firstly, we should know the ipv4 address of **gaia.cs.umass.edu**, so we open the command line and do DNS query:

```
1 nslookup gaia.cs.umass.edu
```

The query result is shown below:

```
C:\Users\Administrator>nslookup gaia.cs.umass.edu
服务器:    nsl.sustech.edu.cn
Address:    172.18.1.92

非权威应答:
名称:      gaia.cs.umass.edu
Address:    128.119.245.12
```

So, then we open the Wireshark, and start capturing the packets, using the **display filters**:

```
1 ip.addr == 128.119.245.12 && tcp.stream
```

Then, open the command line, and invoke a HTTP request:

```
1 curl http://gaia.cs.umass.edu/wiresharklabs/alice.txt
```

And we can get multiple packets:

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
2	0.253159	128.119.245.12	10.26.144.43	TCP	66	80 → 55632 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM WS=128
3	0.253274	10.26.144.43	128.119.245.12	TCP	54	55632 → 80 [ACK] Seq=1 Ack=1 Win=131328 Len=0
4	0.253462	10.26.144.43	128.119.245.12	HTTP	158	GET /wiresharklabs/alice.txt HTTP/1.1
5	0.500723	128.119.245.12	10.26.144.43	TCP	56	80 → 55632 [ACK] Seq=1 Ack=105 Win=29312 Len=0
6	0.500723	128.119.245.12	10.26.144.43	TCP	14654	80 → 55632 [ACK] Seq=1 Ack=105 Win=29312 Len=14600 [TCP segment of a reassembled PDU]
7	0.500897	10.26.144.43	128.119.245.12	TCP	54	55632 → 80 [ACK] Seq=105 Ack=14601 Win=131328 Len=0
8	0.755790	128.119.245.12	10.26.144.43	TCP	20494	80 → 55632 [ACK] Seq=14601 Ack=105 Win=29312 Len=20440 [TCP segment of a reassembled PDU]
9	0.755790	128.119.245.12	10.26.144.43	TCP	5894	[TCP Previous segment not captured] 80 → 55632 [ACK] Seq=36501 Ack=105 Win=29312 Len=5840 [TCP segment of a reassembled PDU]
10	0.756012	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=36501 SRE=42341
11	1.008123	128.119.245.12	10.26.144.43	TCP	7354	[TCP Previous segment not captured] 80 → 55632 [ACK] Seq=43801 Ack=105 Win=29312 Len=7300 [TCP segment of a reassembled PDU]
12	1.008123	128.119.245.12	10.26.144.43	TCP	1514	[TCP Previous segment not captured] 80 → 55632 [ACK] Seq=52561 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
13	1.008123	128.119.245.12	10.26.144.43	TCP	1514	[TCP Out-Of-Order] 80 → 55632 [ACK] Seq=51101 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
14	1.008123	128.119.245.12	10.26.144.43	TCP	7354	80 → 55632 [ACK] Seq=54021 Ack=105 Win=29312 Len=7300 [TCP segment of a reassembled PDU]
15	1.008150	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1045] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=51101 S
16	1.008290	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1042] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=52561 SRE=54021 SLE=43801 SRE=51101 S
17	1.008316	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1043] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=54021 SLE=36501 SRE=42341
18	1.008338	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1044] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=61321 SLE=36501 SRE=42341
19	1.008617	128.119.245.12	10.26.144.43	TCP	13194	80 → 55632 [ACK] Seq=61321 Ack=105 Win=29312 Len=13140 [TCP segment of a reassembled PDU]
20	1.008675	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1045] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=74461 SLE=36501 SRE=42341
21	1.296390	128.119.245.12	10.26.144.43	TCP	1514	80 → 55632 [ACK] Seq=74461 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
22	1.296390	128.119.245.12	10.26.144.43	TCP	2974	[TCP Previous segment not captured] 80 → 55632 [ACK] Seq=78841 Ack=105 Win=29312 Len=2920 [TCP segment of a reassembled PDU]
23	1.296390	128.119.245.12	10.26.144.43	TCP	1514	[TCP Previous segment not captured] 80 → 55632 [ACK] Seq=83221 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
24	1.296390	128.119.245.12	10.26.144.43	TCP	1514	[TCP Out-Of-Order] 80 → 55632 [ACK] Seq=81761 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
25	1.296390	128.119.245.12	10.26.144.43	TCP	1514	80 → 55632 [ACK] Seq=84681 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
26	1.296519	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1046] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=75921 SLE=36501 SRE=42341
27	1.296710	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1047] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=81761 SLE=43801 SRE=75921 S
28	1.296770	10.26.144.43	128.119.245.12	TCP	80	[TCP Dup ACK 1048] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=83221 SRE=84681 SLE=78841 SRE=81761 S
29	1.296844	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1049] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=84681 SLE=43801 SRE=75921 S
30	1.296894	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10410] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=86141 SLE=43801 SRE=75921 S
31	1.297128	128.119.245.12	10.26.144.43	TCP	19034	80 → 55632 [ACK] Seq=86141 Ack=105 Win=29312 Len=18980 [TCP segment of a reassembled PDU]
32	1.297258	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10411] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=105121 SLE=43801 SRE=75921 S

