1.

```
No.     Time           Source                Destination           Protocol Info

199 19:14:25.867722 192.168.1.102         128.119.245.12        HTTP     POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1  (text/plain)

Frame 199 (104 bytes on wire, 104 bytes captured)

Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af:73)

Internet Protocol, Src: 192.168.1.102 (192.168.1.102), Dst: 128.119.245.12 (128.119.245.12)

Transmission Control Protocol, Src Port: health-polling (1161), Dst Port: http (80), Seq: 164041, Ack: 1, Len: 50
```

Hence, IP address of client: 192.168.1.102

TCP port number: 1161

2.

```
No.     Time           Source                Destination           Protocol Info

203 19:14:26.031556 128.119.245.12        192.168.1.102         HTTP     HTTP/1.1 200 OK  (text/html)

Frame 203 (784 bytes on wire, 784 bytes captured)

Ethernet II, Src: LinksysG_da:af:73 (00:06:25:da:af:73), Dst: Actionte_8a:70:1a (00:20:e0:8a:70:1a)

Internet Protocol, Src: 128.119.245.12 (128.119.245.12), Dst: 192.168.1.102 (192.168.1.102)

Transmission Control Protocol, Src Port: http (80), Dst Port: health-polling (1161), Seq: 1, Ack: 164091, Len: 730
```

Hence, IP address of server: 128.119.245.12

TCP port number: 80

3.

```
No.     Time           Source                Destination           Protocol Info

 199 15:16:28.947915 192.168.1.144         128.119.245.12        HTTP     POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1  (text/plain)

Frame 199 (539 bytes on wire, 539 bytes captured)

Ethernet II, Src: IntelCor_c9:cc:96 (00:1c:bf:c9:cc:96), Dst: 58:6d:8f:3d:3b:ca (58:6d:8f:3d:3b:ca)

Internet Protocol, Src: 192.168.1.144 (192.168.1.144), Dst: 128.119.245.12 (128.119.245.12)

Transmission Control Protocol, Src Port: 39707 (39707), Dst Port: http (80), Seq: 152493, Ack: 1, Len: 473
```

Hence, IP address of client: 192.168.1.144

TCP port number: 39707

4.

```
Transmission Control Protocol, Src Port: 39707 (39707), Dst Port: http (80), Seq: 0, Len: 0

    Source port: 39707 (39707)

    Destination port: http (80)

    [Stream index: 3]
    Sequence number: 0    (relative sequence number)
    Header length: 40 bytes
    Flags: 0x02 (SYN)
        0... .... = Congestion Window Reduced (CWR): Not set
        .0.. .... = ECN-Echo: Not set
        ..0. .... = Urgent: Not set
        ...0 .... = Acknowledgement: Not set
        .... 0... = Push: Not set
        .... .0.. = Reset: Not set
        .... ..1. = Syn: Set
            [Expert Info (Chat/Sequence): Connection establish request (SYN): server port http]
        .... ...0 = Fin: Not set
    Window size: 5840
    Checksum: 0x4006 [validation disabled]
    Options: (20 bytes)
```

Sequence number of TCP SYN segment: 0

The setting of Syn flag identifies the segment as a syn segment.

5.

```
Transmission Control Protocol, Src Port: http (80), Dst Port: 39707 (39707), Seq: 0, Ack: 1, Len: 0
    Source port: http (80)
    Destination port: 39707 (39707)
    [Stream index: 1]
    Sequence number: 0    (relative sequence number)
    Acknowledgement number: 1    (relative ack number)
    Header length: 40 bytes
    Flags: 0x12 (SYN, ACK)
        0... .... = Congestion Window Reduced (CWR): Not set
        .0.. .... = ECN-Echo: Not set
        ..0. .... = Urgent: Not set
        ...1 .... = Acknowledgement: Set
        .... 0... = Push: Not set
        .... .0.. = Reset: Not set
        .... ..1. = Syn: Set
            [Expert Info (Chat/Sequence): Connection establish acknowledge (SYN+ACK): server port http]
        .... ...0 = Fin: Not set
```

Sequence number of TCP SYNACK segment: 0

The setting of Syn flag and ACK flag identifies the segment as a synack segment.

