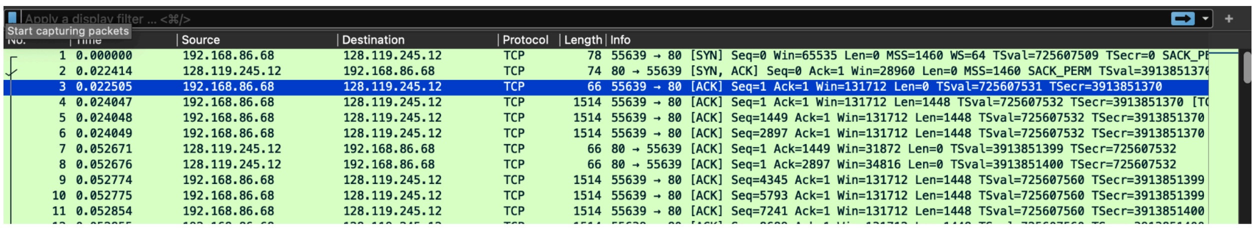
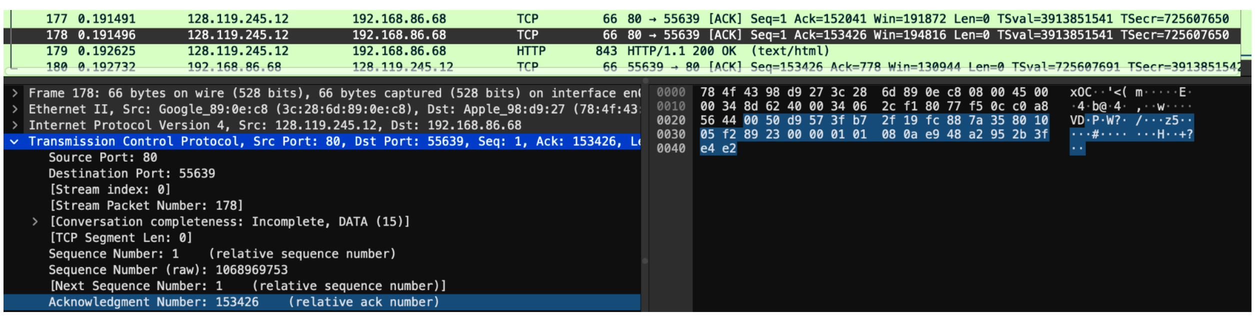
Tutorial 4) Session on TCP using Wireshark

Solution 11)

For calculating throughput, I first determined time difference between when 1st & last tcp segments were sent. Then I identified amount of data transmitted based on ack no. adjusting for zero based count. I calculated throughput by dividing the total amount of data by time difference. Then converted this result from bytes per second to kilobytes per second for easier interpretation. This process provides measure of data transmission rate specified time period.



The time when first segment is send is 0.022505.



The time when last segment is sent is 0.191496 s.
Ack no. here is 153426, so amount of data transmitted is 153425 bytes,

Time difference = 0.191496 - 0.022505= 0.168991 s

Throughput = Amount of data transmitted/ time difference
= 153425/0.168991
=907888.585 Bytes per second
=907.888 KB/s
Therefore throughput for TCP is 907.888 KB/s.

Solution 12)

