Retransmission Timeout

Initialization:

\[ \text{RTO} \leftarrow 1 \text{ sec} \]

After the first measurement:

\[ \text{SRTT} \leftarrow R \]
\[ \text{RTTVAR} \leftarrow R/2 \]

\[ \text{RTO} \leftarrow \text{SRTT} + \max(G, K \times \text{RTTVAR}) \]

After subsequent measurements:

\[ \text{RTTVAR} \leftarrow (1 - \beta) \times \text{RTTVAR} + \beta \times |\text{SRTT} - R'| \]
\[ \text{SRTT} \leftarrow (1 - \alpha) \times \text{SRTT} + \alpha \times R' \]
\[ \text{RTO} \leftarrow \text{SRTT} + \max(G, K \times \text{RTTVAR}) \]

Where:

- \( R \) - first RTT measurement
- \( R' \) - subsequent RTT measurement
- \( \text{RTTVAR} \) - RTT variance
- \( \text{SRTT} \) - smoothed RTT estimate
- \( \text{RTO} \) - retransmission timeout
- \( G \) - clock granularity

Recommended values:

\( \alpha = 1/8, \beta = 1/4, K = 4 \)

RFC 6298
Exponential back-off

RTO after timeout:

\[ \text{RTO} \leftarrow q \times \text{RTO} \]

Recommended value:

\[ q = 2 \]

(binary exponential back-off algorithm)
TCP Timestamp

Question:
- ACK for what?

RTTM - RTT Management
- TCP option, two 4-byte values
- $TS$ value ($TS_{val}$) - current “timer” value
- $TS$ echo reply value ($TS_{ecr}$) - most recently received $TS_{val}$ (only if it acknowledges new data)
Network Congestion Ctrl.

- **Method:**
  \[
  \text{TransWind} = \min(\text{RecvWind}, \text{CongWind})
  \]

- **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
Congestion Window

- Components algorithms of TCP network congestion control (RFC 2001):
  - Slow Start
  - Congestion Avoidance
  - Fast Retransmit
  - Fast Recovery
Variants of TCP (examples)

- Original TCP (RFC1122)
- TCP Tahoe (adds Fast Retransmit)
- TCP Reno (adds Fast Recovery)
- TCP CUBIC (current versions of Linux)
  - does not rely on the receipt of ACKs to increase the window size
- TCP Fast
Routing revisited

- Finding a “good” path through the network

- Network treated as a weighted (directional) graph
  - **weight**: unit, rate, latency, error rate, load, security, …
    - … user assigned

- Unicast, multicast, broadcast (flooding), anycast, …

- Approaches:
  - hop-by-hop (IP, Ethernet bridging/switching)
  - source routing (a rarely used part of IP, mobile ad hoc networks)