The value of the ACK field in the SYNACK segment is determined by gaia.cs.umass.edu

by adding 1 to the initial sequence number of SYN segment from the client computer

6.

```
Transmission Control Protocol, Src Port: 39707 (39707), Dst Port: http (80), Seq: 1, Ack: 1, Len: 644
    Source port: 39707 (39707)
    Destination port: http (80)
    [Stream index: 1]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 645    (relative sequence number)]
    Acknowledgement number: 1    (relative ack number)
    Header length: 32 bytes
    Flags: 0x18 (PSH, ACK)
        0... .... = Congestion Window Reduced (CWR): Not set
        .0.. .... = ECN-Echo: Not set
        ..0. .... = Urgent: Not set
        ...1 .... = Acknowledgement: Set
        .... 1... = Push: Set
        .... .0.. = Reset: Not set
        .... ..0. = Syn: Not set
        .... ...0 = Fin: Not set
    Window size: 5888 (scaled)
    Checksum: 0x77ac [validation disabled]
    Options: (12 bytes)
    [SEQ/ACK analysis]
Data (644 bytes)
```

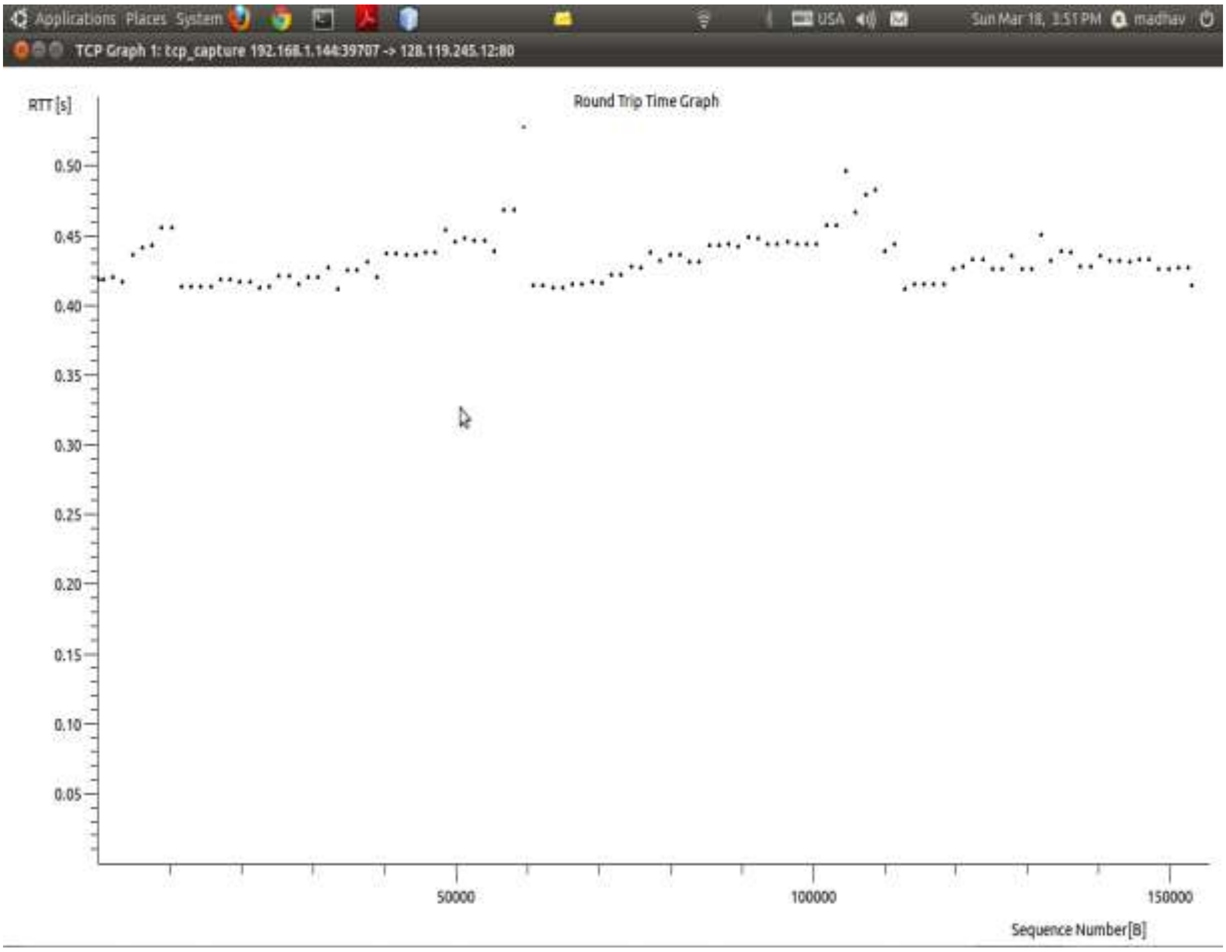
```
0000  50 4f 53 54 20 2f 65 74 68 65 72 65 61 6c 2d 6c   POST /ethereal-l
0010  61 62 73 2f 6c 61 62 33 2d 31 2d 72 65 70 6c 79   abs/lab3-1-reply
0020  2e 68 74 6d 20 48 54 54 50 2f 31 2e 31 0d 0a 48   .htm HTTP/1.1..H
```

