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Part A :

(i) High level view of Wireshark.java program :

This program was written to analyse the assignment2.pcap file.To parse the data in the packet , observations made in wireshark view of the pcap file were used.
For example to obtain sequence number , parsed the bytes (38,39,40,41) in the packet .
Logic : arrBytes={38,39,40,41}

```
for(int i=0;i<arrBytes.length;i++){
res=res*256+(long)packet.getUByte(arrBytes[i]);
}
```

Similarly for ackNo arrBytes= {42,43,44,45} ...

1)Number of TCP flows - 3
Number of unique srcPort+destPort combinations in the file.

2) a) The first two transactions can be noted after TCP Handshake has been established.
I.e.the packets after [SYN] , [SYN , ACK] and [ACK] for each flow.

Sequence Number: 715760239
Ack Number: 1921750144
Receive Window: 3
Sequence Number: 1921750144
Ack Number: 715170903
Receive Window: 100

Sequence Number: 3646264988
Ack Number: 2335809728
Receive Window: 3
Sequence Number: 2335809728
Ack Number: 3646147700
Receive Window: 101

Sequence Number: 2559683006
Ack Number: 3429921723
Receive Window: 3

Sequence Number: 3429921723
Ack Number: 2559322454
Receive Window: 24

For each flow:
We can observe that the acknowledgment number of the packet1 is the sequence number of the packet 2. The difference between sequence number 1 and the acknowledgement 2 is the databytes sent in packet1.Receive window starts with 3 and increases to a different value in each flow based on the window sizes advertised by the source and destination during the handshake.

b)Throughput :This is the sum total of all the packet sizes in the flow divided by the timestamp difference of last and first packet in the flow.

Flow1 - 5388.0 Kilobits/sec
Flow2 - 1323.0 Kilobits/sec
Flow3 - 1522 .0 kilobits/sec

c)Loss Rate : this is the ratio of number of packets not received to the number of packets transmitted.If an acknowledgement number is sent more than once to the same dest port then it is counted as a loss.
Number of packets lost - 3 , 94 and 0 in flow1, flow2 and flow3 respectively.
Flow1 - 0.000573
Flow2 - 0.0134
Flow3 - 0.001371

d) Average RTT : Sum of RTT of packets by the total number of packets.
Round trip time was calculated using seqNo of a sent packet and the corresponding ackno of the return packet which when subtracted with the databytes gives the sequence number.
Rtt of all the packets is recorded and average was computed.
Flow1- 67.0 millisec
Flow2- 121.0millisec
Flow3- 72.0 millisec
Theoretical throughput = ((3/2*p)^½)*(MSS/RTT)
For flow1 - 9544 kilobits/sec
Flow2 - 1036.8 kilobits/sec
Flow3- 5504 kilobits/sec

Part B:
(1)
Congestion window 0 is: 4380

Congestion window 1 is: 5840
Congestion window 2 is: 7300
Congestion window 3 is: 8760
Congestion window 4 is: 10220

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Initial Congestion window is taken to be min (4*MSS, max (2*MSS, 4380 bytes)) from the refernce https://tools.ietf.org/html/rfc3390
Congestion window is in bytes.
The subsequent congestion window has been calculated as follows:
If packet loss is not observed congestion window size is increased by the size of MSS .
No packet loss is observed in the first five transmissions for the packets.

(2)Packets retransmitted due to timeout:

Flow - 1
Flow 2 - 90
Flow3 - 0

This was computed using packets lost (part A(c)) whose time difference was greater than average RTT calculated in part A(d)
Packets retransmitted due to triple duplicate ack : lostpkts calculated in part A(c) - packets retransmitted due to timeout.

NOTE: Part A and Part B were combined in the program Wireshark.java

Part C:
(1)
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[[8092, 36770, 3530046292, 761933658], [8092, 36770, 3530046292, 761933658], [8092, 36770, 3530052601, 761933659]]

The packet which has the http request was identified , taking its srcport as key , all the tcp packets targeted to that port after the request was sent have been listed as the tcp data segments.

