

# 计算机网络实验 3

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## 2. A first look at the captured trace

文档中给出的包截图如下

文件(F) 编辑(E) 视图(V) 跳转(G) 捕获(C) 分析(A) 统计(S) 电话(Y) 无线(W) 工具(T) 帮助(H)

tcp && ip.addr == 128.119.245.12

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565 [TCP segmen
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP seg
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	0.077405	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460 [TCP segment

Frame 1: 62 bytes on wire (496 bits), 62 bytes captured (496 bits) on interface 0

Ethernet II, Src: Actionte\_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG\_da:af:81:27 (08:00:0c:27:81:27)

Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12

Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 0, Len: 0

- Source Port: 1161
- Destination Port: 80
- [Stream index: 0]
- [Conversation completeness: Incomplete, DATA (15)]
- [TCP Segment Len: 0]
- Sequence Number: 0 (relative sequence number)
- Sequence Number (raw): 232129012

Source Port (tcp.srcport), 2 byte(s)

分组: 213 · 已显示: 201 (94.4%)

配置: Default

- 客户计算机使用的 IP 地址为 192.168.0.102 , 端口号为 1161 .
- gaia.cs.umass.edu 的 IP 地址为 128.119.245.12 , 端口号为 80 .
- 我的客户计算机使用的 IP 地址为 192.168.84.1 , 端口号为 36050 .

文件(F) 编辑(E) 视图(V) 跳转(G) 捕获(C) 分析(A) 统计(S) 电话(Y) 无线(W) 工具(T) 帮助(H)

tcp && ip.addr == 128.119.245.12

No.	Time	Source	Destination	Protocol	Length	Info
14	1.161080385	192.168.84.1	128.119.245.12	TCP	74	36050 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=286289497 T
15	1.161107833	192.168.84.1	128.119.245.12	TCP	74	36050 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=286289497 T
17	1.411656219	192.168.84.1	128.119.245.12	TCP	74	36050 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=286289497 T
18	1.478123189	128.119.245.12	192.168.84.1	TCP	74	80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM TSval=286289497 T
19	1.478123208	128.119.245.12	192.168.84.1	TCP	74	80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM TSval=286289497 T
20	1.478208831	192.168.84.1	128.119.245.12	TCP	66	36050 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=286289497 T
21	1.478231312	192.168.84.1	128.119.245.12	TCP	66	36050 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=286289497 T
22	1.478634173	192.168.84.1	128.119.245.12	TCP	784	36050 → 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=718 TSval=286289497 T
23	1.478737989	192.168.84.1	128.119.245.12	TCP	2842	36050 → 80 [PSH, ACK] Seq=719 Ack=1 Win=64256 Len=2776 TSval=286289497 T
24	1.478746270	192.168.84.1	128.119.245.12	TCP	2842	36050 → 80 [PSH, ACK] Seq=3495 Ack=1 Win=64256 Len=2776 TSval=286289497 T

Frame 14: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0

Ethernet II, Src: IntelCor\_9a:07:45 (34:2e:b7:9a:07:45), Dst: 8a:b9:75:16:8a:da (08:00:27:8a:b9:75)

Internet Protocol Version 4, Src: 192.168.84.1, Dst: 128.119.245.12

Transmission Control Protocol, Src Port: 36050, Dst Port: 80, Seq: 0, Len: 0

wireshark\_wlp0s20f3099PU1.pcapng

分组: 187 · 已显示: 162 (86.6%)

配置: Default

## 3. TCP Basics

使用提供的包

4. 序号为 0 ; Flags 字段设为 0x002 表明它是 SYN 报文段.

The image shows a Wireshark packet capture window. The packet list on the left shows a single packet (No. 1) of type Transmission Control Protocol. The details pane on the right shows the structure of the packet. The Ethernet II section shows the source and destination MAC addresses. The Internet Protocol Version 4 section shows the source and destination IP addresses. The Transmission Control Protocol section shows the source and destination ports, sequence number, and flags. The flags field is expanded, showing the Syn flag as set. The status bar at the bottom shows the packet number, time, source and destination IP addresses, and the flags field.