Sequence number: 1

7.

Sequence numbers: 1,645,2013,3381,4749,6117

	Sent	Received ACK	Difference	RTT	Estimated RTT
1.	15:16:26.788813	15:16:27.207136	0.418323	0.418323	0.418323
2.	15:16:26.788894	15:16:27.207211	0.418317	0.418317	0.41832225
3.	15:16:26.788975	15:16:27.208944	0.419969	0.419969	0.418528094
4.	15:16:27.207182	15:16:27.624203	0.417021	0.417021	0.418339707
5.	15:16:27.207270	15:16:27.643212	0.435942	0.435942	0.420539994
6.	15:16:27.207356	15:16:27.648920	0.441564	0.441564	0.423167995


Applications Places System
USA
Sun Mar 18, 3:51 PM madhav
TCP Graph 1: tcp_capture 192.168.1.144:39707 -> 128.119.245.12:80
Round Trip Time Graph
RTT [s]
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
50000
100000
150000
Sequence Number[B]

8.

1.644

2.1368

3.1368

4.1368

5.1368

6.1368

9.

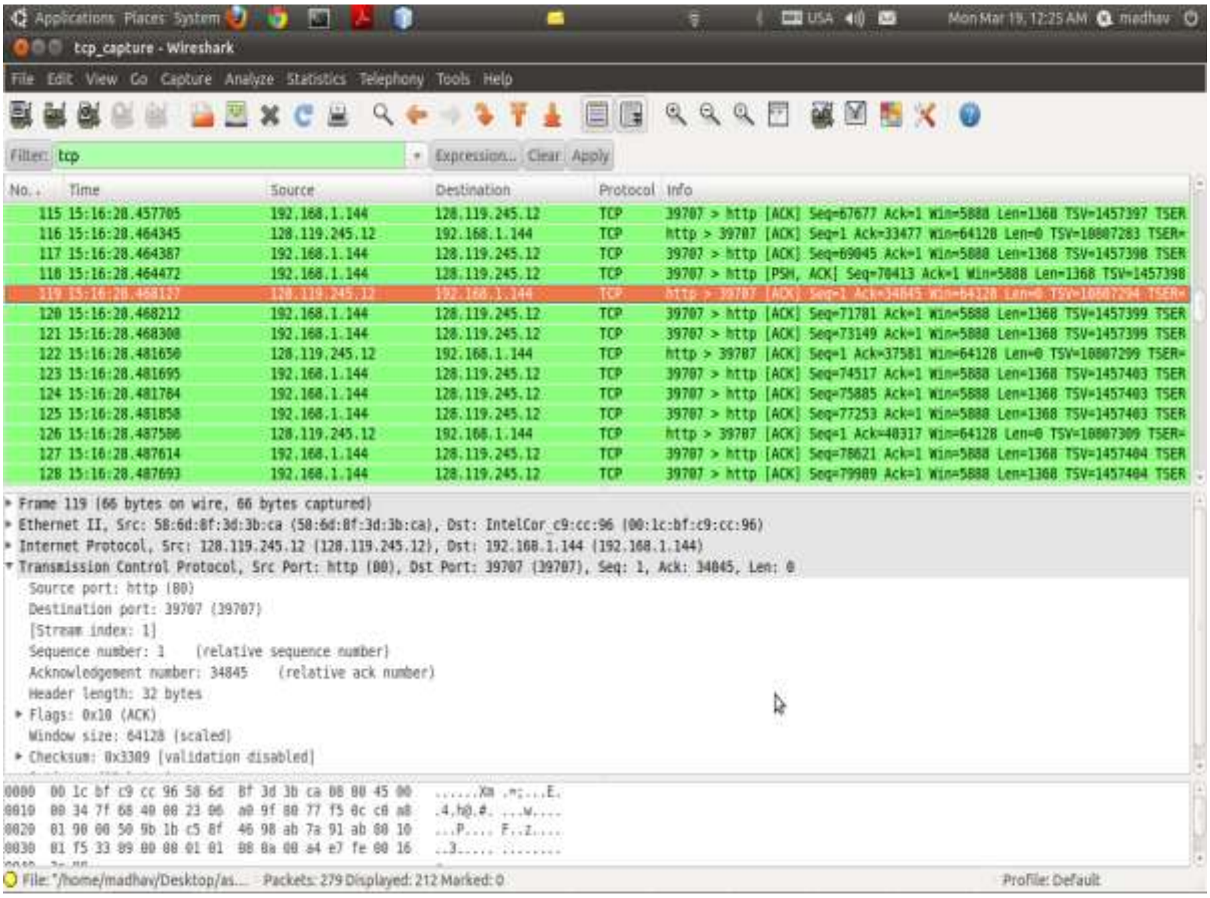
5792 for my trace, 5840 for downloaded trace

