

计算机学院 计算机网络 课程实验报告

实验题目： TCP		学号： 202200130048
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实验方法介绍： 通过 wireshark 捕获 tcp 传输， 具体根据信息和图表了解 TCP 相关知识		
实验过程描述： 1. 捕获从计算机到远程服务器的批量 TCP 传输 2. 首先看一下捕获的跟踪 3. TCP 基础知识 4. TCP 拥塞控制在行动		
结论分析： 1. What is the IP address and TCP port number used by the client computer (source) that is transferring the alice.txt file to gaia.cs.umass.edu? 源 IP:172. 25. 129. 25 端口号： 23361 		
2. What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection? IP: 128. 119. 245. 12 端口号： 80 		
3. 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? Seq=27153442391 (raw) ; seq=0 (relative) 		

```
Sequence Number: 0 (relative sequence number)
Sequence Number (raw): 2715342391
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 0
Acknowledgment number (raw): 0
1000 .... = Header Length: 32 bytes (8)
```

What is it in this TCP segment that identifies the segment as a SYN segment?
Will the TCP receiver in this session be able to use Selective Acknowledgments?

Flags; not selective

```
▼ Flags: 0x002 (SYN)
 000. .... = Reserved: Not set
...0 .... = Accurate ECN: Not set
.... 0... = Congestion Window Reduced: Not set
.... .0.. = ECN-Echo: Not set
.... ..0. = Urgent: Not set
.... ...0 = Acknowledgment: Not set
.... .... 0... = Push: Not set
.... ..... 0.. = Reset: Not set
▼ .... .... .1. = Syn: Set
  ▼ [Expert Info (Chat/Sequence): Connection establish request (SYN): server port 80]
    [Connection establish request (SYN): server port 80]
    [Severity level: Chat]
    [Group: Sequence]
```

4. What is the sequence number of the SYNACK segment sent by gaia.cs.umass.edu to the client computer in reply to the SYN?

Seq=428255010;

```
> [Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 0]
Sequence Number: 0 (relative sequence number)
Sequence Number (raw): 428255010
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 2715342392
```

What is it in the segment that identifies the segment as a SYNACK segment?
What is the value of the Acknowledgement field in the SYNACK segment? How did gaia.cs.umass.edu determine that value?

Flags; set ; 确认连接请求, 返回一个 SYN ACK 段, ack 为 1

```
▼ Flags: 0x012 (SYN, ACK)
 000. .... = Reserved: Not set
...0 .... = Accurate ECN: Not set
.... 0... = Congestion Window Reduced: Not set
.... .0.. = ECN-Echo: Not set
.... ..0. = Urgent: Not set
.... ...1 = Acknowledgment: Set
.... .... 0... = Push: Not set
.... ..... 0.. = Reset: Not set
> .... .... .1. = Syn: Set
  .... .... ...0 = Fin: Not set
[TCP Flags: .....A..S.]
```

5. What is the sequence number of the TCP segment containing the header of the HTTP POST command?

Seq=2715342392 (raw) ; seq (relative) =1

9094	69.714823	172.25.129.25	128.119.245.12	TCP	808 23361 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131328 Len=754 [TCP segment of a reassembled PDU]
9095	69.715022	172.25.129.25	128.119.245.12	TCP	13194 23361 → 80 [ACK] Seq=755 Ack=1 Win=131328 Len=13140 [TCP segment of a reassembled PDU]
9096	69.762569	192.168.254.245	172.25.129.25	DNS	93 Standard query response 0xad64 A gaia.cs.umass.edu A 128.119.245.12
9097	69.762570	192.168.254.245	172.25.129.25	DNS	93 Standard query response 0xff08 A gaia.cs.umass.edu A 128.119.245.12
9098	69.762738	192.168.254.245	172.25.129.25	DNS	77 Standard query response 0x1409 AAAA gaia.cs.umass.edu
9099	69.763156	192.168.254.245	172.25.129.25	DNS	77 Standard query response 0xaf59 AAAA gaia.cs.umass.edu
9100	69.765588	172.25.129.25	192.168.254.245	DNS	94 Standard query 0x7d28 AAA nav-edge.smartscreen.microsoft.com
9101	69.765925	172.25.129.25	192.168.254.245	DNS	94 Standard query 0x2286 A nav-edge.smartscreen.microsoft.com
9102	69.766257	172.25.129.25	192.168.254.245	DNS	94 Standard query 0xf386 HTTPS nav-edge.smartscreen.microsoft.com
9103	69.766647	172.25.129.25	40.119.213.159	TLSv1.3	257 Application Data
9104	69.766734	172.25.129.25	40.119.213.159	TLSv1.3	93 Application Data