Frame 1: 62 bytes on wire (496 bits), 62 bytes captured (496 bits)

Ethernet II, Src: Actionte\_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG\_da:af:73 (00:0c:29:1a:73:00)

Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12

Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 0, Len: 0

- Source Port: 1161
- Destination Port: 80
- [Stream index: 0]
- [Conversation completeness: Incomplete, DATA (15)]
- [TCP Segment Len: 0]
- Sequence Number: 0 (relative sequence number)
- Sequence Number (raw): 232129012
- [Next Sequence Number: 1 (relative sequence number)]
- Acknowledgment Number: 0
- Acknowledgment number (raw): 0
- 0111 .... = Header Length: 28 bytes (7)
- 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
  - .... .... ...0 = Fin: Not set
- [TCP Flags: .....S.]

No.: 1 · Time: 0.000000 · Source: 192.168.1.102 · Destination: 128.119.245.12 · 1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK\_PERM

☐ Show packet bytes

关闭 帮助

5. 序号为 0; Acknowledgement 字段为 1; Acknowledgement 字段的值是由客户发出的 SYN 报文序号加 1 得到; Flags 字段被设为了 0x012 表明它是 SYNACK 报文.

Frame 2: 62 bytes on wire (496 bits), 62 bytes captured (496 bits)

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 Version 4, Src: 128.119.245.12, Dst: 192.168.1.102

Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 0, Ack: 1, Len: 0

- Source Port: 80
- Destination Port: 1161
- [Stream index: 0]
- [Conversation completeness: Incomplete, DATA (15)]
- [TCP Segment Len: 0]
- Sequence Number: 0 (relative sequence number)
- Sequence Number (raw): 883061785
- [Next Sequence Number: 1 (relative sequence number)]
- Acknowledgment Number: 1 (relative ack number)
- Acknowledgment number (raw): 232129013
- 0111 .... = Header Length: 28 bytes (7)

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.]

No.: 2 · Time: 0.023172 · Source: 128.119.245.12 · Destination: 192... 80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK\_PERM

☐ Show packet bytes

关闭 帮助

6. 序号为 1.

Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits)

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 Version 4, Src: 192.168.1.102, Dst: 128.119.245.12

Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565

- Source Port: 1161
- Destination Port: 80
- [Stream index: 0]
- [Conversation completeness: Incomplete, DATA (15)]
- [TCP Segment Len: 565]
- Sequence Number: 1 (relative sequence number)

0000 00 06 25 da af 73 00 20 e0 8a 70 1a 08 00 45 00 ...%s: ..p...E.  
0010 02 5d 1e 21 40 00 80 06 a2 e7 c0 a8 01 66 80 77 ..]!@... ..f.w  
0020 f5 0c 04 89 00 50 0d d6 01 f5 34 a2 74 1a 50 18 .....P...4.t.P.  
0030 44 70 1f bd 00 00 50 4f 53 54 20 2f 65 74 68 63 Dp...PO ST /ethe  
0040 72 65 61 6c 2d 6c 61 62 73 2f 6c 61 62 33 2d 31 real-lab s/lab3-1  
0050 2d 72 65 70 6c 79 2e 68 74 6d 20 48 54 54 50 2f -reply.htm HTTP/  
0060 31 2e 31 0d 0a 48 6f 73 74 3a 20 67 61 69 61 2e 1.1..Host: gaia.  
0070 63 73 2e 75 6d 61 73 73 2e 65 64 75 0d 0a 55 73 cs.umass .edu..Us  
0080 65 72 2d 41 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6c er-Agent : Mozill  
0090 61 2f 35 2e 30 20 28 57 69 6e 64 6f 77 73 3b 20 a/5.0 (Windows;  
00a0 55 3b 20 57 69 6e 64 6f 77 73 20 4e 54 20 35 2e U; Windows NT 5.  
00b0 31 3b 20 65 6e 2d 55 53 3b 20 72 76 3a 31 2e 30 1; en-US ; rv:1.0  
00c0 2e 32 29 20 47 65 63 6b 6f 2f 32 30 30 33 30 32 .2) Gecko/200302  
00d0 30 38 20 4e 65 74 73 63 61 70 65 2f 37 2e 30 32 08 Netscape/7.02  
00e0 0d 0a 41 63 63 65 70 74 3a 20 74 65 78 74 2f 78 ..Accept : text/x  
00f0 6d 6c 2c 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78 ml, application/x  
0100 6d 6c 2c 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78 ml, application/x  
0110 68 74 6d 6c 2b 78 6d 6c 2c 74 65 78 74 2f 68 74 html+xml, text/ht  
0120 6d 6c 3b 71 3d 30 2e 39 2c 74 65 78 74 2f 70 6c ml;q=0.9, text/pl  
0130 61 69 6e 3b 71 3d 30 2e 38 2c 76 69 64 65 6f 2f ain;q=0.8, video/  
0140 78 2d 6d 6e 67 2c 69 6d 61 67 65 2f 70 6e 67 2c x-mng, image/png,