No, it is never throttled

10. There are no retransmitted segments. I checked if any two segments have same sequence number.

Also, from the Time-Sequence-graph(Stevens), all sequence numbers are incresing monotonically with respect to time.

11.


Applications Places System
USA
Mon Mar 19, 12:25 AM madhav
tcp_capture - Wireshark
File Edit View Go Capture Analyze Statistics Telephony Tools Help
Expression... Clear Apply

Filter: tcp

```
No. .  Time              Source           Destination      Protocol  Info
  115 15:16:28.457705    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=67677 Ack=1 Win=5888 Len=1368 TSV=1457397 TSER
  116 15:16:28.464345    128.119.245.12   192.168.1.144    TCP       http > 39707 [ACK] Seq=1 Ack=33477 Win=64128 Len=0 TSV=10807283 TSER=
  117 15:16:28.464387    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=69045 Ack=1 Win=5888 Len=1368 TSV=1457398 TSER
  118 15:16:28.464472    192.168.1.144    128.119.245.12   TCP       39707 > http [PSH, ACK] Seq=70413 Ack=1 Win=5888 Len=1368 TSV=1457398
  119 15:16:28.468127    128.119.245.12   192.168.1.144    TCP       http > 39707 [ACK] Seq=1 Ack=34845 Win=64128 Len=0 TSV=10807294 TSER=
  120 15:16:28.468212    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=71781 Ack=1 Win=5888 Len=1368 TSV=1457399 TSER
  121 15:16:28.468308    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=73149 Ack=1 Win=5888 Len=1368 TSV=1457399 TSER
  122 15:16:28.481650    128.119.245.12   192.168.1.144    TCP       http > 39707 [ACK] Seq=1 Ack=37581 Win=64128 Len=0 TSV=10807299 TSER=
  123 15:16:28.481695    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=74517 Ack=1 Win=5888 Len=1368 TSV=1457403 TSER
  124 15:16:28.481784    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=75885 Ack=1 Win=5888 Len=1368 TSV=1457403 TSER
  125 15:16:28.481858    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=77253 Ack=1 Win=5888 Len=1368 TSV=1457403 TSER
  126 15:16:28.487586    128.119.245.12   192.168.1.144    TCP       http > 39707 [ACK] Seq=1 Ack=40317 Win=64128 Len=0 TSV=10807309 TSER=
  127 15:16:28.487614    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=78621 Ack=1 Win=5888 Len=1368 TSV=1457404 TSER
  128 15:16:28.487693    192.168.1.144    128.119.245.12   TCP       39707 > http [ACK] Seq=79989 Ack=1 Win=5888 Len=1368 TSV=1457404 TSER
```

```
▸ Frame 119 (66 bytes on wire, 66 bytes captured)
▸ Ethernet II, Src: 58:6d:8f:3d:3b:ca (58:6d:8f:3d:3b:ca), Dst: IntelCor_c9:cc:96 (00:1c:bf:c9:cc:96)
▸ Internet Protocol, Src: 128.119.245.12 (128.119.245.12), Dst: 192.168.1.144 (192.168.1.144)
▾ Transmission Control Protocol, Src Port: http (80), Dst Port: 39707 (39707), Seq: 1, Ack: 34845, Len: 0
    Source port: http (80)
    Destination port: 39707 (39707)
    [Stream index: 1]
    Sequence number: 1    (relative sequence number)
    Acknowledgement number: 34845    (relative ack number)
    Header length: 32 bytes
  ▸ Flags: 0x10 (ACK)
    Window size: 64128 (scaled)
  ▸ Checksum: 0x3309 [validation disabled]
```

