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| Wireshark Lab:  TCP v8.0  Supplement to *Computer Networking: A Top-Down Approach, 8th ed.,* J.F. Kurose and K.W. Ross  *“Tell me and I forget. Show me and I remember. Involve me and I understand.”* Chinese proverb  © 2005-2020, J.F Kurose and K.W. Ross, All Rights Reserved | ***Ian Ressa***  ***Jared Myers***  ***Muhammed Syed***  ***Joe Monaco*** |

In this lab, we’ll investigate the behavior of the celebrated TCP protocol in detail. We’ll do so by analyzing a trace of the TCP segments sent and received in transferring a 150KB file (containing the text of Lewis Carrol’s *Alice’s Adventures in Wonderland*) from your computer to a remote server. We’ll study TCP’s use of sequence and acknowledgement numbers for providing reliable data transfer; we’ll see TCP’s congestion control algorithm – slow start and congestion avoidance – in action; and we’ll look at TCP’s receiver-advertised flow control mechanism. We’ll also briefly consider TCP connection setup and we’ll investigate the performance (throughput and round-trip time) of the TCP connection between your computer and the server.

Before beginning this lab, you’ll probably want to review sections 3.5 and 3.7 in the text[[1]](#footnote-2).

1. Capturing a bulk TCP transfer from your computer to a remote server

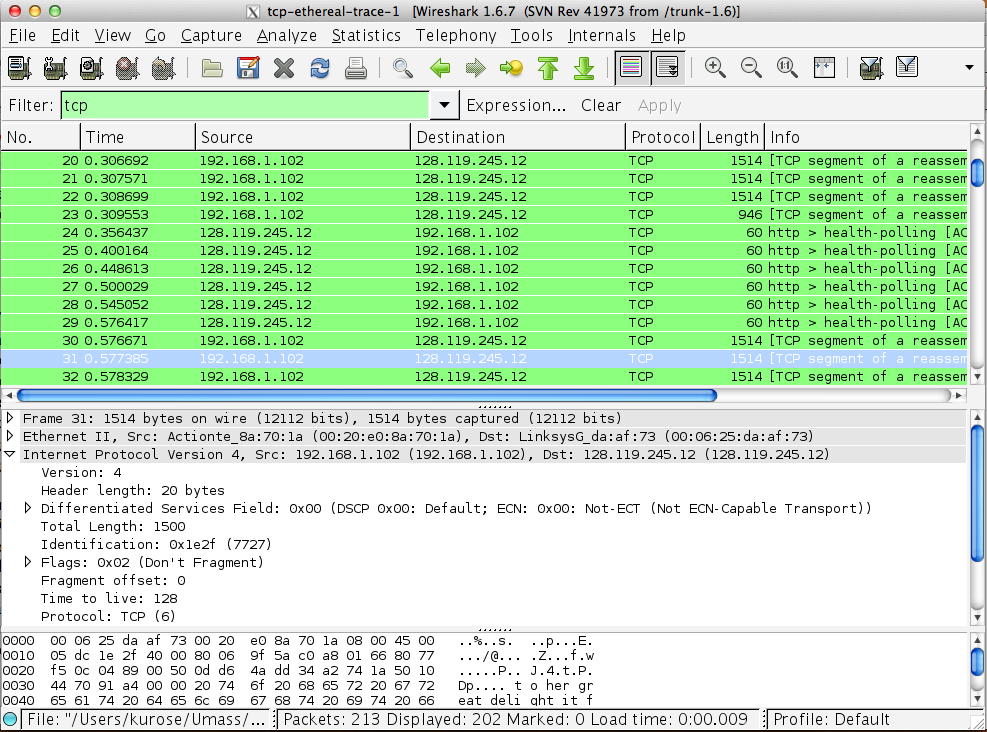
Before beginning our exploration of TCP, we’ll need to use Wireshark to obtain a packet trace of the TCP transfer of a file from your computer to a remote server. You’ll do so by accessing a Web page that will allow you to enter the name of a file stored on your computer (which contains the ASCII text of *Alice in Wonderland*), and then transfer the file to a Web server using the HTTP POST method (see section 2.2.3 in the text). We’re using the POST method rather than the GET method as we’d like to transfer a large amount of data *from* your computer to another computer. Of course, we’ll be running Wireshark during this time to obtain the trace of the TCP segments sent and received from your computer.