Q1: Duplicate ACKs

Change filters into this:

```
1 ip.addr == 128.119.245.12 && tcp.stream && tcp.analysis.duplicate_ack
```

So, we get many Duplicate ACKs packets.

bin_addr = 128.119.245.12 66 tcp_stream 66 tcp_analysis duplicate_ack								
No.	Time	Source	Destination	Protocol	Length	Info		
15	1.008190	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1081] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=43801 SRE=51101 SLE=36501 SRE=42341		
16	1.008290	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1082] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=52561 SRE=54021 SLE=43801 SRE=51101 SLE=36501 SRE=42341		
17	1.008316	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1083] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=43801 SRE=54021 SLE=36501 SRE=42341		
18	1.008338	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1084] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=43801 SRE=61321 SLE=36501 SRE=42341		
20	1.008675	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1085] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=43801 SRE=74461 SLE=36501 SRE=42341		
21	1.296519	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1086] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
27	1.296710	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1087] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=81761 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
28	1.296778	10.26.144.43	128.119.245.12	TCP	80	[TCP Dup ACK 1088] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=83221 SRE=84681 SLE=78841 SRE=81761 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
29	1.296844	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1089] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=86141 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
30	1.296904	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1090] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=86141 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
32	1.297258	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1091] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=10521 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
37	1.545483	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10912] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=106581 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
38	1.545541	10.26.144.43	128.119.245.12	TCP	80	[TCP Dup ACK 10913] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=108041 SRE=109501 SLE=78841 SRE=106581 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
39	1.545660	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10914] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=109501 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
40	1.545682	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10915] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=1131328 Len=0 SLE=78841 SRE=11381 SLE=43801 SRE=75921 SLE=36501 SRE=42341		
48	1.590329	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4781] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=78841 SRE=119721		
49	1.590384	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4782] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=121181 SRE=122641 SLE=78841 SRE=119721		
50	1.590433	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4783] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=78841 SRE=122641		
52	1.797410	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4784] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=78841 SRE=128481		
56	1.802383	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4785] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=131401 SRE=140161 SLE=78841 SRE=128481		
57	1.802442	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 4786] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=141621 SRE=143081 SLE=131401 SRE=140161 SLE=78841 SRE=128481		
58	1.802463	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4787] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=131401 SRE=143081 SLE=78841 SRE=140161 SLE=140161 SLE=78841 SRE=128481		
62	0.048885	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4788] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=131401 SRE=144541 SLE=78841 SRE=128481		
65	0.054124	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4789] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=1131328 Len=0 SLE=77381 SRE=128481 SLE=131401 SRE=144541		
67	0.054243	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 6691] 55632 → 80 [ACK] Seq=105 Ack=128481 Win=1131328 Len=0 SLE=148921 SRE=151841 SLE=131401 SRE=144541		
68	0.054479	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 6692] 55632 → 80 [ACK] Seq=105 Ack=128481 Win=1131328 Len=0 SLE=148921 SRE=152448 SLE=131401 SRE=144541		

The possible cause is that some packet segments are lost during sending. The receiving end receives the sequence after these packet segments (out-of-order arrival). Therefore, the receiving end sends **Duplicate ACKs packets** to the sending end.

