CS 725/825 & IT 725

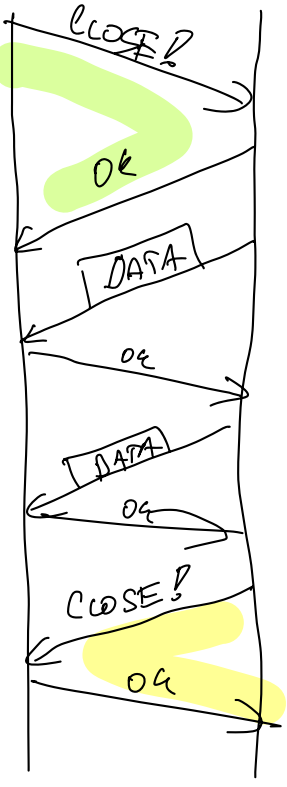
Lecture 18

Transport Layer

November 6, 2023

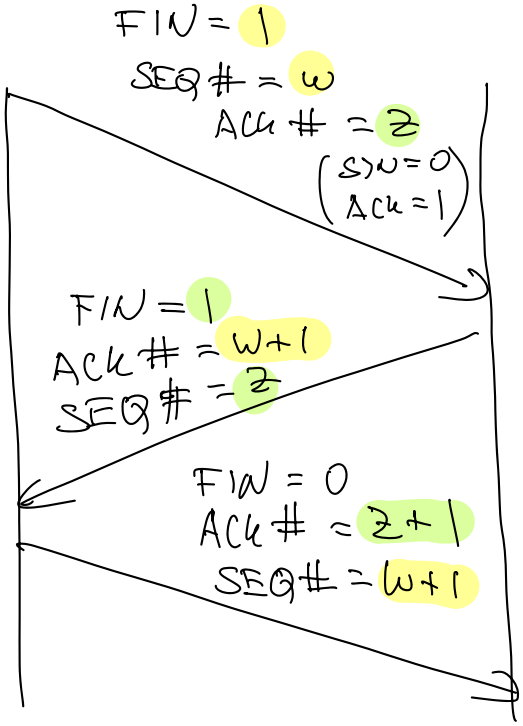
CLOSING CONNECTION

SYM. RELEASE



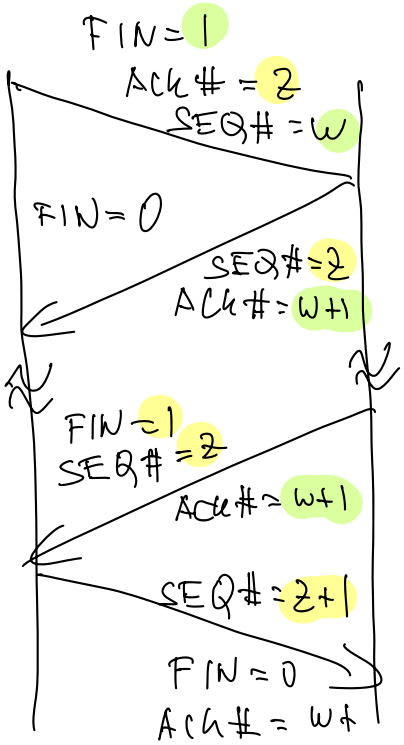
ASYM. RELEASE

TCP - SYM. RELEASE

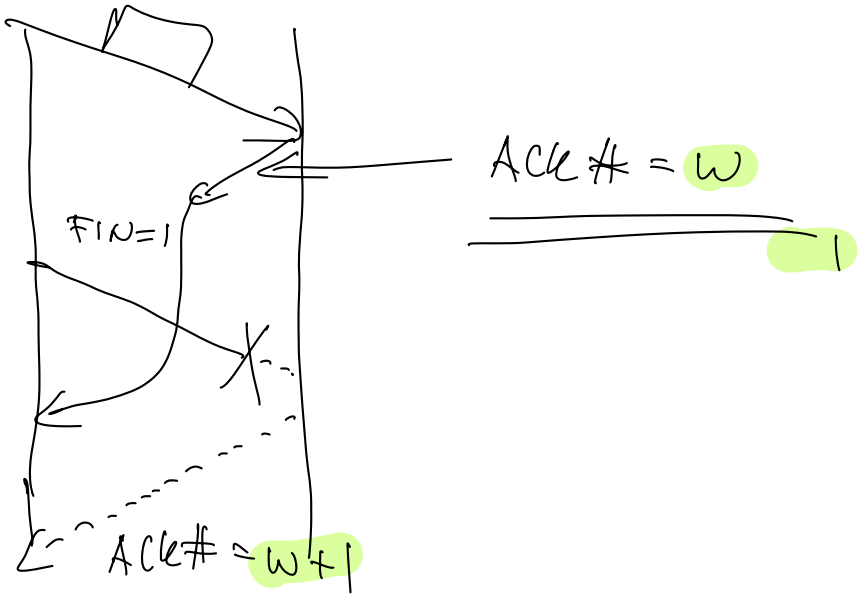


FIN - finish

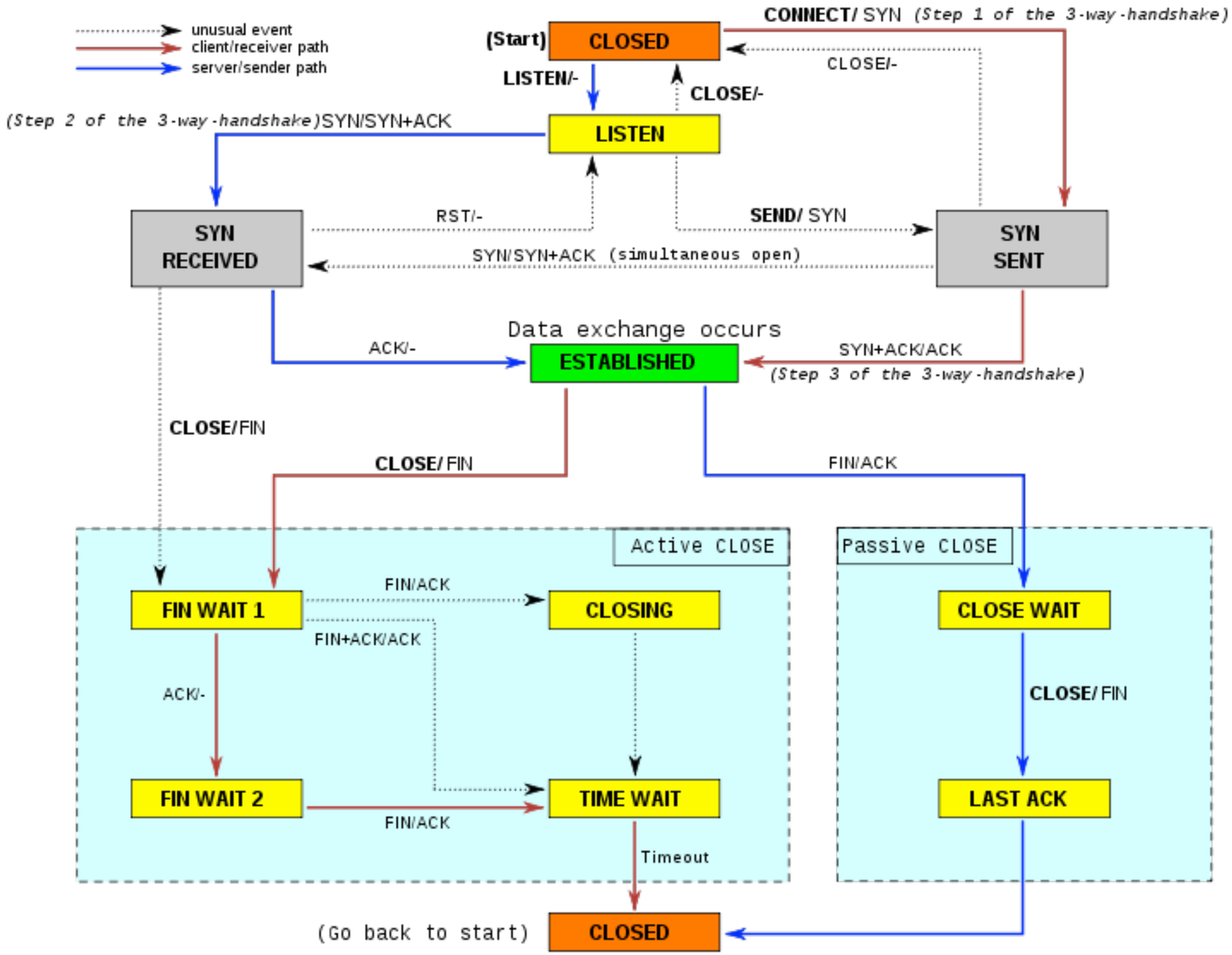
TCP - ASYM. RELEASE



MOTIVATION FOR "COUNTING" FIN = 1 AS ONE BYTE in SEQ/ACK # CALCULATION



TCP State Diagram



TCP Congestion Control

- Flow (receiver congestion) control
  - **Window Size field** - explicitly reported by the receiver
  - TCP Window Scale Option
- Network congestion control
  - **Retransmission timeout** - based on observed RTT
  - **Transmission window** - based on detected packet loss

Implicit Congestion Notification

- Round Trip Time (RTT)
  - time between data packet transmission and reception of it acknowledgement
  - increase in RTT could be interpreted as due to an increase in queue lengths in nodes (congestion)
  - … or it could be due to a route change...
- Packet Loss
  - packet loss due to queue overflow (congestion)
  - … or it could be packet loss due to random packet errors

Retransmission Timeout

RFC 6298

Initialization:

RTO ← 1 sec

After the first measurement:

SRTT ← R

RTTVAR ← R/2

RTO ← SRTT + max (G, K * RTTVAR)

After subsequent measurements:

RTTVAR ← (1 - beta) * RTTVAR + beta * |SRTT - R'|

SRTT ← (1 - alpha) * SRTT + alpha * R'

RTO ← SRTT + max (G, K * RTTVAR)

Where:

R - first RTT measurement
R' - subsequent RTT measurement
RTTVAR - RTT variance
SRTT - smoothed RTT estimate
RTO - retransmission timeout
G - clock granularity

Recommended values:

alpha=1/8, beta=1/4, K=4

Exponential Back-off

RTO after a timeout:

$$RTO \leftarrow q * RTO$$

Recommended value: q = 2

This a congestion control mechanism since retransmissions are delayed after packet loss detected. The delay is increasing exponentially with more packet losses.