Source Address:	172.25.129.25	0030	02 01 a5 c3 00 00 50 4f	53 54 20 2f 77 69 72 65	00 ST /wip
Destination Address:	128.119.245.12	0040	73 68 61 72 6b 2d 6c 61	62 73 2f 6c 61 62 33 2d	0000 0000 0000 0000 0000 0000 0000 0000
Transmission Control Protocol, Src Port:	23361, Dst Port:	0050	31 2d 72 65 70 6c 70 2e	68 74 6d 20 48 54 54 56	0000 0000 0000 0000 0000 0000 0000 0000
Seq:	1, Ack:	0060	2f 31 2e 31 0d 0a 4b 6f	73 74 3a 20 67 61 69 61	0000 0000 0000 0000 0000 0000 0000 0000
Len:	754	0070	2e 63 73 2e 75 6d 61 73	73 2e 65 64 75 0d 0a 43	0000 0000 0000 0000 0000 0000 0000 0000
Stream index:	69	0080	6f 6e 6e 65 63 74 69 6f	6e 3a 20 6b 65 65 70 2d	0000 0000 0000 0000 0000 0000 0000 0000
Connection Complete: Complete, WITH DATA (31)		0090	61 6c 69 70 65 0d 0a 43	6f 6e 74 65 6e 74 2d 4c	0000 0000 0000 0000 0000 0000 0000 0000
TCP Segment Len:	754	00a0	65 6e 67 74 6b 3a 20 31	35 32 33 32 31 0d 0a 43	0000 0000 0000 0000 0000 0000 0000 0000
Sequence Number:	1 (relative sequence number)	00b0	61 63 68 65 2d 43 6f 6e	74 72 6f 6c 3a 20 6d 61	0000 0000 0000 0000 0000 0000 0000 0000
Sequence Number (raw):	271532392	00c0	78 2d 61 67 65 3d 30 0d	0a 55 70 67 72 61 64 65	0000 0000 0000 0000 0000 0000 0000 0000
Next Sequence Number:	755 (relative sequence number)	00d0	2d 4b 6e 73 65 63 75 72	65 2d 52 65 71 75 65 73	0000 0000 0000 0000 0000 0000 0000 0000
Acknowledgment Number:	1 (relative ack number)	00e0	74 73 3a 20 31 0d 0a 4f	72 69 67 69 6a 3a 20 68	0000 0000 0000 0000 0000 0000 0000 0000
Acknowledgment number (raw):	42825011	00f0	74 74 70 3a 2f 2f 67 61	69 61 2e 63 73 2e 75 6d	0000 0000 0000 0000 0000 0000 0000 0000
0101 = Header Length: 20 bytes (5)		0100	61 73 73 2e 65 64 75 0d	0a 43 6f 6e 74 65 6e 74	0000 0000 0000 0000 0000 0000 0000 0000
Flags: 0x010 (PSH, ACK)		0110	2d 54 79 70 65 3a 20 6d	75 6c 74 69 70 61 72 74	0000 0000 0000 0000 0000 0000 0000 0000
0000 = Reserved: Not set		0120	2f 6e 6f 72 6d 2d 64 61	74 61 3b 20 62 6f 75 6e	0000 0000 0000 0000 0000 0000 0000 0000
...0 = Accurate ECH: Not set		0130	64 61 72 79 3d 2d 2d 2d	2d 57 65 62 4b 69 74 6e	0000 0000 0000 0000 0000 0000 0000 0000
		0140	6f 72 6d 42 6f 75 6e 64	61 72 79 42 75 39 56 37	0000 0000 0000 0000 0000 0000 0000 0000
		0150	32 6d 34 75 49 4a 39 76	6d 4b 52 0d 0a 55 73 65	0000 0000 0000 0000 0000 0000 0000 0000
		0160	72 2d 41 67 65 6e 74 3a	20 4d 6f 7a 69 6c 6c 61	0000 0000 0000 0000 0000 0000 0000 0000
		0170	2f 35 2e 30 20 28 57 69	6e 64 6f 77 73 20 4e 5d	0000 0000 0000 0000 0000 0000 0000 0000

