Homework 2

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Q1

a. It's TCP Reno since the congestion window size is cut in half after the 16th transmission round, which can only happen in Reno.

> The closed interval [l, r] in (b) and (c) represents all packets sent in these transmission rounds.

−1 b. It includes intervals [1, 5] and [23, 26]. The window size increases exponentially with the transmission round during this period. In 6th round, the window size changes to increase linearly.

−1 c. It includes intervals [6, 15] and [17, 21]. The window size increases linearly with the transmission round. Note that in 16th and 22nd rounds, the window size decreases due to a triple duplicate or a loss.

d. After the 16th transmission round, **a triple duplicate ACK happened** since the window size was cut in half.

e. After the 22nd transmission round, **a packet loss happened** since the congestion window size dropped to 1.

timeout?

f. **It's 32** since at this window size slow start stops and congestion avoidance begins.

g. When the triple duplicate ACK is detected during transmission round 16, the congestion window size is 42. So **the threshold is 21** at the 18th transmission round.

h. When loss is detected during round 22, the window size is 26. So **the threshold is 13** at the 24th transmission round.

i.

Round	1	2	3	4	5	6	7
packets transmitted	1	2, 3	4 - 7	8 - 15	16 - 31	32 - 63	64 - 96

Thus the 90th packet is sent during the 7th round.

Q2

a). The IP header checksum is incorrect.

0x4500+0x05DC+0x08DB+0x2000+0x4006+0x8EF1+0x8F59+0x567B+0x8F59+0x2822=0x2dffd

0x2 + 0xdffd = 0xdfff != 0xffff

The packet will be discarded by the router.

b). The "Do not fragment" flag is set. But the length of the packet (1500 bytes) is longer than the MTU size (512 bytes). So the packet will be discarded.

c) The TTL field of the packet is 1. The router will discard it.

d) This packet will be fragmented and transmitted. The offset fields for each segment are given as below.

Offset	Packet Length
0	508
61 (0x3d)	508
122 (0x7a)	508
183 (0xb7)	36

Q3

a.

$$\#packets = \sum_{i=W/2}^{W} i = \frac{3W}{4}(1 + \frac{W}{2}) = \frac{3W^2}{8} + \frac{3W}{4}$$
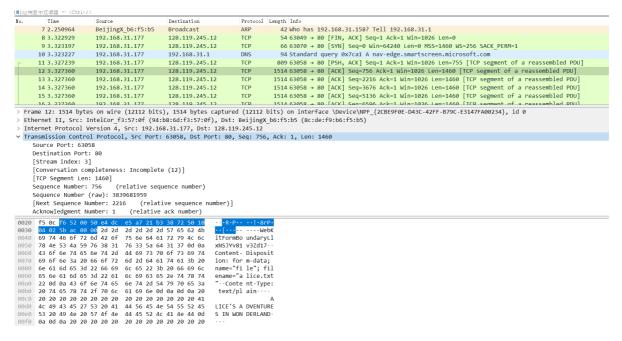
$$L = 1/(\frac{3W^2}{8} + \frac{3W}{4})$$

b.

For large W, W is negligible compared to W^2.

$$L \approx 1/(3W^2/8) = 8/(3W^2)$$

$$W \approx \sqrt{\frac{8}{3L}}$$

$$\text{average throughput} = \frac{3W}{4 \times MSS \times RTT} \approx \frac{1.22 MSS}{\sqrt{L} \times RTT}$$