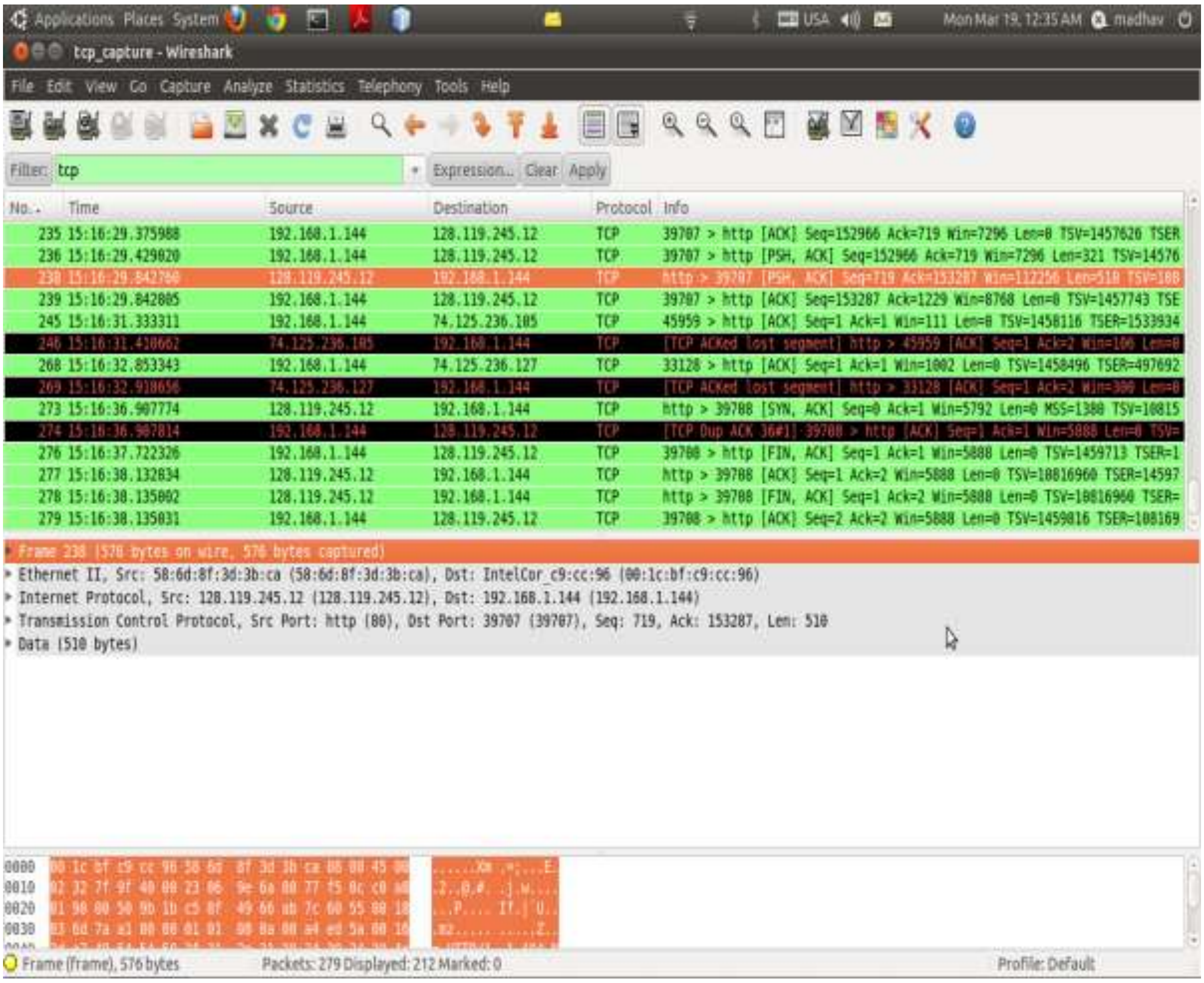
```
0000  00 1c bf c9 cc 96 58 6d  8f 3d 3b ca 08 00 45 00   ......Xm .=;...E.
0010  00 34 7f 68 40 00 23 06  a0 9f 80 77 f5 0c c0 a8   .4.h@.#. ...w....
0020  01 90 00 50 9b 1b c5 8f  46 98 ab 7a 91 ab 80 10   ...P.... F..z....
0030  01 f5 33 09 00 00 01 01  08 0a 00 a4 e7 fe 00 16   ..3..... ........
```

File: "/home/madhav/Desktop/as... Packets: 279 Displayed: 212 Marked: 0 Profile: Default

1368 bytes are typically acknowledged in an ACK.

