Assignment 1 Report(Bufferbloat)

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Q1. **Why do you see a difference in webpage fetch times with short and large router buffers?**
Ans: As seen the average fetch time for a router with queue size 20 is approximately 0.5 s while it is around 1s for a router with queue size 100. This is due to the reason that large queue size results in storing of the large number of packets at the router. The queuing delay for such packets is large. This results in larger fetch times.

Q2. Bufferbloat can occur in other places such as your network interface card (NIC). Check the output of ifconfig eth0 on your VirtualBox VM. What is the (maximum) transmit queue length on the network interface reported by ifconfig? For this queue size, if you assume the queue drains at 100Mb/s, what is the maximum time a packet might wait in the queue before it leaves the NIC?
Ans: The Txqueuelen reported by ifconfig at virtualbox is 1000, which means the queue length is 1000 packets. The MTU is 1500 Bytes. So, the maximum wait occurs when the queue is full. The last packet has to wait for the transmission of 999 packets. This corresponds to transmission of approx. 11 Mbits. Since channel has a capacity of 100Mbps. The maximum time the last packet might wait is 0.11 seconds or 110 ms.

Q3. How does the RTT reported by ping vary with the queue size? Describe the relation between the two.
Ans: As seen in graphs, the RTT increases with queue size due to queuing delay. The RTT is close 40 ms(average) for a queue size of 20 packets, while it is 150 ms(average) for queue size of 100 packets. So, RTT is proportional to the queue size.

Q4. Identify and describe two ways to mitigate the bufferbloat problem.
Ans: One is to use small buffer size. The buffer size is equal to channel capacity x RTT / sqrt(n). Here n is the number of senders sharing the bottleneck router. This reduces the buffer size while maintaining the throughput as shown in https://people.eecs.berkeley.edu/~sylvia/cs268-2019/papers//buffer-sizing.pdf.
The other way is to use Random Early Discard(RED) algorithm. Here, the router will randomly drop packets once queue size crosses some threshold. This will lead to the sender to reduce the window size. Thus, the queue length will decrease and so will latency.

Q5. Describe how and why your results change when you re-run the emulation.
Ans: When the simulation is rerun, parameters such as average page access time varies slightly and also there is variation in active queue length at different time points.

Example, in one run the average page access time for queue length 100 is 0.97s while in the second run, it is 1 s. This is due to the reason that, the three processes are started simultaneously. The hosts are single processor(CPU Limited). The different order of scheduling of the three processes by the Scheduler at the hosts results in changes in the parameters(queue length etc.).