

## 1. Count the number of TCP flows initiated from the sender

When there are signs of SYN and ACK, it means that the synchronization handshake is successful, and it is recorded as a flow. There are a total of 3 flows in this file.

## 2. For each TCP flow

Flow: 1 | Source Port: 43498 | Destination Port: 80

1.Sequence number: 705669102 | Ack number: 0 | Receive Window size: 42340

2.Sequence number: 705669103 | Ack number: 1921750144 | Receive Window size: 49152

Throughput at 80 : 2490219.599880601 bytes/sec

loss rate: 0.0002866561559409231

Average RTT: 0.07261712322942689 Seconds

Theoretical throughput: 1454383.0648431669 bytes/sec

Flow: 2 | Source Port: 43500 | Destination Port: 80

1.Sequence number: 3636173851 | Ack number: 0 | Receive Window size: 42340

2.Sequence number: 3636173852 | Ack number: 2335809728 | Receive Window size: 49152

Throughput at 80 : 535017.0752023294 bytes/sec

loss rate: 0.00028296547821160534

Average RTT: 0.07247269927185253 Seconds

Theoretical throughput: 1466754.1336219683 bytes/sec

Flow: 3 | Source Port: 43502 | Destination Port: 80

1.Sequence number: 2558634629 | Ack number: 0 | Receive Window size: 42340

2.Sequence number: 2558634630 | Ack number: 3429921723 | Receive Window size: 49152

Throughput at 80 : 895397.0943574397 bytes/sec

loss rate: 0.002743484224965731

Average RTT: 0.07448008320091515 Seconds

Theoretical throughput: 458360.4092531807 bytes/sec

(a) Use the raw values for the sequence number and ack number. Explain these values.

In the above data, each flow has two TCP connections.

Sequence number: It is the packet number sent by the sender, which varies with the number of packets sent.

Ack number: It is the sequence number of the request sent by the receiver. The ACK will not change until the requested data packet is sent.

Receive Window size: It is the buffer size of the receiver.

(b) Compute the throughput at the receiver.

$$\text{Throughput} = (\text{all MSS}) / (\text{flow's time from start to finish})$$

(c) Compute the loss rate for each flow.

When the Source Port, Destination Port, Sequence number, and Ack number of the two packets are the same, the first one is marked as loss.

loss rate = (number of losses) / total. If this flow has no packet loss, the loss count is marked as 1.

(d) Estimate the average RTT. Compare empirical throughput from (b) and the theoretical throughput.

RTT = time difference between sending a packet and acknowledging a packet. Sequence number of sending data packet = Ack number of confirming data packet, Ack number of sending data packet = Sequence number of confirming data packet. Average all RTTs.

$$\text{theoretical throughput} = (\text{sqrt}(3/2) * \text{MSS}) / (\text{RTT} * \text{sqrt}(\text{loss rate}))$$

In the above data, the empirical throughput of Flow 2 is small, and the other two flows have large theoretical throughput. The reason may be that the buffer area of the receiver is large, so it can receive a large amount of data at one time. Therefore, the empirical throughput of the two flows is large.