Do the following:

* Start up your web browser. Go the <http://gaia.cs.umass.edu/wireshark-labs/alice.txt> and retrieve an ASCII copy of *Alice in Wonderland.* Store this file somewhere on your computer.
* Next go to <http://gaia.cs.umass.edu/wireshark-labs/TCP-wireshark-file1.html>.
* You should see a screen that looks like:



* Use the *Browse* button in this form to enter the name of the file (full path name) on your computer containing *Alice in Wonderland* (or do so manually).Don’t yet press the “*Upload alice.txt file*” button.
* Now start up Wireshark and begin packet capture *(Capture->Start)* and then press *OK* on the Wireshark Packet Capture Options screen (we’ll not need to select any options here).
* Returning to your browser, press the “*Upload alice.txt file*” button to upload the file to the gaia.cs.umass.edu server. Once the file has been uploaded, a short congratulations message will be displayed in your browser window.
* Stop Wireshark packet capture. Your Wireshark window should look similar to the window shown below.



If you are unable to run Wireshark on a live network connection, you can download a packet trace file that was captured while following the steps above on one of the author’s computers. You may well find it valuable to download this trace even if you’ve captured your own trace and use it, as well as your own trace, when you explore the questions below.

2. A first look at the captured trace

Before analyzing the behavior of the TCP connection in detail, let’s take a high level view of the trace.

* First, filter the packets displayed in the Wireshark window by entering “tcp” (lowercase, no quotes, and don’t forget to press return after entering!) into the display filter specification window towards the top of the Wireshark window.

What you should see is series of TCP and HTTP messages between your computer and gaia.cs.umass.edu. You should see the initial three-way handshake containing a SYN message. You should see an HTTP POST message. Depending on the version of Wireshark you are using, you might see a series of “HTTP Continuation” messages being sent from your computer to gaia.cs.umass.edu. Recall from our discussion in the earlier HTTP Wireshark lab, that is no such thing as an HTTP Continuation message – this is Wireshark’s way of indicating that there are multiple TCP segments being used to carry a single HTTP message. In more recent versions of Wireshark, you’ll see “[TCP segment of a reassembled PDU]” in the Info column of the Wireshark display to indicate that this TCP segment contained data that belonged to an upper layer protocol message (in our case here, HTTP). You should also see TCP ACK segments being returned from gaia.cs.umass.edu to your computer.

Answer the following questions, by opening the Wireshark captured packet file *tcp-ethereal-trace-1* in <http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip> (that is download the trace and open that trace in Wireshark; see footnote 2). Whenever possible, when answering a question you should hand in a printout of the packet(s) within the trace that you used to answer the question asked. Annotate the printout[[2]](#footnote-3) to explain your answer. To print a packet, use *File->Print*, choose *Selected packet only*, choose *Packet summary line,* and select the minimum amount of packet detail that you need to answer the question.

1. What is the IP address and TCP port number used by the client computer (source) that is transferring the file to gaia.cs.umass.edu? To answer this question, it’s probably easiest to select an HTTP message and explore the details of the TCP packet used to carry this HTTP message, using the “details of the selected packet header window” (refer to Figure 2 in the “Getting Started with Wireshark” Lab if you’re uncertain about the Wireshark windows.