How many bytes of data are contained in the payload (data) field of this TCP segment? Did all of the data in the transferred file alice.txt fit into this single segment?

754bytes; 不在一个段里

[Bytes in flight: 754]

[Bytes sent since last PSH flag: 754]

TCP payload (754 bytes)

[Reassembled PDU in frame: 9138]

TCP segment data (754 bytes)

6. At what time was the first segment (the one containing the HTTP POST) in the data-transfer part of the TCP connection sent?

69.714823s

Arrival Time: Apr 2, 2024 08:19:52.253943000 中国标准时间
 UTC Arrival Time: Apr 2, 2024 00:19:52.253943000 UTC
 Epoch Arrival Time: 1712017192.253943000
 [Time shift for this packet: 0.000000000 seconds]
 [Time delta from previous captured frame: 0.007187000 seconds]
 [Time delta from previous displayed frame: 0.007187000 seconds]
 [Time since reference or first frame: 69.714823000 seconds]
 Frame Number: 9094

At what time was the ACK for this first data-containing segment received?

70.04395s

Arrival Time: Apr 2, 2024 08:19:52.583070000 中国标准时间
 UTC Arrival Time: Apr 2, 2024 00:19:52.583070000 UTC
 Epoch Arrival Time: 1712017192.583070000
 [Time shift for this packet: 0.000000000 seconds]
 [Time delta from previous captured frame: 0.174393000 seconds]
 [Time delta from previous displayed frame: 0.174393000 seconds]
 [Time since reference or first frame: 70.043950000 seconds]
 Frame Number: 9119

What is the RTT for this first data-containing segment?

0.329127s

[Time since previous frame in this TCP stream: 0.329127000 seconds]
 [SEQ/ACK analysis]
 [This is an ACK to the segment in frame: 9094]
 [The RTT to ACK the segment was: 0.329127000 seconds]
 [iRTT: 0.261088000 seconds]

What is the RTT value the second data-carrying TCP segment and its ACK?
0.261088s

```
[Time since previous frame in this TCP stream: 0.000000000 seconds]
▼ [SEQ/ACK analysis]
  [This is an ACK to the segment in frame: 9095]
  [The RTT to ACK the segment was: 0.328929000 seconds]
  [iRTT: 0.261088000 seconds]
```

What is the EstimatedRTT value (see Section 3.5.3, in the text) after the ACK for the second data-carrying segment is received? $\alpha = 0.125$

$$\text{EstimatedRTT} = (1 - \alpha) \times \text{CurrentEstimatedRTT} + \alpha \times \text{SampleRTT}$$
$$= (1 - 0.125) * 0.329127 + 0.125 * 0.261088 = 0.320622125s$$

7. What is the length (header plus payload) of each of the first four data-carrying TCP segments?

Header=20;

754+20=774; 13140+20=13160; 27740+20=27760; 55480+20=55500

```
▼ [5 Reassembled TCP Segments (153075 bytes): #9094(754), #9095(13140), #9123(27740), #9129(55480),
  [Frame: 9094, payload: 0-753 (754 bytes)]
  [Frame: 9095, payload: 754-13893 (13140 bytes)]
  [Frame: 9123, payload: 13894-41633 (27740 bytes)]
  [Frame: 9129, payload: 41634-97113 (55480 bytes)]
  [Frame: 9138, payload: 97114-153074 (55961 bytes)]
  [Segment count: 5]
```

8. What is the minimum amount of available buffer space advertised to the client by gaia.cs.umass.edu among these first four data-carrying TCP segments? Does the lack of receiver buffer space ever throttle the sender for these first four data-carrying segments?

