Topics Covered:

Reliable data transfer (RDT) protocols.

TCP: Segment structure, reliable data transfer, flow control, and connection management.

Principles of congestion control.

TCP congestion control mechanisms e.g AIMD, slow start, congestion avoidance.

Evolution of transport-layer functionality e.g QUIC.

Reliable Data Transfer (RDT)

RDT 3.0: Uses timers and retransmissions to handle both bit errors and packet losses.

> Stop-and-Wait Protocol: The sender sends a packet, waits for the receiver to acknowledge (ACK) it, then sends another packet. It has low efficiency on account of long delay.
>
> Pipelining: Increases the utilization of the data path by allowing multiple packets to be in flight simultaneously.
>
> Go-Back-N (GBN): In GBN, the sender maintains a window of transmission of up to N packets that have not been acknowledged. On timeout, the sender retransmits all packets in the window.
>
> Selective-receiver: The receiver independently acknowledges each correctly received packet, thereby requiring only the retransmission of packets lost or corrupted.

TCP Overview

TCP Characteristics:

Connection oriented: A three-way handshake is required to create a connection.

Reliable: Guarantees the data will be delivered correctly and in order.

Flow control: Prevents the sender from sending more data than what the receiver can handle.

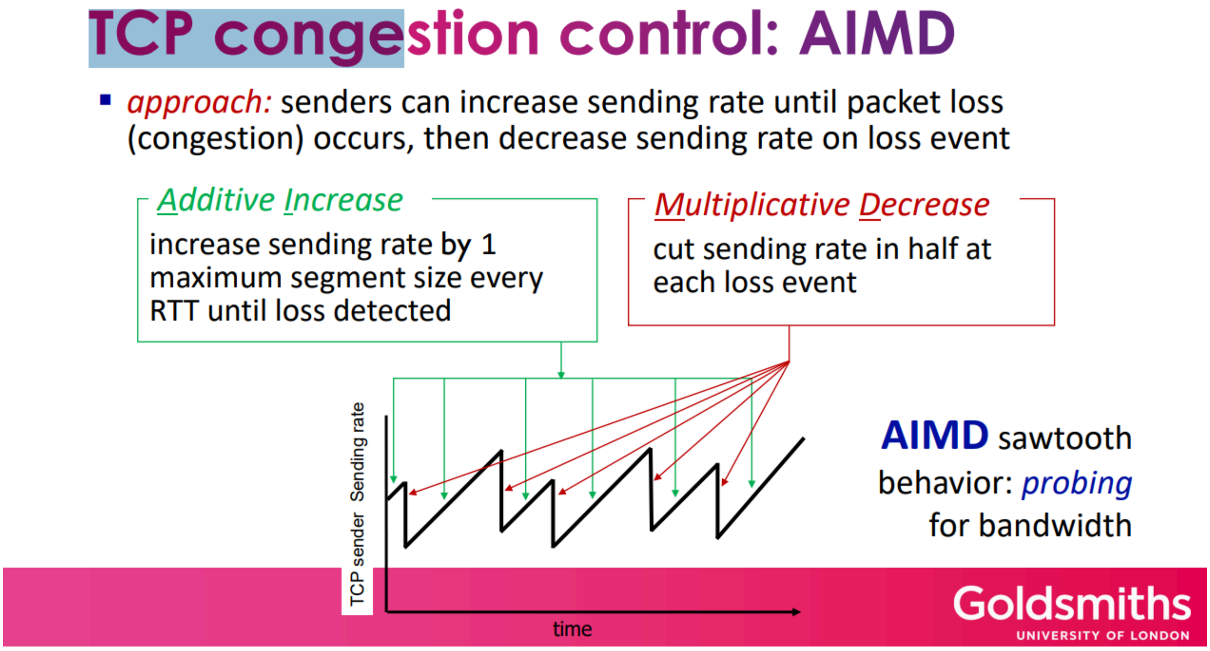
Congestion control: Prevents packet loss from congested networks.

TCP Segment Structure:

Source port, destination port, sequence number, acknowledgment number, flags (e.g SYN, ACK, etc.), window size, checksum, and data.

TCP Sequence Numbers and ACKs:

Sequence Numbers: The byte stream number of the first byte in the segment's data.Acknowledgment: Cumulative ACKs indicate the next expected byte.



Principles of Congestion Control

Congestion: This phenomenon occurs when a large number of sources attempt to send too much data through the network too quickly.

Effects: Long delays, packet drops, and reduced throughput.

Congestion Control versus Flow Control: Congestion control acts in an overall timeframe applicable to an entire network, whereas flow control acts specifically on the transfer of data between sender and receiver.

Approaches to Congestion Control:

End-to-End Congestion Control: It depends on the packet loss and delay perceived by the TCP sender; it signals itself depending on the traffic.
Forward Notification Congestion Control: The routers inform the sender unambiguously about the network condition; for instance, in ECN.

Evolution of Transport-Layer Functionality

QUIC (Quick UDP Internet Connections):

An application-layer protocol running on UDP.

Combines reliability, congestion control, and encryption in a single handshake.

Lowers latency and increases performance with respect to HTTP/3.

Avoids HOL blocking through stream multiplexing in one connection.