Program used for part (1) is HttpWireShark.java

(2)For http_8092.pcap :
HTTP/1.1
HTTP/1.0
18
Total time: 759millisecs
total number of bytes sent: 2188029
Number of packets: 754

Protocols used are HTTP/1.1 and HTTP/1.0
These protocols are obtained from the http header request version field.
Total number of connections -18

For http_8093.pcap:
6
Total time: 689 millisecs
total number of bytes sent: 2220224
Number of packets: 753

Protocol used for this version is Http 1.1 as multiple connections are opened

For http_8094.pcap:

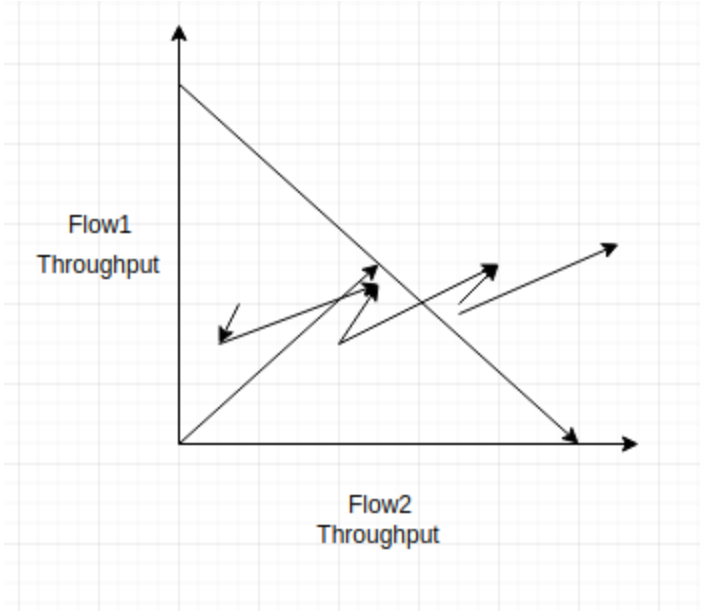
6
Total time: 610 millisecs
total number of bytes sent: 2220639
Number of packets: 525
Protocol used is HTTP 2 - Number of packets are less as some requests and responses are multiplexed which was introduced in this version of HTTP.

(3)Site loaded fastest under HTTP 2 as it uses multiplexing.
Most number of packets sent by the first capture http_8092.pcap, when http 1.0 and http 1. Were used.
Least number of packets sent by HTTP2 as it uses multiplexing

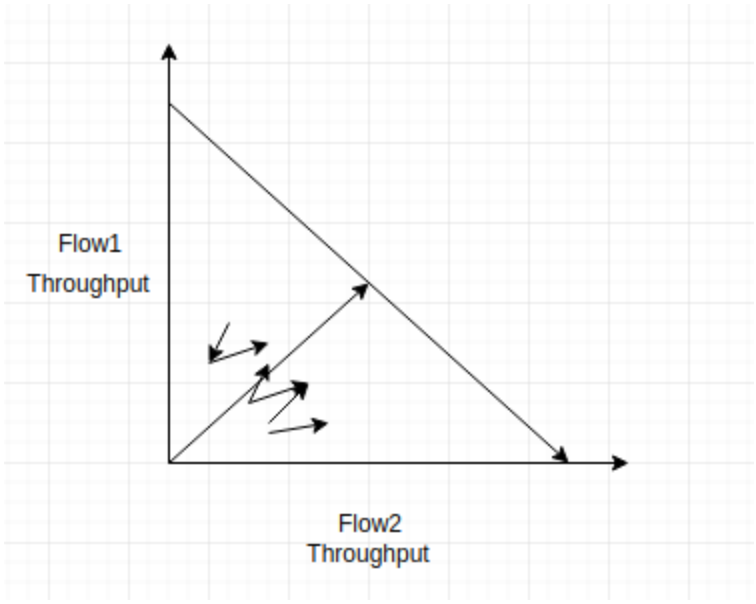
Tcpdump command used to capture pcap file is:
tcpdump port 8092 -w http_8092.pcap
tcpdump port 8093 -w http_8093.pcap
tcpdump port 8094 -w http_8094.pcap

Part D:

Multiplicative increase additive decrease



Multiplicative Increase multiplicative decrease



Additive Increase Additive Decrease