CS 168 | Packets in Flight
Spring 2026 | Discussion 2

1 True or False

1.1 On a fast cross-continental link (~100Gbps), **propagation delay** usually dominates **end-to-end packet delay** (Most messages are smaller than 100MB).

1.2 On the same cross-continental link (~100Gbps), when transferring a 100GB file, **propagation delay** still dominates end-to-end file delivery.

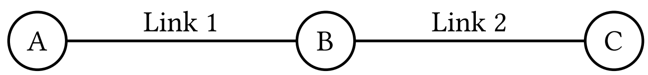
1.3 On-demand circuit-switching is adopted by the Internet.

1.4 The aggregate (i.e., sum) of peaks is usually much larger than peak of aggregates in terms of bandwidth usage.

1.5 Bursty traffic (i.e., when packet arrivals are not evenly spaced in time) always leads to queuing delays.

2 End-to-End Delay

In the diagram below, we have two different links, each with different physical properties (e.g. because they're made of different materials):



	Link 1	**Link 2**
Physical length of link	L_1 meters	L_2 meters
Speed of data propagation	S_1 meters/sec	S_2 meters/sec
Bandwidth of link	T_1 bits/sec	T_2 bits/sec

Assumptions:

- All nodes can send and receive bits at full rate.
- Processing delay is negligible. For example, a node has received a packet the instant it receives the last byte of the packet.
- A node can only start forwarding a packet after it has received all bytes of the packet.

2.1 Suppose $T_1 = 10000$, $L_1 = 100000$, and $S_1 = 2.5 \times 10^8$.

How long would it take to send a 500-byte packet from Node A to Node B?

2.2 The RTT (Round Trip Time) is the time it takes to send a packet (from source to destination) and receive a response (from destination to source). Count from the time the source transmits the first byte, to the time the source receives the last byte of the response.

Node A sends a x-byte packet to Node C. Then, Node C sends an x-byte response back to Node A. What is the RTT for this exchange?

Note: We assume processing delay is negligible, so Node C starts transmitting the response immediately after it receives the last byte of the packet.

2.3 Node A sends two packets:

- Packet P_1 of size D_1 bytes.
- Packet P_2 of size D_2 bytes.

Node A starts sending packet P_1 at $t = 0$. Node A immediately starts sending packet P_2 after it finishes transmitting all the bits of P_1.

When will Node C receive the last bit of packet P_2?

2.4 Find the variable relations that need to be satisfied in order to have no queuing delays for part (c).

3 Statistical Multi-What?

Consider three flows (F_1, F_2, F_3) sending packets over a single link. The sending pattern of each flow is described by how many packets it sends within each one-second interval; the table below shows these numbers for the first ten intervals. A perfectly smooth (i.e., non-bursty) flow would send the same number of packets in each interval, but our three flows are very bursty, with highly varying numbers of packets in each interval:

Time (s)	1	2	3	4	5	6	7	8	9	10
F_1	1	8	3	15	2	1	1	34	3	4
F_2	6	2	5	5	7	40	21	3	34	5
F_3	45	34	15	5	7	9	21	5	3	34

3.1 What is the peak rate of F_1? F_2? F_3? What is the sum of the peak rates?

3.2 Now consider all packets to be in the same aggregate flow. What is the peak rate of this aggregate flow?

3.3 Which is higher - the sum of the peaks, or the peak of the aggregate?