Yes,there are cases. For example segment no 122 acknowledged 2736 = 1368*2 bytes.

12.


Applications Places System
USA
Mon Mar 19, 12:35 AM
madhav
tcp_capture - Wireshark
File Edit View Go Capture Analyze Statistics Telephony Tools Help
Filter: tcp
Expression... Clear Apply

```
No. .  Time              Source            Destination       Protocol  Info
  235 15:16:29.375988    192.168.1.144     128.119.245.12    TCP       39707 > http [ACK] Seq=152966 Ack=719 Win=7296 Len=0 TSV=1457626 TSER
  236 15:16:29.429020    192.168.1.144     128.119.245.12    TCP       39707 > http [PSH, ACK] Seq=152966 Ack=719 Win=7296 Len=321 TSV=14576
  238 15:16:29.842760    128.119.245.12    192.168.1.144     TCP       http > 39707 [PSH, ACK] Seq=719 Ack=153287 Win=112256 Len=510 TSV=108
  239 15:16:29.842805    192.168.1.144     128.119.245.12    TCP       39707 > http [ACK] Seq=153287 Ack=1229 Win=8768 Len=0 TSV=1457743 TSE
  245 15:16:31.333311    192.168.1.144     74.125.236.105    TCP       45959 > http [ACK] Seq=1 Ack=1 Win=111 Len=0 TSV=1458116 TSER=1533934
  246 15:16:31.410662    74.125.236.105    192.168.1.144     TCP       [TCP ACKed lost segment] http > 45959 [ACK] Seq=1 Ack=2 Win=106 Len=0
  268 15:16:32.853343    192.168.1.144     74.125.236.127    TCP       33128 > http [ACK] Seq=1 Ack=1 Win=1002 Len=0 TSV=1458496 TSER=497692
  269 15:16:32.918656    74.125.236.127    192.168.1.144     TCP       [TCP ACKed lost segment] http > 33128 [ACK] Seq=1 Ack=2 Win=306 Len=0
  273 15:16:36.907774    128.119.245.12    192.168.1.144     TCP       http > 39708 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1380 TSV=10815
  274 15:16:36.907814    192.168.1.144     128.119.245.12    TCP       [TCP Dup ACK 36#1] 39708 > http [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSV=
  276 15:16:37.722326    192.168.1.144     128.119.245.12    TCP       39708 > http [FIN, ACK] Seq=1 Ack=1 Win=5888 Len=0 TSV=1459713 TSER=1
  277 15:16:38.132834    128.119.245.12    192.168.1.144     TCP       http > 39708 [ACK] Seq=1 Ack=2 Win=5888 Len=0 TSV=10816960 TSER=14597
  278 15:16:38.135002    128.119.245.12    192.168.1.144     TCP       http > 39708 [FIN, ACK] Seq=1 Ack=2 Win=5888 Len=0 TSV=10816960 TSER=
  279 15:16:38.135031    192.168.1.144     128.119.245.12    TCP       39708 > http [ACK] Seq=2 Ack=2 Win=5888 Len=0 TSV=1459816 TSER=108169

▸ Frame 238 (576 bytes on wire, 576 bytes captured)
▸ Ethernet II, Src: 58:6d:8f:3d:3b:ca (58:6d:8f:3d:3b:ca), Dst: IntelCor_c9:cc:96 (00:1c:bf:c9:cc:96)
▸ Internet Protocol, Src: 128.119.245.12 (128.119.245.12), Dst: 192.168.1.144 (192.168.1.144)
▸ Transmission Control Protocol, Src Port: http (80), Dst Port: 39707 (39707), Seq: 719, Ack: 153287, Len: 510
▸ Data (510 bytes)

0000  00 1c bf c9 cc 96 58 6d  8f 3d 3b ca 08 00 45 00   ......Xm .=;....E.
0010  02 32 7f 9f 40 00 23 06  9e 6a 80 77 f5 0c c0 a8   .2..@.#. .j.w....
0020  01 90 00 50 9b 1b c5 8f  49 66 ab 7c 00 55 00 18   ...P.... If.|.U..
0030  03 6d 7a a1 00 00 01 01  08 0a 00 a4 ed 5a 00 16   .mz..... .....Z..

Frame (frame), 576 bytes      Packets: 279 Displayed: 212 Marked: 0      Profile: Default
```