Q2: SACK

1. sack permit option

Change filters into this:

```
1 ip.addr == 128.119.245.12 && tcp.stream && tcp.option_kind==4
```

So we can get two TCP packets:

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
2	0.253159	128.119.245.12	10.26.144.43	TCP	66	80 → 55632 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM WS=128

Expand the packet one we can get sack permit option:

1	0.000000	10.26.144.43	128.119.245.12	TCP	66	55632 → 80	[SYN]	Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
2	0.253159	128.119.245.12	10.26.144.43	TCP	66	80 → 55632	[SYN, ACK]	Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM WS=128

```
[Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 0]
Sequence Number: 0 (relative sequence number)
Sequence Number (raw): 3376027240
[Next sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 0
Acknowledgment number (raw): 0
1000 .... = Header Length: 32 bytes (8)
> Flags: 0x002 (SYN)
Window: 64240
[Calculated window size: 64240]
Checksum: 0xab12 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
v Options: (12 bytes), Maximum segment size, No-Operation (NOP), Window scale, No-Operation (NO
  > TCP option - Maximum segment size: 1460 bytes
  > TCP option - No-Operation (NOP)
  > TCP option - Window scale: 8 (multiply by 256)
  > TCP option - No-Operation (NOP)
  > TCP option - No-Operation (NOP)
  v TCP option - SACK permitted
    Kind: SACK Permitted (4)
    Length: 2
  > [Timestamps]
```

2. sack option

Change filters into this:

```
1 | ip.addr == 128.119.245.12 && tcp.stream && tcp.option_kind==5
```

So we can get many TCP packets:

No.	Time	Source	Destination	Protocol	Length	Info
10	0.756012	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=36501 SRE=42341
15	1.008190	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1041] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=51101 SLE=36501 SRE=42341
16	1.008290	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1042] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=52561 SRE=54021 SLE=43801 SRE=51101 S
17	1.008316	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1043] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=54021 SLE=36501 SRE=42341
18	1.008338	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1044] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=61321 SLE=36501 SRE=42341
20	1.008675	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1045] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=74461 SLE=36501 SRE=42341
26	1.296519	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1046] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=75921 SLE=36501 SRE=42341
27	1.296710	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1047] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=81761 SLE=43801 SRE=75921 S
28	1.296778	10.26.144.43	128.119.245.12	TCP	90	[TCP Dup ACK 1048] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=83221 SRE=84681 SLE=78841 SRE=81761 S
29	1.296844	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1049] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=84681 SLE=43801 SRE=75921 S
30	1.296894	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10410] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=86141 SLE=43801 SRE=75921
32	1.297258	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10411] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=105121 SLE=43801 SRE=75921
37	1.545403	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10412] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=106581 SLE=43801 SRE=75921
38	1.545541	10.26.144.43	128.119.245.12	TCP	90	[TCP Dup ACK 10413] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=108041 SRE=109501 SLE=78841 SRE=1065
39	1.545602	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10414] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=109501 SLE=43801 SRE=75921
40	1.545660	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10415] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=113881 SLE=43801 SRE=75921
46	1.550049	10.26.144.43	128.119.245.12	TCP	74	55632 → 80 [ACK] Seq=105 Ack=42341 Win=131328 Len=0 SLE=78841 SRE=113881 SLE=43801 SRE=75921
47	1.550246	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=78841 SRE=113881
48	1.550329	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4741] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=78841 SRE=119721
49	1.550384	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4742] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=121181 SRE=122641 SLE=78841 SRE=11972
50	1.550433	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4743] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=78841 SRE=122641
52	1.797410	10.26.144.43	128.119.245.12	TCP	66	[TCP Dup ACK 4744] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=78841 SRE=128481
53	1.802383	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4745] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=131401 SRE=140161 SLE=78841 SRE=12848
57	1.802442	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 4746] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=141621 SRE=143081 SLE=131401 SRE=1401
58	1.802463	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4747] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=131401 SRE=143081 SLE=78841 SRE=12848
60	2.048885	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4748] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=131401 SRE=144541 SLE=78841 SRE=12848
65	2.054124	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 4749] 55632 → 80 [ACK] Seq=105 Ack=75921 Win=131328 Len=0 SLE=77381 SRE=128481 SLE=131401 SRE=14454

Expand the packet NO.15 we can get sack option:

