Reliable Transmission

Transmission strategies under a lossless channel
- Simplex connection
- Simplex Stop-and-wait

Transmission strategies under a lossy channel
- Process of retransmitting frames that cannot be corrected by CRC codes
- Stop-and-wait
- Go-back-N
- Selective repeat

Simplex Protocol – Lossless Channel

- Data flows one direction only
- Communication channel never loses frames
- Receiver is always ready to receive packets

Problem: receiver can be flooded if it does not process packets fast enough

Solution: Introduce delay at sender
Simplex Protocol – Lossy Channel

Stop-and-wait

Failure of the Stop-and-Wait

ACK is lost or arrives after timeout

Solution based on Sequence No

Use a one-bit sequence number on the header
(In)Efficiency of Stop-and-Wait

Example: Consider 1.5Mbps link, 45ms RTT

\[ \text{Delay} \times \text{Bandwidth} = 67.5 \text{kb} = 8 \text{KB} \]

If frames are 1KB long then max rate

\[ \frac{1024 \times 8}{0.045} = 182 \text{Kbps} \]

Only \(\frac{1}{8}\)th of link's capacity

Goal: keep the pipe full, i.e. have maximum # of bits unacknowledged at any given time

Our example, we could have 8 frames unacknowledged

Go-back-N Protocol

Main idea: Leave up to \(N\) frames unacknowledged at any given time

Go-Back-N

Each frame is assigned a SeqNum

Variables at the sender
- \(\text{SWS}\): Send Window Size
- \(\text{LAR}\): Last Acknowledgment Received
- \(\text{LFS}\): Last Frame Sent

Rule: \(\text{LFS} - \text{LAR} \leq \text{SWS}\) (at most SWS frames unACKed)

Variables at the receiver
- \(\text{RWS}\): Receive Window Size
- \(\text{LAF}\): Largest Acceptable Frame (in seq #)
- \(\text{LFR}\): Last Frame Received

Rule: \(\text{LAF} - \text{LFR} \leq \text{RWS}\)
Sliding Window Depicted

At the sender

\[ \leq \text{SWS} \]

\[ \text{LAR} \quad \text{LFS} \]

At the receiver

\[ \leq \text{RWS} \]

\[ \text{LFR} \quad \text{LAF} \]

Updating Variables

\[ S_i = \text{LFR}_i + 1 \] (Go-back-N only accepts packets in order)

\[ S_i \leq \text{LAF}_i \] (which is guaranteed in our case, for \( \text{RWS} \geq 1 \))

\[ \text{LSF}_{i+1} = \text{LSF}_i + 1, \quad \text{LFR}_{i+1} = \text{LFR}_i + 1, \quad \text{LAF}_{i+1} = \text{LAF}_i + 1 \]

Window at sender advanced only if ACK received

Example of Go-Back-N

\[ \text{SWS} = 4 \quad \text{RWS} = 1 \]

\[ \text{LFS} = 4 \quad \text{LAR} = 0 \]

\[ \text{LFR} = 0 \quad \text{LAF} = 1 \]

Max Sequence Number \( \geq \text{SWS} + 1 \)

Link does not re-arrange packets
Piggypacking

Duplex communication, attach ACK on the reply frame
Asymmetry in frame size can cause timeouts
Go-Back-N can be turned into Stop-and-Wait

Selective Repeat

Window size can be very large for nets with large delay x bandwidth
Inefficient to retransmit all N frames if one is lost
Selective repeat allows the re-transmission of only the lost packets
Accepts out-of-order packets

Simply increase the RWS up to SWS (does not make sense to allow for RWS > SWS)

Example of Selective Repeat

\[
\begin{align*}
\text{Max Sequence Number} & \geq 2 \text{ SWS} \\
\end{align*}
\]