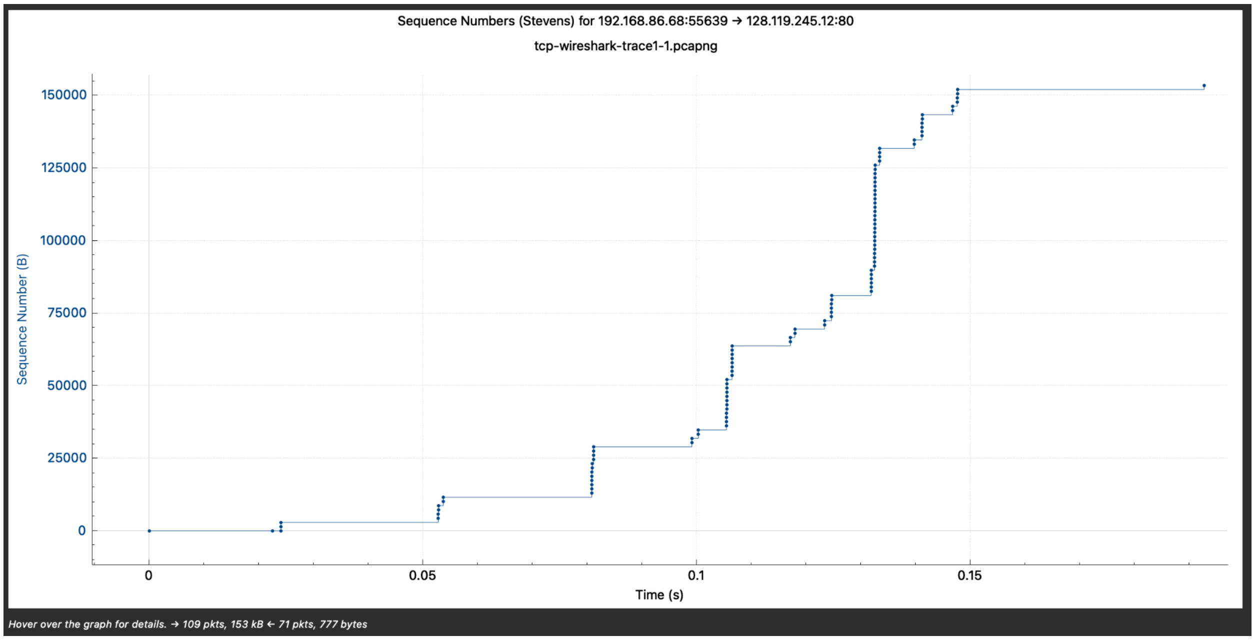


Fig- Time sequence graph(stevens)

Considering fleets of packets sent at around t = 0.025, 0.053, 0.082 , 0.1, as in above figure.

In the above graph, TCP's **slow start phase** can be identified by the distinct pattern of fleet of packets sent at intervals around t = 0.025, t = 0.053, t = 0.082 & t = 0.1 seconds. Slow start phase begins at t=0 & continues up to around t=0.15 seconds, where each packet burst grows in size due to the exponential increase in congestion window. During this slow start, TCP sends few packets initially, waits for acknowledgments & then rapidly increases the amount of data sent by doubling the cwnd after each RTT which is resulting in stair step pattern on the graph, with each burst becoming larger than the previous one, which indicates aggressive approach of TCP to utilize available bandwidth.

Around t=0.15 seconds, graph shows signs of a possible transition to **congestion avoidance phase from slow start phase**. In this phase, growth becomes linear as observed in above graph rather than exponential as TCP aims to maintain stability in network by slowly increasing the cwnd for avoiding overwhelming the connection. The shift occurs when TCP reaches a threshold or detected packet loss which indicating that network is full. The stair step pattern of sequence no. in slow start contrasts with gradual linear progression seen in congestion avoidance, which would follow if the connection remained stable.

Solution 13)

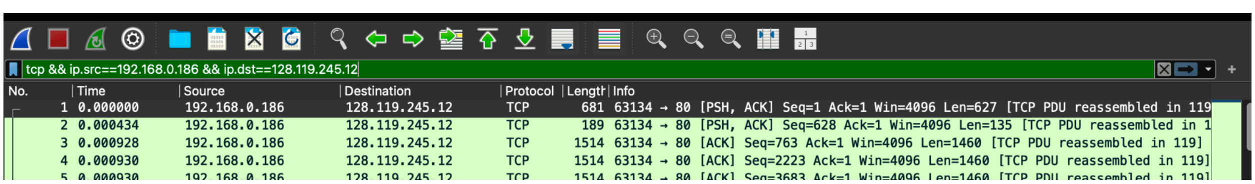
Fleets of segments in above graph appears to follow the periodic pattern, where bursts of packets are sent at approx fairly regular intervals. This differences are around close but not identical which is common in real world network conditions due to variability in RTTs & other network factors. By observing we can estimate an **average period of around 0.025 seconds** for these fleets