513*256=131328, 最小可用缓冲空间为 131328; 空间不足会限制段的使用

Window: 513

[Calculated window size: 131328]

[Window size scaling factor: 256]

9. Are there any retransmitted segments in the trace file? What did you check for (in the trace) in order to answer this question?

没有重传段。检查是否有[TCP Retransmission]标记, 在Wireshark中, 右键点击感兴趣的TCP流, 选择“Analyze”->“TCP Stream”, 在弹出的对话框中查看“Retransmissions”区域, 如果有重传发生, 这里会列出具体的重传次数和相关段信息。

9094	69.714823	172.25.129.25	128.119.245.12	TCP	800	23361 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131328 Len=754 [TCP segment of a reassembled PDU]
9095	69.715822	172.25.129.25	128.119.245.12	TCP	13194	23361 → 80 [ACK] Seq=755 Ack=1 Win=131328 Len=13140 [TCP segment of a reassembled PDU]
9123	70.043952	172.25.129.25	128.119.245.12	TCP	27794	23361 → 80 [PSH, ACK] Seq=13895 Ack=1 Win=131328 Len=27740 [TCP segment of a reassembled PDU]
9124	70.352435	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=21195 Win=71680 Len=0
9125	70.352436	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=28495 Win=86272 Len=0
9126	70.352436	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=31415 Win=92032 Len=0
9127	70.352436	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=38715 Win=106752 Len=0
9128	70.352436	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=41635 Win=112512 Len=0
9129	70.352490	172.25.129.25	128.119.245.12	TCP	55534	23361 → 80 [PSH, ACK] Seq=41635 Ack=1 Win=131328 Len=55480 [TCP segment of a reassembled PDU]
9130	70.658355	128.119.245.12	172.25.129.25	TCP	56	80 → 23361 [ACK] Seq=1 Ack=48935 Win=127104 Len=0

10. How much data does the receiver typically acknowledge in an ACK among the first ten data-carrying segments sent from the client to gaia.cs.umass.edu? Can you identify cases where the receiver is ACKing

every other received segment (see Table 3.2 in the text) among these first ten data-carrying segments?

大约 6000 左右数据

808	23361 → 80	[PSH, ACK]	Seq=1	Ack=1	Win=131328	Len=754	[TCP segment of a reassembled PDU]
13194	23361 → 80	[ACK]	Seq=755	Ack=1	Win=131328	Len=13140	[TCP segment of a reassembled PDU]
56	80 → 23361	[ACK]	Seq=1	Ack=755	Win=30720	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=8055	Win=45312	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=13895	Win=57088	Len=0	
27794	23361 → 80	[PSH, ACK]	Seq=13895	Ack=1	Win=131328	Len=27740	[TCP segment of a reassembled PDU]
56	80 → 23361	[ACK]	Seq=1	Ack=21195	Win=71680	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=28495	Win=86272	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=31415	Win=92032	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=38715	Win=106752	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=41635	Win=112512	Len=0	
55534	23361 → 80	[PSH, ACK]	Seq=41635	Ack=1	Win=131328	Len=55480	[TCP segment of a reassembled PDU]
56	80 → 23361	[ACK]	Seq=1	Ack=48935	Win=127104	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=56235	Win=141696	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=63535	Win=156288	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=70835	Win=170880	Len=0	
56	80 → 23361	[ACK]	Seq=1	Ack=78135	Win=179584	Len=0	

Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 428255011
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 755 (relative ack number)
Acknowledgment number (raw): 2715343146
0101 = Header Length: 20 bytes (5)

Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 428255011
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 8055 (relative ack number)
Acknowledgment number (raw): 2715350446
0101 = Header Length: 20 bytes (5)

Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 428255011
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 13895 (relative ack number)
Acknowledgment number (raw): 2715356286