☒ Show packet bytes

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7. 如下表所示 (时间单位为秒), 这 6 个报文分别对应编号为 4, 5, 7, 8, 10, 11 的包, 其 ACK 报文分别对应编号为 6, 9, 12, 14, 15, 16 的包.

	序号	报文发送时间	ACK 接收时间	RTT	接收到 ACK 报文后的 EstimatedRTT
报文 1	1	0.026477	0.053937	0.027460	0.027460
报文 2	566	0.041737	0.077294	0.035557	0.028472
报文 3	2026	0.054026	0.124085	0.070059	0.033670
报文 4	3486	0.054690	0.169118	0.114428	0.043765
报文 5	4946	0.077405	0.217299	0.139894	0.055781
报文 6	6406	0.078157	0.267802	0.189645	0.072514

The figure displays two screenshots of the Wireshark network protocol analyzer interface, showing a packet capture of a TCP connection.

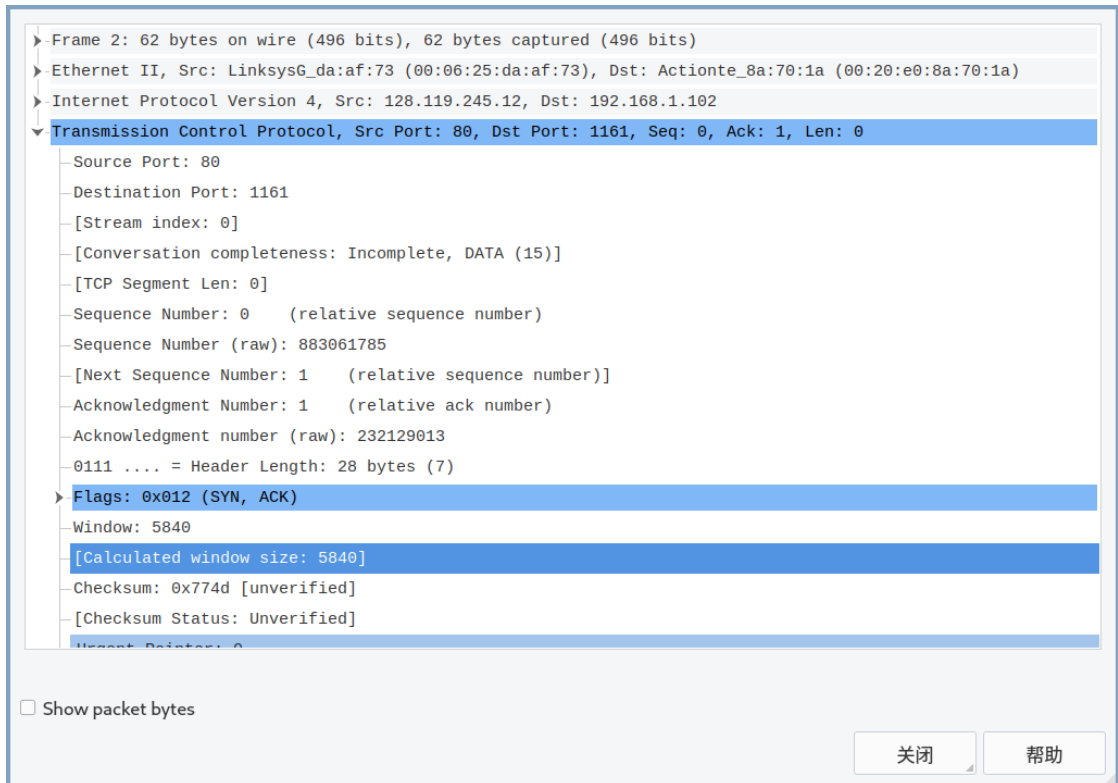
**Top Screenshot:**

- Filter:** tcp && ip.addr == 128.119.245.12