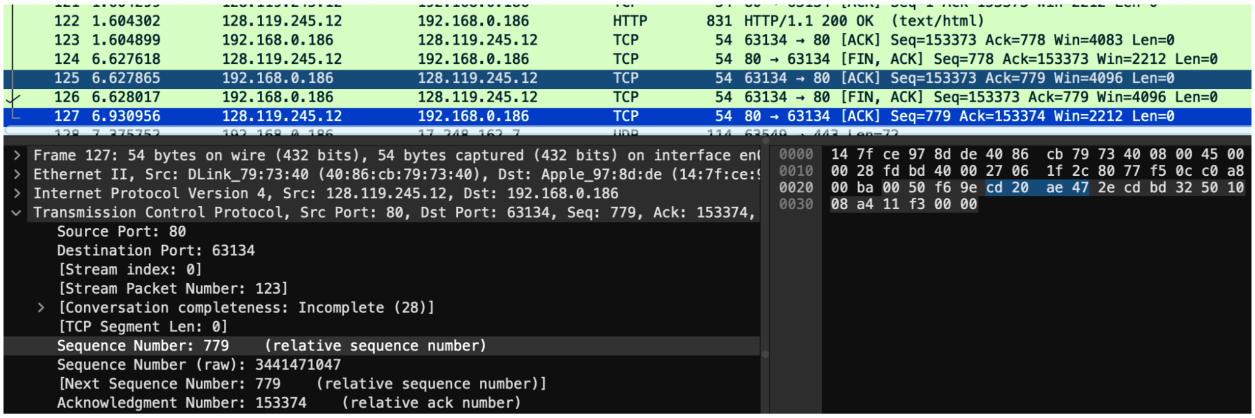
My Interpretation-

This periodicity suggests that sender is adjusting its congestion window based on ACKs received in manner that aligns with round trip time. Here, each burst represents the new round of transmissions,in which window increases in response to received ACKs which is allowing sender to send more data in next burst.

Periodic pattern observed here matches with behavior of TCP in **slow start phase**, where each RTT results in a doubling of congestion window size &, consequently, the burst of packets being sent. As this RTT stabilizes, these bursts become more periodic until congestion is detected or transition to congestion avoidance occurs.

Solution 14) a)Throughput of TCP for my trace-





Total duration =6.930956

Last ack no. is 153374, so total data transmitted is 153373 bytes.

Throughput = Amount of data transmitted/ time difference

=153373 /6.930956

=22128.693 B/s

=22.128 KB/s

Therefore throughput for TCP is 22.128 KB/s.