No.	Time	Source	Destination	Protocol	Length	Info
10	0.756012	10.26.144.43	128.119.245.12	TCP	66	55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=36501 SRE=42341
15	1.008190	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1041] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=51101 SLE=36501 SRE=42341
16	1.008290	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1042] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=52561 SRE=54021 SLE=43801 SRE=51101 S
17	1.008316	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1043] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=54021 SLE=36501 SRE=42341
18	1.008338	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1044] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=61321 SLE=36501 SRE=42341
20	1.008675	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1045] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=74461 SLE=36501 SRE=42341
26	1.296519	10.26.144.43	128.119.245.12	TCP	74	[TCP Dup ACK 1046] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=43801 SRE=75921 SLE=36501 SRE=42341
27	1.296710	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1047] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=81761 SLE=43801 SRE=75921 S
28	1.296778	10.26.144.43	128.119.245.12	TCP	90	[TCP Dup ACK 1048] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=83221 SRE=84681 SLE=78841 SRE=81761 S
29	1.296844	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 1049] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=84681 SLE=43801 SRE=75921 S
30	1.296894	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10410] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=86141 SLE=43801 SRE=75921
32	1.297258	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10411] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=105121 SLE=43801 SRE=75921
37	1.545403	10.26.144.43	128.119.245.12	TCP	82	[TCP Dup ACK 10412] 55632 → 80 [ACK] Seq=105 Ack=35041 Win=131328 Len=0 SLE=78841 SRE=106581 SLE=43801 SRE=75921

1010 = Header Length: 40 bytes (10)
> Flags: 0x010 (ACK)
Window: 513
[Calculated window size: 131328]
[Window size scaling factor: 256]
Checksum: 0x435 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
Options: (20 bytes), No-Operation (NOP), No-Operation (NOP), SACK
 > TCP Option - No-Operation (NOP)
 > TCP Option - No-Operation (NOP)
 > TCP Option - SACK 43801-51101 36501-42341
 Kind: SACK (5)
 Length: 18
 left edge = 43801 (relative)
 right edge = 51101 (relative)
 left edge = 36501 (relative)
 right edge = 42341 (relative)
 [TCP sack count: 2]
 > [Timestamps]
 > [SEQ/ACK analysis]

0000 00111100 10001100 10010011 11010000 10010011 11000001 11010100 00110111 <----->
0008 00000100 10101101 10011010 10011001 00001000 00000000 01000101 00000000E
0010 00000000 00111100 01011111 10100101 01000000 00000000 10000000 00000110 <- @-...
0018 10010101 00100000 00001010 00101101 10010000 00101011 10000000 01110111 ...+-W
0020 11110101 00001100 11011001 01010000 00000000 01010000 11001001 00111010 ...P:P:
0028 00010110 11010001 10011010 01000110 00110101 01001010 10100000 00010000 ...F:P:
0030 00000010 00000001 11100100 00110101 00000000 00000000 00000001 00000001 ...S...
0038 00000101 00010010 10011010 01000110 01011110 10000010 10011010 01000110 ...F: F
0040 01111010 00000110 10011010 01000110 00111111 11111110 10011010 01000110 ...F?F
0048 01010110 11001110 V

So, in this sack option, the segment ranges 43801 - 51101 and 36501 - 42301 is acked.

(Note: sack option is the option information contained in the duplicate ack reply packet)

Q3: Retransmission

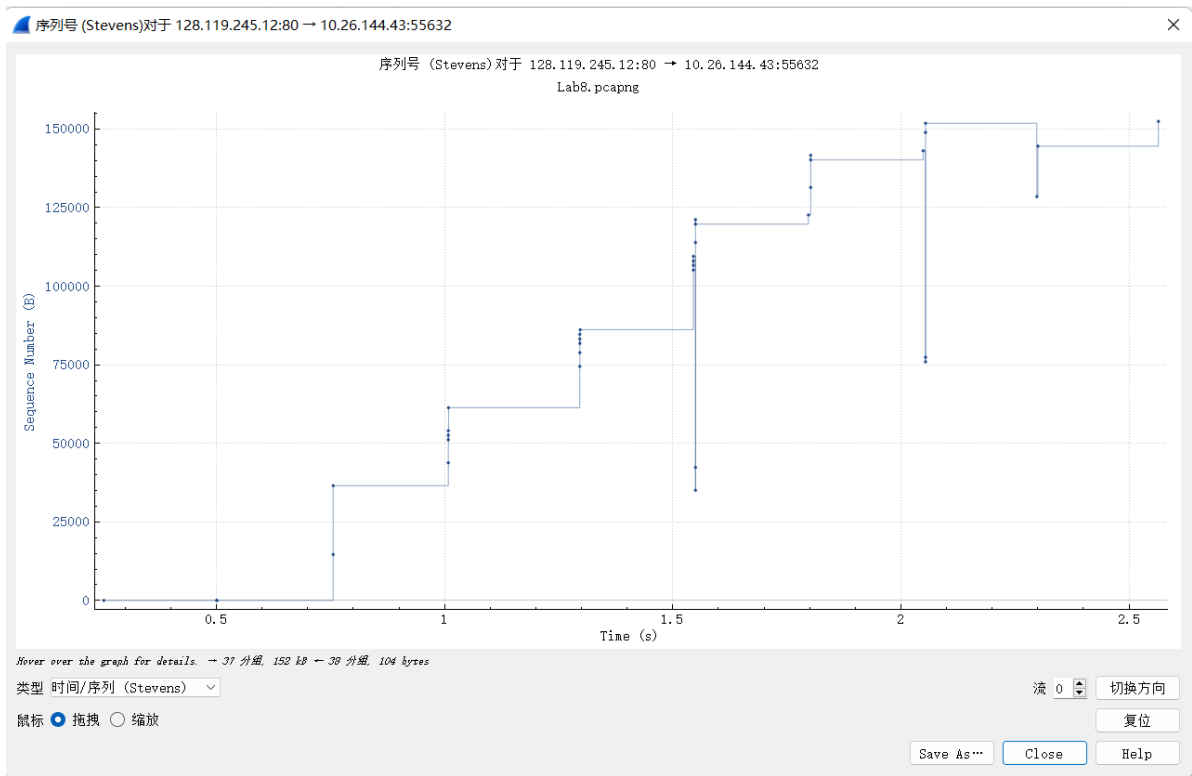
Change filters into this:

```
1 | ip.addr == 128.119.245.12 && tcp.stream && tcp.analysis.retransmission
```