Throughput = Total Data/Total time taken

= (Acknowledged Sequence number of last ACK - Sequence number of first segment)

/Timeinstant of last ACK - Time instant of first TCP segment

= 153287 - 1   /15:16:29.842760 - 15:16:26.375202

= 153286/3.467558

= 44205.749406355B/sec

= 43.169677155 KBytes/sec

13. The criteria to determine the end of slow start and the beginning of the

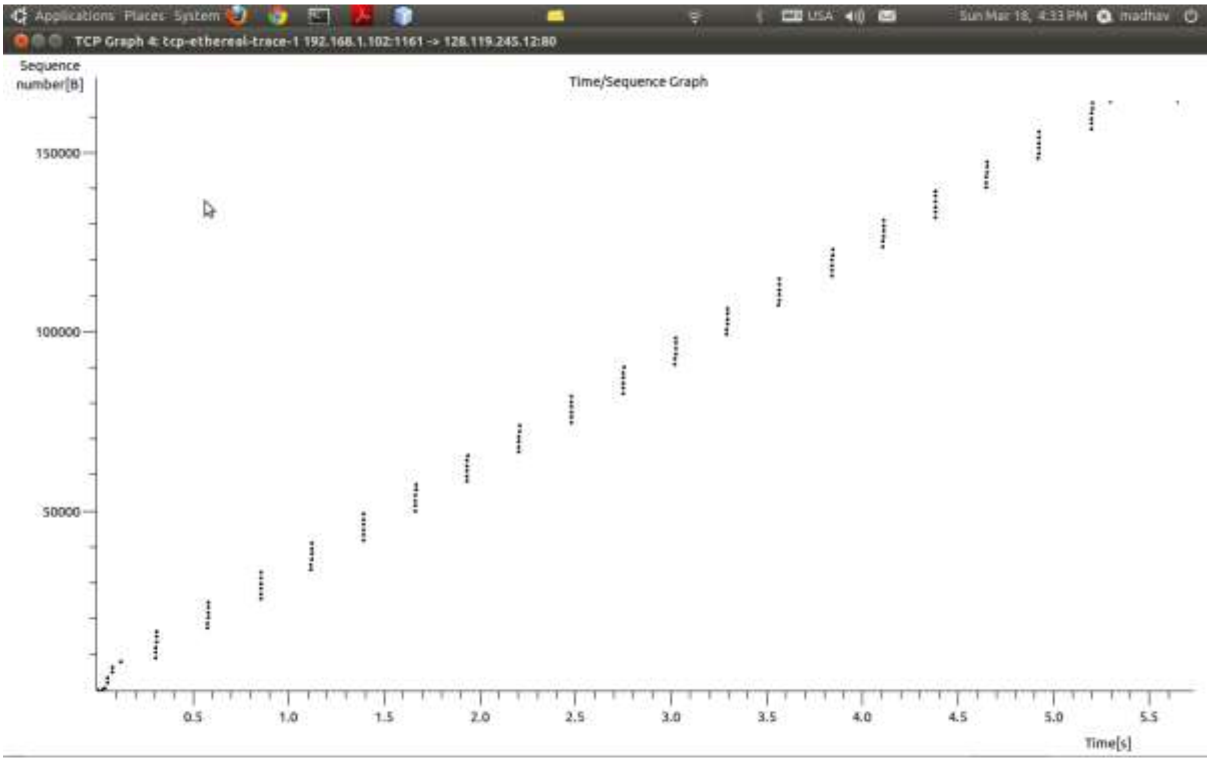
congestion avoidance is the way how congestion window size reacts to the arrival of

ACKs. Upon an ACK arrival, if the congestion window size increases by one MSS, TCP sender still stays in the slow start phase. In the congestion avoidance phase, the congestion window size increases at 1/(current_congestion_window_size). By inspecting the change of the congestion window upon the arrival of ACKs, we can infer the states of the TCP sender.