**The client computer’s IP address and TCP port number are 129.1.237.49, 44010.**

1. What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection?

**gaia.cs.umass.edu is sending and receiving TCP segments on 128.119.245.12:80.**

If you have been able to create your own trace, answer the following question:

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

**The client computer’s IP address and TCP port number are 129.1.237.49, 44010.**

Since this lab is about TCP rather than HTTP, let’s change Wireshark’s “listing of captured packets” window so that it shows information about the TCP segments containing the HTTP messages, rather than about the HTTP messages. To have Wireshark do this, select *Analyze->Enabled Protocols.* Then uncheck the HTTP box and select *OK*. You should now see a Wireshark window that looks like:



This is what we’re looking for - a series of TCP segments sent between your computer and gaia.cs.umass.edu. We will use the packet trace that you have captured (and/or the packet trace *tcp-ethereal-trace-1* in <http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip>; see earlier footnote) to study TCP behavior in the rest of this lab.

3. TCP Basics

Answer the following questions for the TCP segments:

1. 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?

**The sequence number of the TCP SYN segment is 1149450663. The SYN segment has the SYN flag set within the TCP header.**

1. 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?

**The sequence number of the SYNACK segment from the web server is 3716626096. The acknowledgement number is 1149450664.**

1. 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.

**HTTP POST is contained in the data of the packet with sequence number 1149450664.**

1. Consider the TCP segment containing the HTTP POST as the first segment in the TCP connection. What are the sequence numbers of the first six segments in the TCP connection (including the segment containing the HTTP POST)? At what time was each segment sent? When was the ACK for each segment received? Given the difference between when each TCP segment was sent, and when its acknowledgement was received, what is the RTT value for each of the six segments? What is the EstimatedRTT value (see Section 3.5.3, page 242 in text) after the receipt of each ACK? Assume that the value of the EstimatedRTT is equal to the measured RTT for the first segment, and then is computed using the EstimatedRTT equation on page 242 for all subsequent segments.

**The first six segments containing data are numbered as**

**1149450664 (1)**

**1149452112 (1449)**

**1149453560 (2897)**

**1149455008 (4345)**

**1149456456 (5793)**

**1149457904 (7241)**

**Respective sent timestamps relative to the first frame (seconds):**

**0.033506168**

**0.033509374**

**0.033538939**

**0.033540021**

**0.033566852**

**0.033567463**

**Respective ACK timestamp relative to the first frame (seconds):**

**0.033350556 (1149450664) { EstimatedRTT = 0.033350556 }**

**0.069908928 (1149452112, 1149453560) { EstimatedRTT = 0.0379265253 }**

**0.069958310 (1149455008, 1149456456) { EstimatedRTT = 0.0419304984 }**

**0.069958350 (1149457904) { EstimatedRTT = 0.0450589799 }**

*Note:* Wireshark has a nice feature that allows you to plot the RTT for each of the TCP segments sent. Select a TCP segment in the “listing of captured packets” window that is being sent from the client to the gaia.cs.umass.edu server. Then select: *Statistics->TCP Stream Graph->Round Trip Time Graph.*

1. What is the length of each of the first six TCP segments?[[3]](#footnote-4)

**The length of the first six TCP segments are 1448 bits each.**

1. What is the minimum amount of available buffer space advertised at the receiver for the entire trace? Does the lack of receiver buffer space ever throttle the sender?

**It seems the receiver advertises a buffer window of 502 bytes for the entire trace. The window size scale factor is 128, so the calculated window size is actually 64256 bytes. This doesn’t throttle the sender as the sender is only pushing up 1448 bytes per segment.**

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

**There are no retransmitted segments in the trace. This can be confirmed by setting the filter *tcp.analysis.retransmission*.**

1. How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment (see Table 3.2 on page 250 in the text).

**The receiver is typically acknowledging two packets (2896 bytes) simultaneously. Multiple ACKs can be seen in the first six packets acknowledged, where sequence numbers 1149452112, 1149453560 are acknowleged jointly.**

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

**The throughput is calculated as bytes over time. We can get the number of bytes by using the sequence numbers of the first and last bytes and the timestamp of the final segment.**

**throughput = (1149604097-1149450663=153434)/(0.183341971 seconds) = 836873.2984 bytes/sec = 0.8368732984 MB/sec**

4. TCP congestion control in action

Let’s now examine the amount of data sent per unit time from the client to the server. Rather than (tediously!) calculating this from the raw data in the Wireshark window, we’ll use one of Wireshark’s TCP graphing utilities - *Time-Sequence-Graph(Stevens*) - to plot out data.