TCP LAB

Q3

What is the IP address and TCP port number used by your client computer (source) to transfer the file to gaia.cs.umass.edu?

```
|■|应用显示过滤器 … ⟨Ctrl-/⟩
No.      Time        Source              Destination       Protocol  Length  Info
         7 2.250964  BeijingX_b6:f5:b5   Broadcast         ARP          42  Who has 192.168.31.158? Tell 192.168.31.1
         8 3.322929  192.168.31.177      128.119.245.12    TCP          54  63049 → 80 [FIN, ACK] Seq=1 Ack=1 Win=1026 Len=0
         9 3.323197  192.168.31.177      128.119.245.12    TCP          66  63070 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
        10 3.323227  192.168.31.177      192.168.31.1      DNS          94  Standard query 0x7ca1 A nav-edge.smartscreen.microsoft.com
        11 3.327239  192.168.31.177      128.119.245.12    TCP         809  63058 → 80 [PSH, ACK] Seq=1 Ack=1 Win=1026 Len=755 [TCP segment of a reassembled PDU]
        12 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=756 Ack=1 Win=1026 Len=1460 [TCP segment of a reassembled PDU]
        13 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=2216 Ack=1 Win=1026 Len=1460 [TCP segment of a reassembled PDU]
        14 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=3676 Ack=1 Win=1026 Len=1460 [TCP segment of a reassembled PDU]
        15 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=5136 Ack=1 Win=1026 Len=1460 [TCP segment of a reassembled PDU]
        16 3.327360  192.168.31.177      128.119.245.12    TCP        6506 [TCP segment of a reassembled PDU]

> Frame 12: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface \Device\NPF_{2CBE9F0E-D43C-42FF-B79C-E3147FA00234}, id 0
> Ethernet II, Src: IntelCor_f3:57:0f (94:b8:6d:f3:57:0f), Dst: BeijingX_b6:f5:b5 (8c:de:f9:b6:f5:b5)
> Internet Protocol Version 4, Src: 192.168.31.177, Dst: 128.119.245.12
∨ Transmission Control Protocol, Src Port: 63058, Dst Port: 80, Seq: 756, Ack: 1, Len: 1460
    Source Port: 63058
    Destination Port: 80
    [Stream index: 3]
    [Conversation completeness: Incomplete (12)]
    [TCP Segment Len: 1460]
    Sequence Number: 756    (relative sequence number)
    Sequence Number (raw): 3839681959
    [Next Sequence Number: 2216    (relative sequence number)]
    Acknowledgment Number: 1    (relative ack number)

0020  f5 0c f6 52 00 50 e4 dc  e5 a7 21 b3 38 72 50 10   ··R·P·· ··!·8rP·
0030  04 02 5b ac 00 00 2d 2d  2d 2d 2d 2d 57 65 62 4b   ··[···-- ----WebK
0040  69 74 46 6f 72 6d 42 6f  75 6e 64 61 72 79 4c 6c   itFormBo undaryLl
0050  78 4e 53 4a 59 76 38 31  76 33 5a 64 31 37 0d 0a   xNSJYv81 v3Zd17··
0060  43 6f 6e 74 65 6e 74 2d  44 69 73 70 6f 73 69 74   Content- Disposit
0070  69 6f 6e 3a 20 66 6f 72  6d 2d 64 61 74 61 3b 20   ion: for m-data;
0080  6e 61 6d 65 3d 22 66 69  6c 65 22 3b 20 66 69 6c   name="fi le"; fil
0090  65 6e 61 6d 65 3d 22 61  6c 69 63 65 2e 74 78 74   ename="a lice.txt
00a0  22 0d 0a 43 6f 6e 74 65  6e 74 2d 54 79 70 65 3a   "··Conte nt-Type:
00b0  20 74 65 78 74 2f 70 6c  61 69 6e 0d 0a 0d 0a 20    text/pl ain····
00c0  20 20 20 20 20 20 20 20  20 20 20 20 20 20 20 41                   A
00d0  4c 49 43 45 27 53 20 41  44 56 45 4e 54 55 52 45   LICE'S A DVENTURE
00e0  53 20 49 4e 20 57 4f 4e  44 45 52 4c 41 4e 44 0d   S IN WON DERLAND·
00f0  0a 0d 0a 20 20 20 20 20  20 20 20 20 20 20 20 20   ···
```