Transmission Window

- Network provides no explicit indication of congestion
- Source observes RTT and packet loss and adjusts transmission rate according to its estimate of the congestion state of the network
- Transmission window size is proportional to the maximum transmission rate
- Additive Increase Multiplicative Decrease (AIMD)
  - better safe than sorry

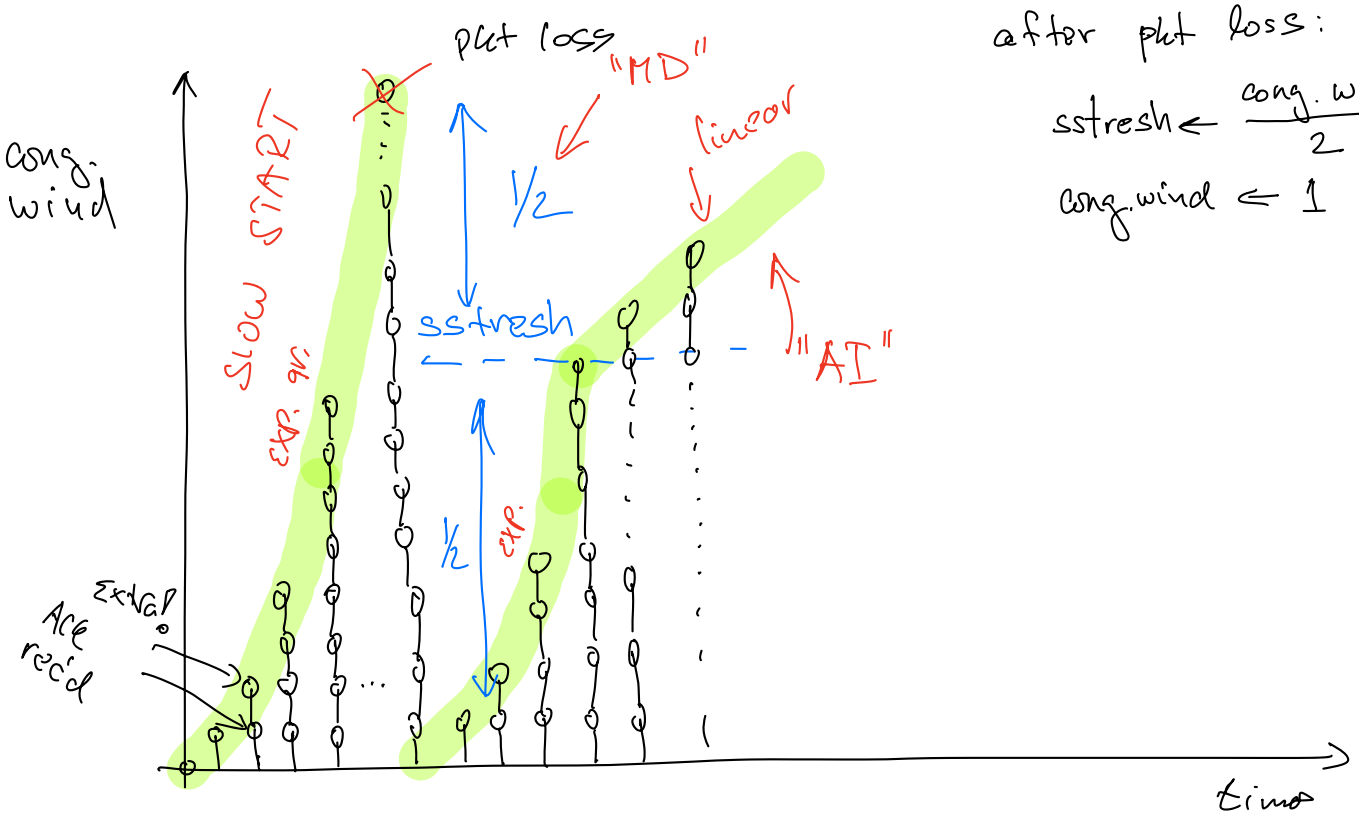
Network Congestion Control

- **Method**:

  TransWind = min(RecvWind, CongWind)

- TransWind - used in transmission
- RecvWind - from Window Size field
- CongWind - transmitter's estimate of how many unacknowledged packets can be pushed onto the network without causing congestion

TCP CONGESTION WINDOW



after pkt loss:

$ssthresh \leftarrow \frac{cong.\ wind}{2}$

$cong.\ wind \leftarrow 1$