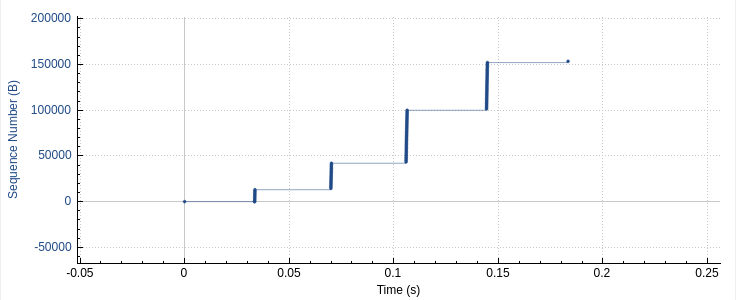
* Select a TCP segment in the Wireshark’s “listing of captured-packets” window. Then select the menu : *Statistics->TCP Stream Graph-> Time-Sequence-Graph(Stevens*). You should see a plot that looks similar to the following plot, which was created from the captured packets in the packet trace [*tcp-ethereal-trace-1* in http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip](http://gaia.cs.umass.edu/ethereal-labs/traces/lab3-1-trace) (see earlier footnote ):



Here, each dot represents a TCP segment sent, plotting the sequence number of the segment versus the time at which it was sent. Note that a set of dots stacked above each other represents a series of packets that were sent back-to-back by the sender.

Answer the following questions for the TCP segments the packet trace [*tcp-ethereal-trace-1* in http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip](http://gaia.cs.umass.edu/ethereal-labs/traces/lab3-1-trace)

1. 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. Can you identify where TCP’s slowstart phase begins and ends, and where congestion avoidance takes over? Comment on ways in which the measured data differs from the idealized behavior of TCP that we’ve studied in the text.

**We can see the slowstart phase begin at the start of the exchange, and we can see congestion avoidance begin at around 0.11 seconds, where the amount of segments transferred at once seems to increase at a slower rate. I think the most striking difference between the TCP model and the sample is scale. Slowstart is quicker to ramp up immediately to 10 segments, and then to 20 as slowstart remains the active protocol.**

1. 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

1. References to figures and sections are for the 8th edition of our text, *Computer Networks, A Top-down Approach, 8th ed., J.F. Kurose and K.W. Ross, Addison-Wesley/Pearson, 2020.* [↑](#footnote-ref-2)
2. What do we mean by “annotate”? If you hand in a paper copy, please highlight where in the printout you’ve found the answer and add some text (preferably with a colored pen) noting what you found in what you ‘ve highlight. If you hand in an electronic copy, it would be great if you could also highlight and annotate. [↑](#footnote-ref-3)
3. The TCP segments in the tcp-ethereal-trace-1 trace file are all less that 1460 bytes. This is because the computer on which the trace was gathered has an Ethernet card that limits the length of the maximum IP packet to 1500 bytes (40 bytes of TCP/IP header data and 1460 bytes of TCP payload). This 1500 byte value is the standard maximum length allowed by Ethernet. If your trace indicates a TCP length greater than 1500 bytes, and your computer is using an Ethernet connection, then Wireshark is reporting the wrong TCP segment length; it will likely also show only one large TCP segment rather than multiple smaller segments. Your computer is indeed probably sending multiple smaller segments, as indicated by the ACKs it receives. This inconsistency in reported segment lengths is due to the interaction between the Ethernet driver and the Wireshark software. We recommend that if you have this inconsistency, that you perform this lab using another computer. [↑](#footnote-ref-4)