My source IP: 192.168.31.177 Port: 63058

Q4

What is the sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and gaia.cs.umass.edu? What is it in the segment that identifies the segment as a SYN segment?

```
         7 2.250964  BeijingX_b6:f5:b5   Broadcast         ARP          42  Who has 192.168.31.158? Tell 192.168.31.1
         8 3.322929  192.168.31.177      128.119.245.12    TCP          54  63049 → 80 [FIN, ACK] Seq=1 Ack=1 Win=1026 Len=0
         9 3.323197  192.168.31.177      128.119.245.12    TCP          66  63070 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
        10 3.323227  192.168.31.177      192.168.31.1      DNS          94  Standard query 0x7ca1 A nav-edge.smartscreen.microsoft.com
        11 3.327239  192.168.31.177      128.119.245.12    TCP         809  63058 → 80 [PSH, ACK] Seq=1 Ack=1 Win=1026 Len=755 [TCP segment of a reasse
        12 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=756 Ack=1 Win=1026 Len=1460 [TCP segment of a reassemb
        13 3.327360  192.168.31.177      128.119.245.12    TCP        1514  63058 → 80 [ACK] Seq=2216 Ack=1 Win=1026 Len=1460 [TCP segment of a reasse

ransmission Control Protocol, Src Port: 63070, Dst Port: 80, Seq: 0, Len: 0
  Source Port: 63070
  Destination Port: 80
  [Stream index: 2]
  [Conversation completeness: Incomplete, ESTABLISHED (7)]
  [TCP Segment Len: 0]
  Sequence Number: 0    (relative sequence number)
  Sequence Number (raw): 1837821236
  [Next Sequence Number: 1    (relative sequence number)]
  Acknowledgment Number: 0
  Acknowledgment number (raw): 0
  1000 .... = Header Length: 32 bytes (8)
  Flags: 0x002 (SYN)

  8c de f9 b6 f5 b5 94 b8  6d f3 57 0f 08 00 45 00   ········ m·W···E·
  00 34 28 46 40 00 40 06  00 00 c0 a8 1f b1 80 77   ·4(F@·@· ·······w
  f5 0c f6 5e 00 50 6d 8a  ed 34 00 00 00 00 80 02   ···^·Pm· ·4······
  fa f0 56 04 00 00 02 04  05 b4 01 03 03 08 01 01   ··V····· ········
  04 02                                              ··
```

The sequence number of SYN segment is 1837821236.

The SYN bit in the flags field is set to 1, indicating that the packet is a SYN segment.

Q5

What is the sequence number of the SYNACK segment sent by gaia.cs.umass.edu to the client computer in reply to the SYN? What is the value of the Acknowledgement field in the SYNACK segment? How did gaia.cs.umass.edu determine that value? What is it in the segment that identifies the segment as a SYNACK segment?

```
42 3.513673      192.168.31.177      20.212.97.243      TCP      54 63071 → 443 [FIN, ACK] Seq=2842 Ack=6890 Win=263424 Len=0
43 3.541881      128.119.245.12      192.168.31.177     TCP      66 80 → 63070 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM=1 WS=128
44 3.541952      192.168.31.177      128.119.245.12     TCP      54 63070 → 80 [ACK] Seq=1 Ack=1 Win=262656 Len=0
45 3.546290      128.119.245.12      192.168.31.177     TCP      54 80 → 63058 [ACK] Seq=1 Ack=756 Win=240 Len=0
46 3.546290      128.119.245.12      192.168.31.177     TCP      54 80 → 63058 [ACK] Seq=1 Ack=3676 Win=286 Len=0
47 3.546290      128.119.245.12      192.168.31.177     TCP      54 80 → 63058 [ACK] Seq=1 Ack=6596 Win=332 Len=0
48 3.546290      128.119.245.12      192.168.31.177     TCP      54 80 → 63058 [ACK] Seq=1 Ack=13896 Win=446 Len=0
49 3.546358      192.168.31.177      128.119.245.12     TCP      1514 63058 → 80 [ACK] Seq=13896 Ack=1 Win=1026 Len=1460 [TCP segment of a reassembled
```

```
Destination Port: 63070
[Stream index: 2]
[Conversation completeness: Incomplete, ESTABLISHED (7)]
[TCP Segment Len: 0]
Sequence Number: 0    (relative sequence number)
Sequence Number (raw): 2989343983
[Next Sequence Number: 1    (relative sequence number)]
Acknowledgment Number: 1    (relative ack number)
Acknowledgment number (raw): 1837821237
1000 .... = Header Length: 32 bytes (8)
Flags: 0x012 (SYN, ACK)
Window: 29200
[Calculated window size: 29200]
```

```
94 b8 6d f3 57 0f 8c de  f9 b6 f5 b5 08 00 45 00    ··m·W··· ······E·
00 34 00 00 40 00 2a 06  fa e6 80 77 f5 0c c0 a8    ·4··@·*· ···w····
1f b1 00 50 f6 5e b2 2d  c4 ef 6d 8a ed 35 80 12    ···P·^·- ··m··5··
72 10 de 86 00 00 02 04  05 b4 01 01 04 02 01 03    r······· ········
03 07                                               ··
```