[TCP Segment Len: 0]
Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 428255011
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 21195 (relative ack number)
Acknowledgment number (raw): 2715363586
0101 = Header Length: 20 bytes (5)

Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 428255011
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 28495 (relative ack number)
Acknowledgment number (raw): 2715370886
0101 = Header Length: 20 bytes (5)
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 31415 (relative ack number)

[next sequence number: 1 (relative sequence number)]

Acknowledgment Number: 38715 (relative ack number)

[next sequence number: 1 (relative sequence number)]

Acknowledgment Number: 41635 (relative ack number)

[next sequence number: 1 (relative sequence number)]

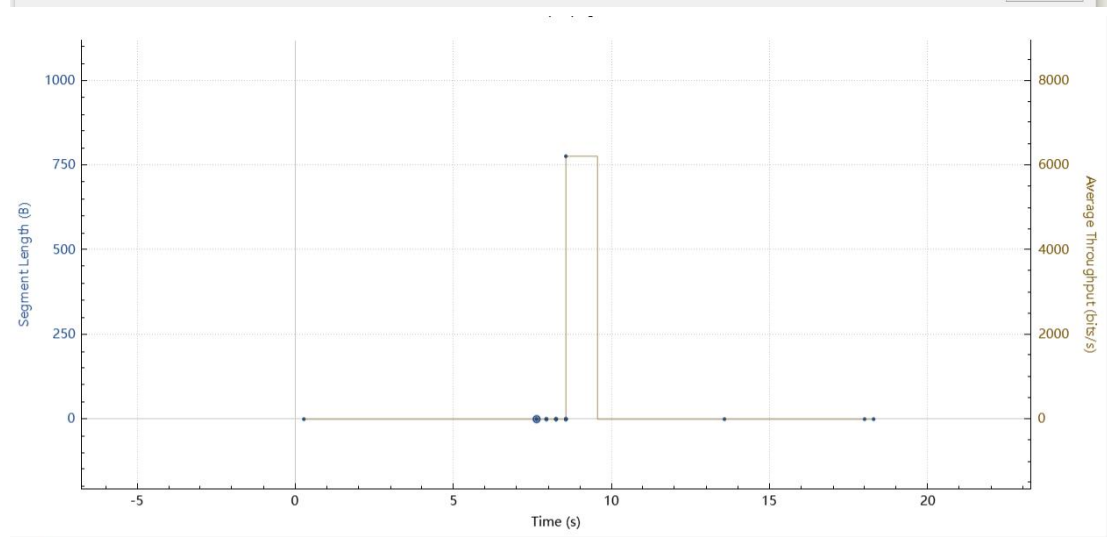
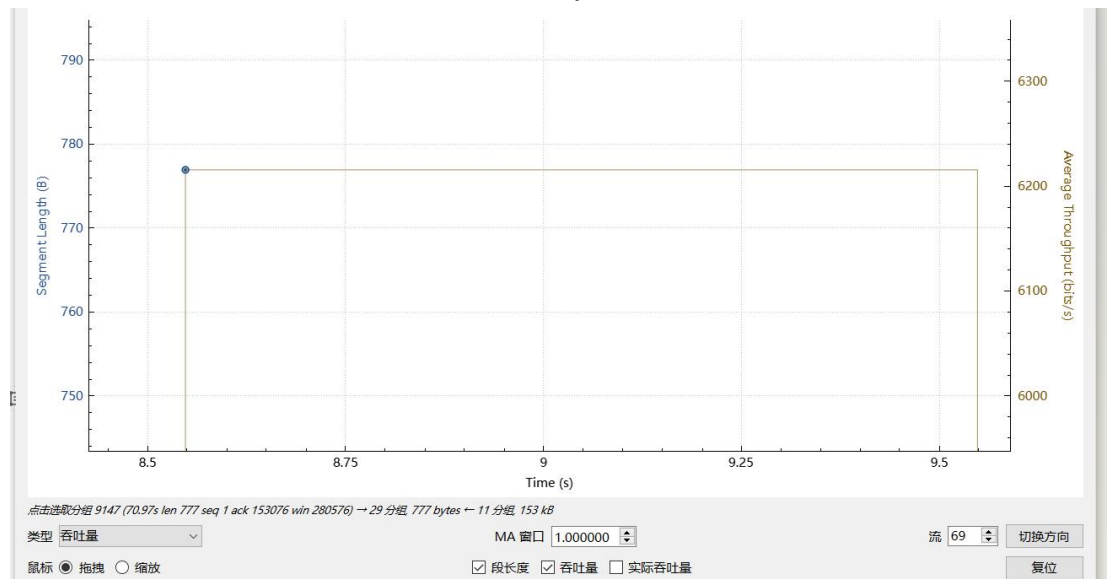
Acknowledgment Number: 48935 (relative ack number)