So, we can get two packets which use the fast retransmission

No.	Time	Source	Destination	Protocol	Length	Info
41	1.549886	128.119.245.12	10.26.144.43	TCP	1514	[TCP Fast Retransmission] 80 → 55632 [ACK] Seq=35041 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]
62	2.054007	128.119.245.12	10.26.144.43	TCP	1514	[TCP Fast Retransmission] 80 → 55632 [ACK] Seq=75921 Ack=105 Win=29312 Len=1460 [TCP segment of a reassembled PDU]

Also, we can consider the sequence number-time graph:



We can see that the sequence number is decreasing at some time, thus there exists retransmission(fast retransmission).

Q4& Q5: TCP Windows size

1. Zero window size

Change filters into this:

```
1 | ip.addr == 128.119.245.12 && tcp.stream && tcp.window_size == 0
```

Then, we cannot see any packets. So, there is no one whose windows size is 0.

No.	Time	Source	Destination	Protocol	Length	Info
No packets are visible in the packet list due to the filter.						

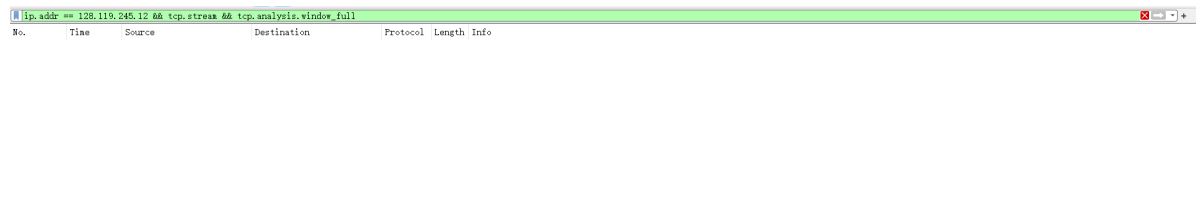
If there exists some packet which window sizes is zeros, it means the window size of the receiver (The host send this window size message) is 0. Then, the sender will stop to send the packet, it will send "[TCP Keep-Alive]" to keep the TCP connection, waiting for the changing of receiver's window. Wireshark收到的报文显示的wi n=***代表该报文发送方的接收窗口的大小

2. Full window size

Change filters into this:

```
1 | ip.addr == 128.119.245.12 && tcp.stream && tcp.analysis.window_full
```

Then, we cannot see any packets. So, there is no one whose windows size is full.



If there exists some packet which window sizes is full, it means the sender (The host send this window size message) will not send any segment at this moment (The size of its usable window turn to be 0, because the number of bytes in transmit (Seq + Len-Ack [the lastest Ack of the other host]) is equal to the receiving window of the other host). At this time, wireshark mark the segment with "[Tcp Window Full]".

Note: TCP implements congestion control and traffic control by dynamically adjusting the size of the sending window.