b) Observing fleets-

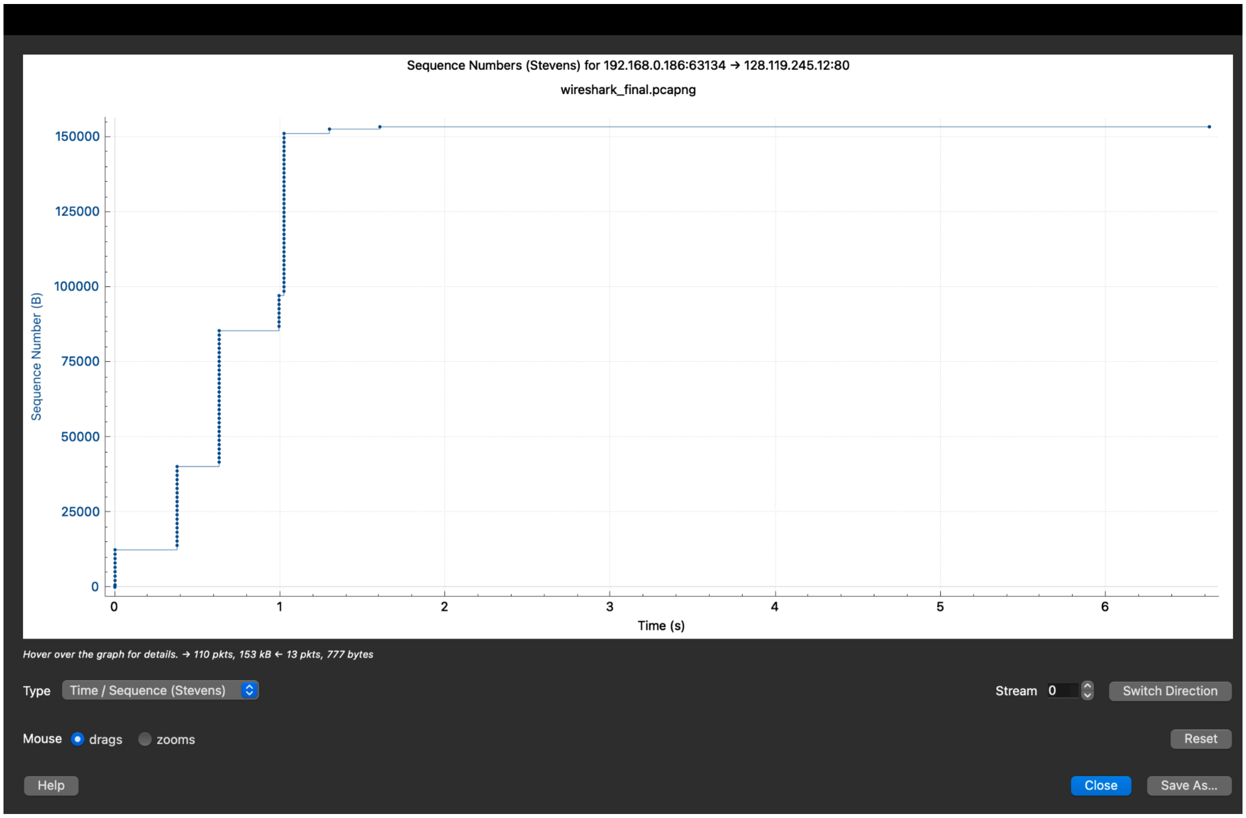


Fig- Time sequence graph(stevens)

Here we can observe fleets around t= 0.4, t=0.6, t=1 s.

In time sequence graph above, we can observe multiple steps in sequence no. increments at start which indicate bursts of packets being sent. These initial steps represent **slow start phase**, where the congestion window grows exponentially which allows more packets to be sent with each round trip time. This phase continues until around 1 second(just after 1 second), where sequence no. growth very slowly(linearly) which indicates transition to a congestion avoidance state.

In this slow start phase, the congestion window is expanding rapidly, as indicated by the increasing packet bursts around t= 0.4, t=0.6, t=0.8, t=1 s. This pattern aligns with slow start behavior, where transmission rate increases until capacity of network is approached, potentially triggering the transition to the slower growth in congestion avoidance phase. So it is in slow start from 0 to 1 s and in congestion avoidance after 1s.

c) Periodicity in fleets-

In my trace fleets of segments in above graph also appears to follow the periodic pattern as in trace provided earlier, where bursts of packets are sent at approx fairly regular intervals. This differences are around close but not identical which is common in real world network conditions due to variability in RTTs & other network factors. By observing we can estimate an **average period of around 0.3 seconds** (avg of their difference 0.4,0.2,0.4) for these fleets.

My Interpretation

Here, each burst represents the new round of transmissions,in which window increases in response to received ACKs which is allowing sender to send more data in next burst. In my traceThis periodicity suggests that sender is adjusting its congestion window based on ACKs received in manner that aligns with round trip time.

Similar to trace in que no. 11, here also periodic pattern observed here matches with behavior of TCP in **slow start phase**, where each RTT results in a doubling of congestion window size &, consequently, burst of packets being sent. As this RTT stabilizes, these bursts become more periodic until transition to congestion avoidance occurs or congestion is detected.