[next sequence number: 1 (relative sequence number)]

Acknowledgment Number: 56235 (relative ack number)

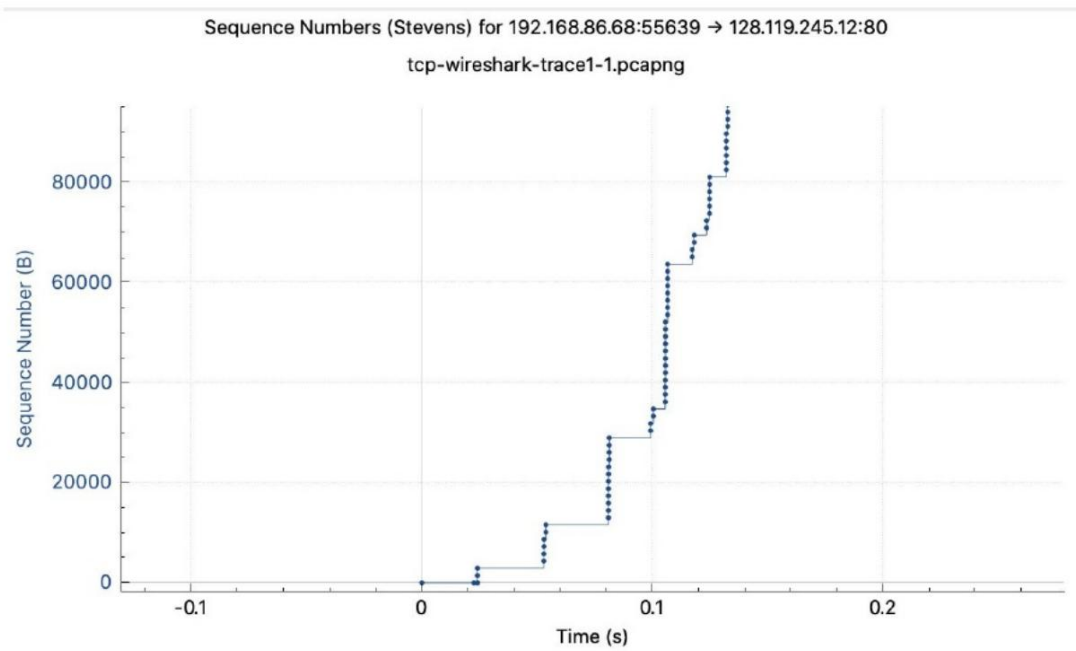
11. What is the throughput (bytes transferred per unit time) for the TCP connection? Explain how you calculated this value.

吞吐量 = 总字节数 / 时间单位 = 777bytes / 1s = 6216bits/s



12. Use the Time-Sequence-Graph(Stevens) plotting tool to view the sequence number versus time plot of segments being sent from the client to the gaia.cs.umass.edu server. Consider the “fleets” of packets sent around $t = 0.025$, $t = 0.053$, $t = 0.082$ and $t = 0.1$.