The sequence number of the SYNACK segment is 2989343983.

The Acknowledgement field is 1837821237, which is one plus the sequence number of the SYN segment sent by my computer. This is the sequence number of the next byte that the server expects to receive.

Both the SYN and ACK bit in the flags field are set to 1, indicating that the packet is a SYNACK segment.

Q6

What is the sequence number of the TCP segment containing the HTTP POST command? Note that in order to find the POST command, you'll need to dig into the packet content field at the bottom of the Wireshark window, looking for a segment with a "POST" within its DATA field.

10 3.323227	192.168.31.177	192.168.31.1	DNS	94 Standard query 0x7ca1 A
11 3.327239	192.168.31.177	128.119.245.12	TCP	809 63058 → 80 [PSH, ACK] Se
12 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=756
13 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=221
14 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=367
15 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=513
16 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=659
17 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=805
18 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=951
19 3.327360	192.168.31.177	128.119.245.12	TCP	1514 63058 → 80 [ACK] Seq=109

Destination Port: 80
[Stream index: 3]
[Conversation completeness: Incomplete (12)]
[TCP Segment Len: 755]
Sequence Number: 1   (relative sequence number)
Sequence Number (raw): 3839681204
[Next Sequence Number: 756   (relative sequence number)]
Acknowledgment Number: 1   (relative ack number)
Acknowledgment number (raw): 565393522
0101 .... = Header Length: 20 bytes (5)
Flags: 0x018 (PSH, ACK)
Window: 1026
[Calculated window size: 1026]

```
8c de f9 b6 f5 b5 94 b8  6d f3 57 0f 08 00 45 00   ········ m·W···E·
03 1b 28 47 40 00 40 06  00 00 c0 a8 1f b1 80 77   ··(G@·@· ······w
f5 0c f6 52 00 50 e4 dc  e2 b4 21 b3 38 72 50 18   ···R·P·· ··!·8rP·
04 02 58 eb 00 00 50 4f  53 54 20 2f 77 69 72 65   ··X··PO ST /wire
73 68 61 72 6b 2d 6c 61  62 73 2f 6c 61 62 33 2d   shark-la bs/lab3-
31 2d 72 65 70 6c 79 2e  68 74 6d 20 48 54 54 50   1-reply. htm HTTP
2f 31 2e 31 0d 0a 48 6f  73 74 3a 20 67 61 69 61   /1.1··Ho st: gaia
2e 63 73 2e 75 6d 61 73  73 2e 65 64 75 0d 0a 43   .cs.umas s.edu··C
6f 6e 6e 65 63 74 69 6f  6e 3a 20 6b 65 65 70 2d   onnectio n: keep-
61 6c 69 76 65 0d 0a 43  6f 6e 74 65 6e 74 2d 4c   alive··C ontent-L
65 6e 67 74 68 3a 20 31  35 32 33 32 31 0d 0a 43   ength: 1 52321··C
61 63 68 65 2d 43 6f 6e  74 72 6f 6c 3a 20 6d 61   ache-Con trol: ma
78 2d 61 67 65 3d 30 0d  0a 4f 72 69 67 69 6e 3a   x-age=0· ·Origin:
20 68 74 74 70 3a 2f 2f  67 61 69 61 2e 63 73 2e    http:// gaia.cs.
```

The sequence number of the TCP segment containing the HTTP POST command is 3839681204.

It is interesting to note that different source ports are used for establishing TCP connections and transferring files.