- Packet List:** Shows 18 packets. The first packet (No. 1) is a SYN packet from 192.168.1.102 to 128.119.245.12, establishing a connection. Subsequent packets show data transfer.
- Packet Details:** The selected packet (No. 1) is expanded, showing the TCP header and options. The TCP header includes: Seq=0, Win=16384, Len=0, MSS=1460, SACK\_PERM.

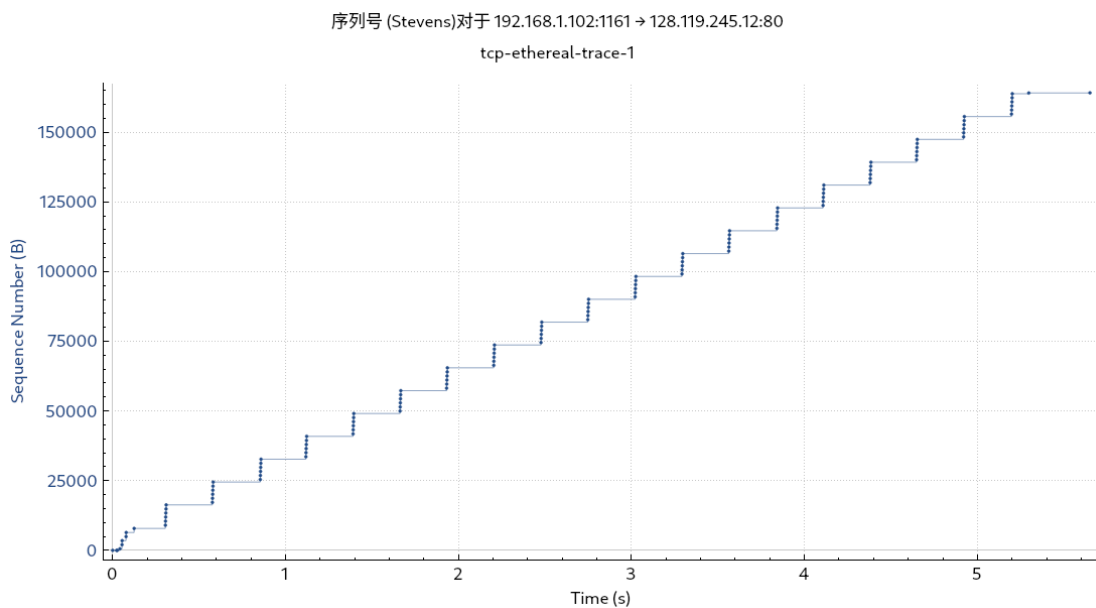
**Bottom Screenshot:**

- Filter:** tcp && ip.addr == 128.119.245.12
- Packet List:** Shows 18 packets. The first packet (No. 1) is a SYN packet from 192.168.1.102 to 128.119.245.12, establishing a connection. Subsequent packets show data transfer.
- Packet Details:** The selected packet (No. 1) is expanded, showing the TCP header and options. The TCP header includes: Seq=0, Win=16384, Len=0, MSS=1460, SACK\_PERM.