根据题设给出的图可以看出 0.1 之前的传输间隔时间在变短而传输的数据在成倍变多，处于缓慢启动阶段。

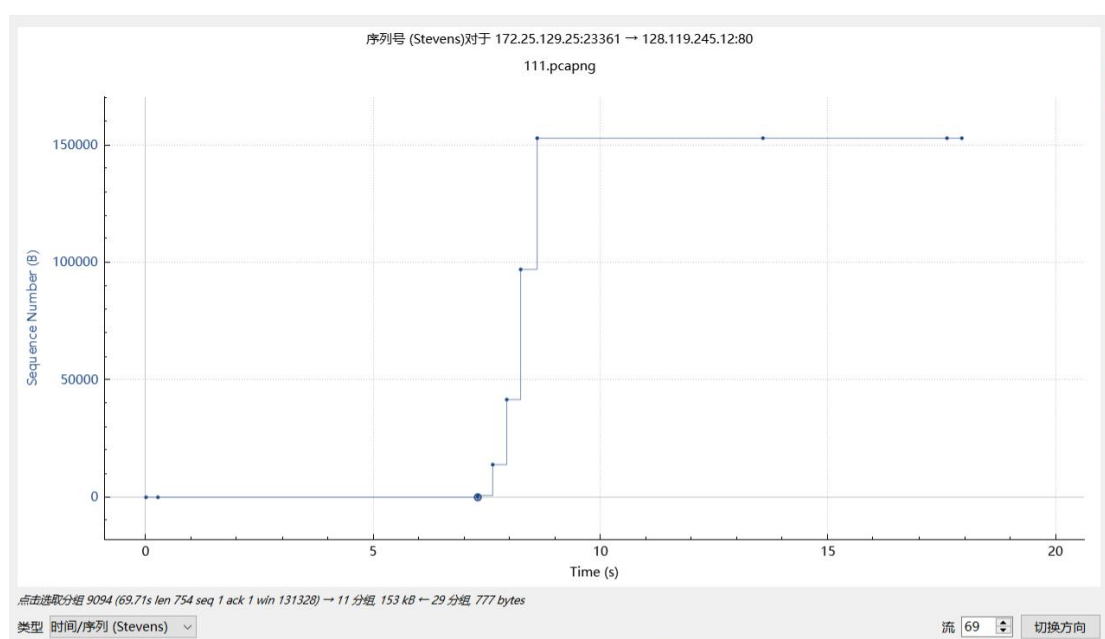


13. These “fleets” of segments appear to have some periodicity. What can you say about the period?

0.1s 前在数据成倍增长，而 0.14s 后数据从一个较高值大幅度减半，这通常意味着网络严重拥塞已被检测到，TCP 进入慢启动阶段重新开始增长，即拥塞发生与拥塞窗口减半阶段。可以看出这个周期就是从慢启动到拥塞一个不断重复的过程。

14. Answer each of two questions above for the trace that you have gathered when you transferred a file from your computer to gaia.cs.umass.edu

(12) 在 7.3s-8.2s 可以看出慢启动，传输的数据成倍增加。



(13) 在 8.2s 之后也就是最后一个传输增幅很小，进入了拥塞避免阶段，直到传输结束，可以看出每段传输间隔时间相同。

结论：

1. 三次握手进行 TCP 传输（SYN 段，SYN ACK 段，ACK 段）

2. 吞吐率 = 总字节数 / 时间单位

3. 大文件会进行多次 TCP 传输

4. 拥塞控制

（1）慢启动阶段：当 TCP 连接刚建立或者经历过重置后，通常从一个较小的值开始增长。在慢启动阶段，每次收到一个确认 ACK 时，cwnd 大小翻倍。

（2）拥塞避免阶段：当 cwnd 达到某个阈值时，TCP 进入拥塞避免阶段。在此阶段，cwnd 的增长不再是指数级，而是按照每个往返时间（RTT）增加 1 个 MSS 的线性速度增长。序列号间隔有规律地、小幅度地递增。

（3）快速重传与快速恢复：若在图中观察到序列号突然跳跃回退，随后 cwnd 有所减小并重新开始增长，这表明网络中出现了短暂的拥塞，TCP 正在执行快速重传与恢复机制。

（4）拥塞发生与拥塞窗口减半：若序列号增长突然大幅下降，且后续 cwnd 从一个较高值大幅度减半，这通常意味着网络严重拥塞已被检测到，TCP 进入慢启动阶段重新开始增长。