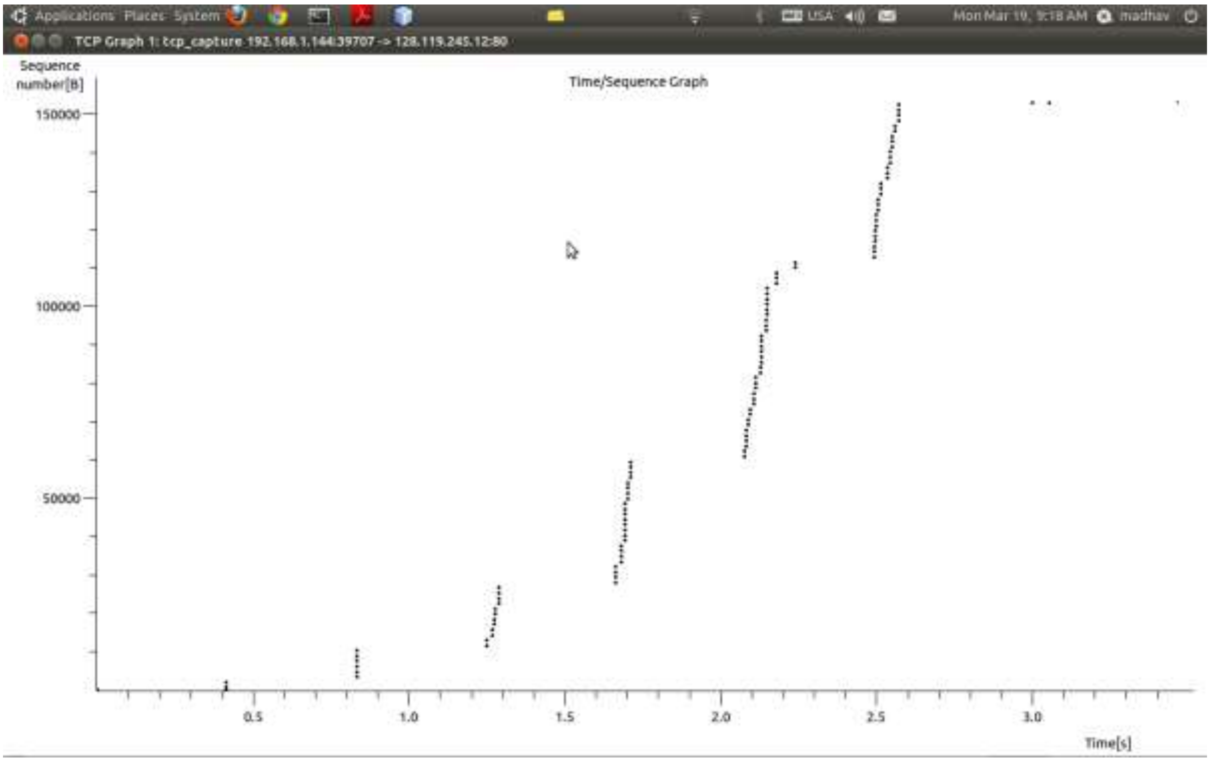
The identification of the TCP slow start phase and congestion avoidance phase depends on the value of the congestion window size of this TCP sender.

We cannot determine the end of the slow start phase and the start of the congestion avoidance phase for this trace. The major reason is that this TCP sender is not sending data aggressively enough to push to the congestion state. Before the end of the slow start phase, the application already stops transmission.

The idealized behavior of TCP in the text assumes that TCP senders are aggressive in sending data. In the practice, TCP behavior also largely depends on the application. In this example, when the TCP sender can send out data, there are no data available for transmission. In the web application,some of web objects have very small sizes. Before the end of slow start phase, the transmission is over



14.


Applications Places System
USA
Mon Mar 19, 9:18 AM madhav
TCP Graph 1: tcp_capture 192.168.1.144:39707 -> 128.119.245.12:80
Sequence number[B]
Time/Sequence Graph
150000
100000
50000
0.5
1.0
1.5
2.0
2.5
3.0
Time[s]

We cannot determine the end of the slow start phase and the start of the congestion avoidance phase for this trace. The major reason is that this TCP sender is not sending data aggressively enough to push to the congestion state. Before the end of the slow start phase, the application already stops transmission.