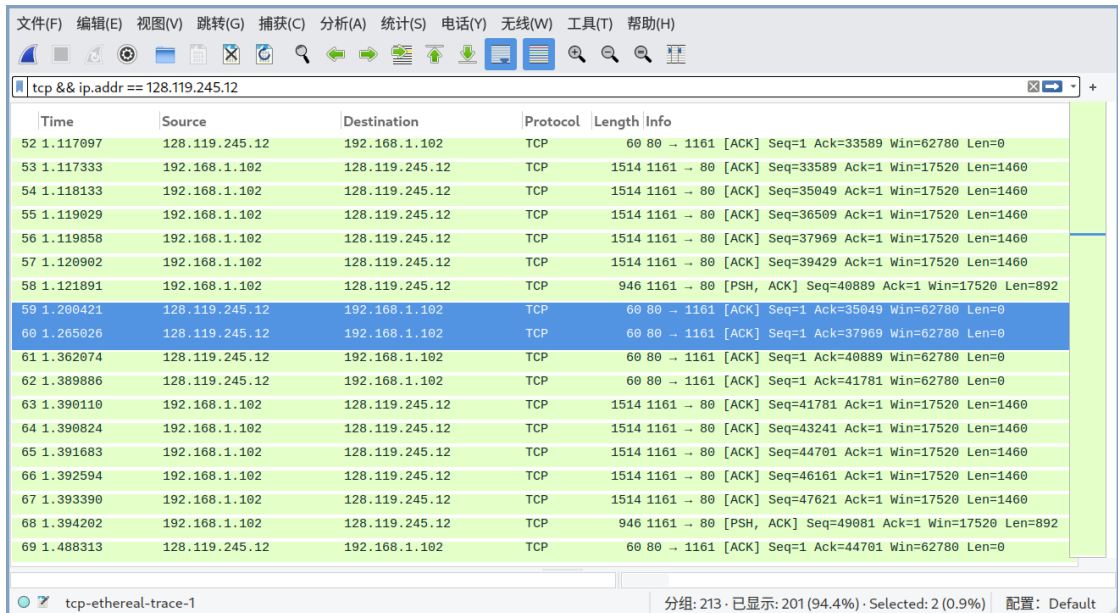
8. 依次为 565, 1460, 1460, 1460, 1460, 1460 字节。
9. 最小可用缓冲区空间为 5840 字节 (即第一个 ACK 报文中的 Calculated window size); 接收方的缓冲区空间没有影响到发送者。



10. 没有重发的报文, 通过观察时间序列图 (Stevens) 可以发现报文序号一直是增加的, 如果有重发的报文, 则序号会在某一处减少。



11. 接收方通常会确认 1460 字节数据; 可以找到发送累积 ACK 的情况, 比如编号为 60, Ack=37969 的 ACK 报文, 上一个 ACK 报文 (编号 59) 的 Ack=35049, 相差  $2920=1460*2$ .



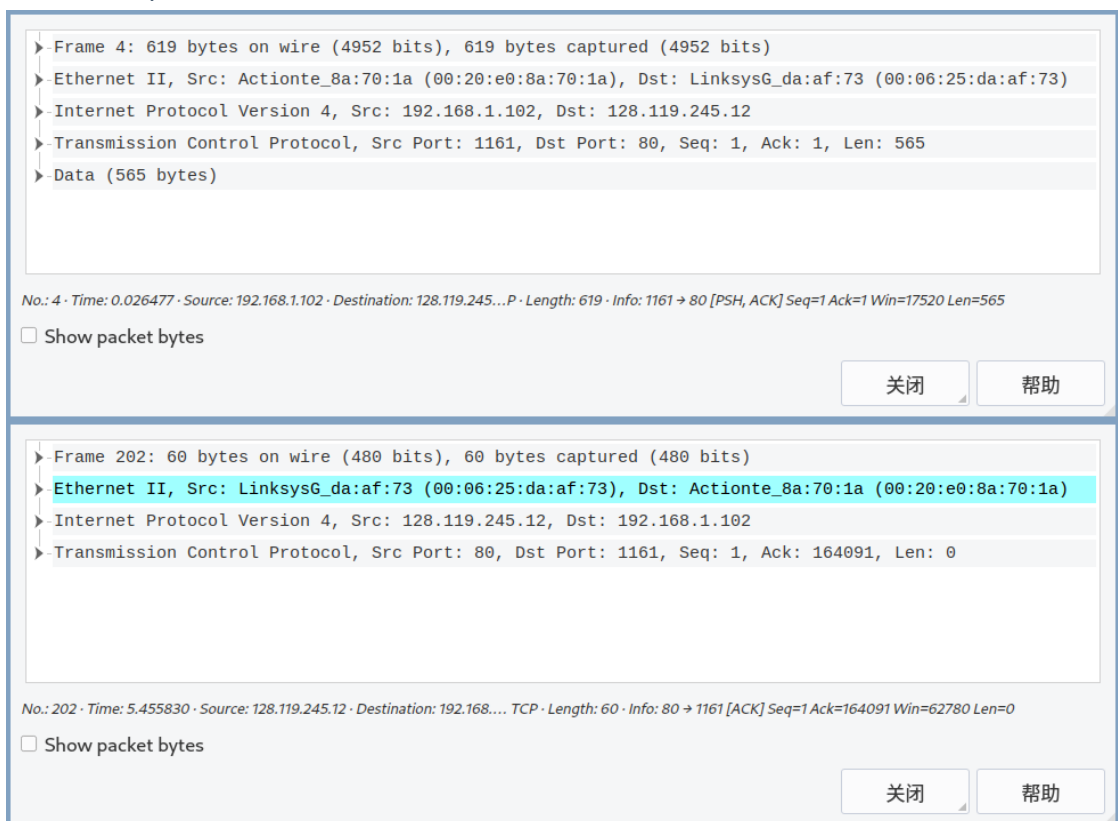
文件(F) 编辑(E) 视图(V) 跳转(G) 捕获(C) 分析(A) 统计(S) 电话(Y) 无线(W) 工具(T) 帮助(H)

tcp && ip.addr == 128.119.245.12

Time	Source	Destination	Protocol	Length	Info
52	1.117097	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=33589 Win=62780 Len=0
53	1.117333	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=33589 Ack=1 Win=17520 Len=1460
54	1.118133	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=35049 Ack=1 Win=17520 Len=1460
55	1.119029	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=36509 Ack=1 Win=17520 Len=1460
56	1.119858	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=37969 Ack=1 Win=17520 Len=1460
57	1.120902	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=39429 Ack=1 Win=17520 Len=1460
58	1.121891	192.168.1.102	128.119.245.12	TCP	946 1161 → 80 [PSH, ACK] Seq=40889 Ack=1 Win=17520 Len=892
59	1.200421	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=35049 Win=62780 Len=0
60	1.265026	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=37969 Win=62780 Len=0
61	1.362074	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=40889 Win=62780 Len=0
62	1.389886	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=41781 Win=62780 Len=0
63	1.390110	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=41781 Ack=1 Win=17520 Len=1460
64	1.390824	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=43241 Ack=1 Win=17520 Len=1460
65	1.391683	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=44701 Ack=1 Win=17520 Len=1460
66	1.392594	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=46161 Ack=1 Win=17520 Len=1460
67	1.393390	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=47621 Ack=1 Win=17520 Len=1460
68	1.394202	192.168.1.102	128.119.245.12	TCP	946 1161 → 80 [PSH, ACK] Seq=49081 Ack=1 Win=17520 Len=892
69	1.488313	128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=44701 Win=62780 Len=0

tcp-ethereal-trace-1 分组: 213 · 已显示: 201 (94.4%) · Selected: 2 (0.9%) 配置: Default

12. 计算整个连接中的平均吞吐量, 观察第一个 TCP 报文 (编号为 1) 的序号为 1, 发送时间为 0.026477, 传输过程最后一个 ACK 报文 (编号为 202) 的 Ack 号为 164091, 接收时间为 5.455830. 因此整个传输过程发送了 164090 字节的数据, 使用的时间为 5.429353s, 平均吞吐量为 30.22275KBps.



Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits)

- 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 Version 4, Src: 192.168.1.102, Dst: 128.119.245.12
- Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565
- Data (565 bytes)

No.: 4 · Time: 0.026477 · Source: 192.168.1.102 · Destination: 128.119.245.12 · Length: 619 · Info: 1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565

☐ Show packet bytes

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Frame 202: 60 bytes on wire (480 bits), 60 bytes captured (480 bits)

- 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 Version 4, Src: 128.119.245.12, Dst: 192.168.1.102
- Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 1, Ack: 164091, Len: 0

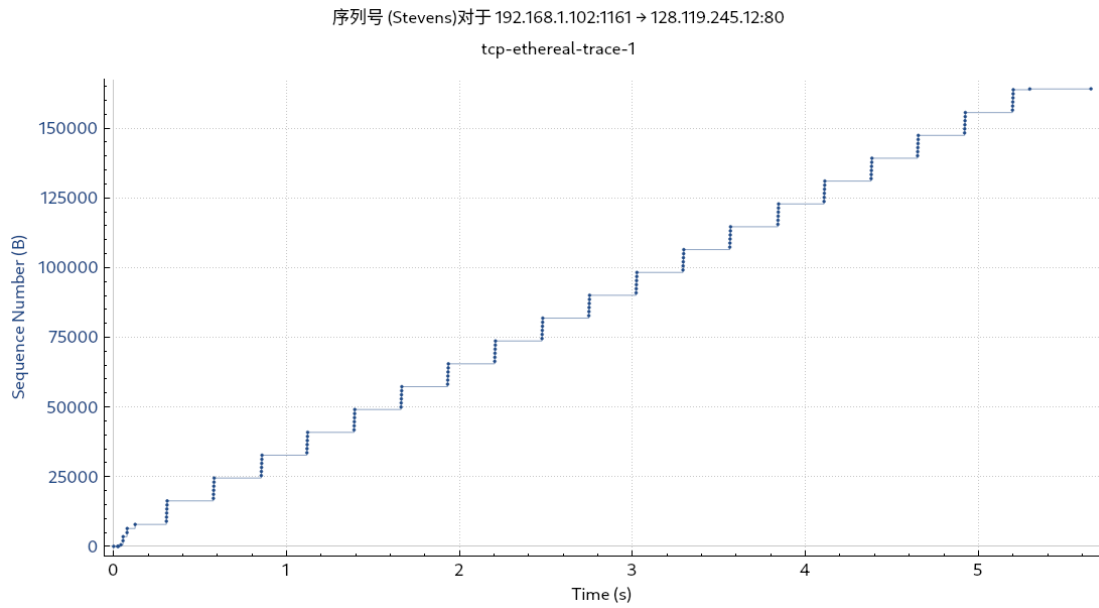
No.: 202 · Time: 5.455830 · Source: 128.119.245.12 · Destination: 192.168.1.102 · TCP · Length: 60 · Info: 80 → 1161 [ACK] Seq=1 Ack=164091 Win=62780 Len=0

☐ Show packet bytes

关闭 帮助

## 4. TCP congestion control in action

13. 时间序列图如下, 慢启动从大约 0s 时刻开始到大约 0.1s 时刻结束, 在大约 0.3s 时刻进入拥塞避免阶段. 其与理想化的 TCP 行为不同的是在慢启动后每次都发送 6 个报文, 而不是线性增长.



14. 时间序列图如下, 慢启动从大约 0.32s 时刻开始到大约 1.1s 时刻结束, 大约 1.3s 时刻进入拥塞避免阶段.

