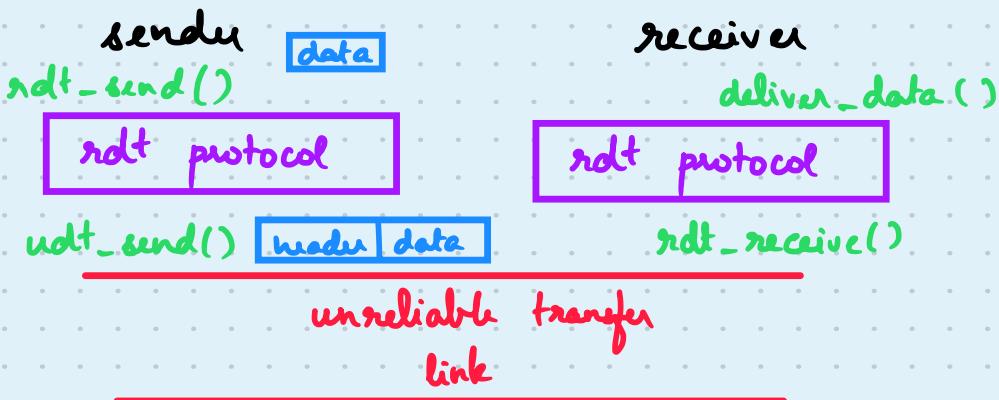


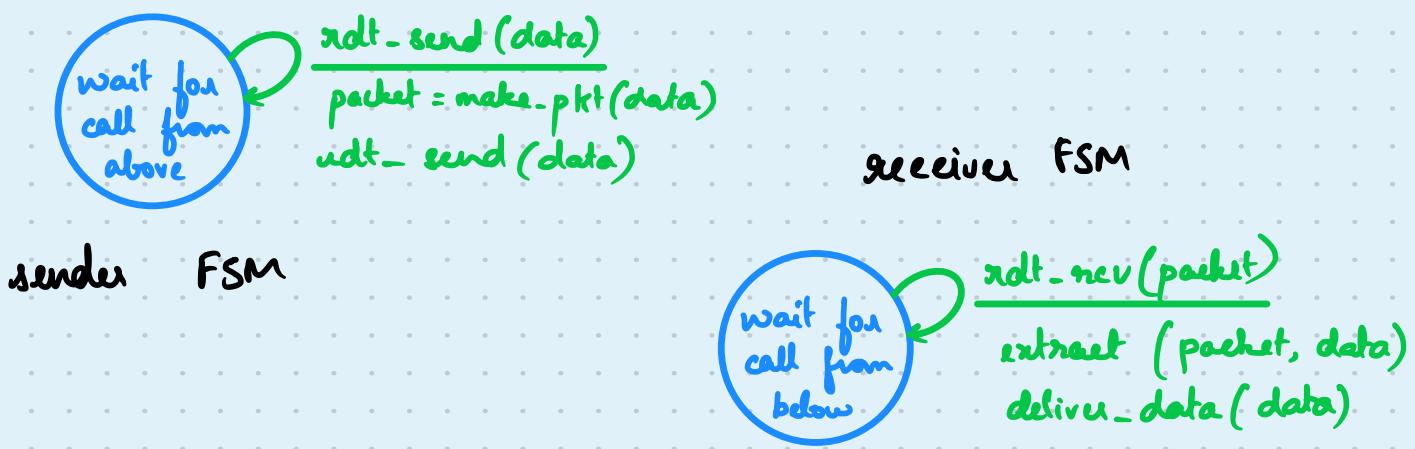
Transport layer

RELIABLE DATA TRANSFER



rdt 1.0

Assume lossless perfect link



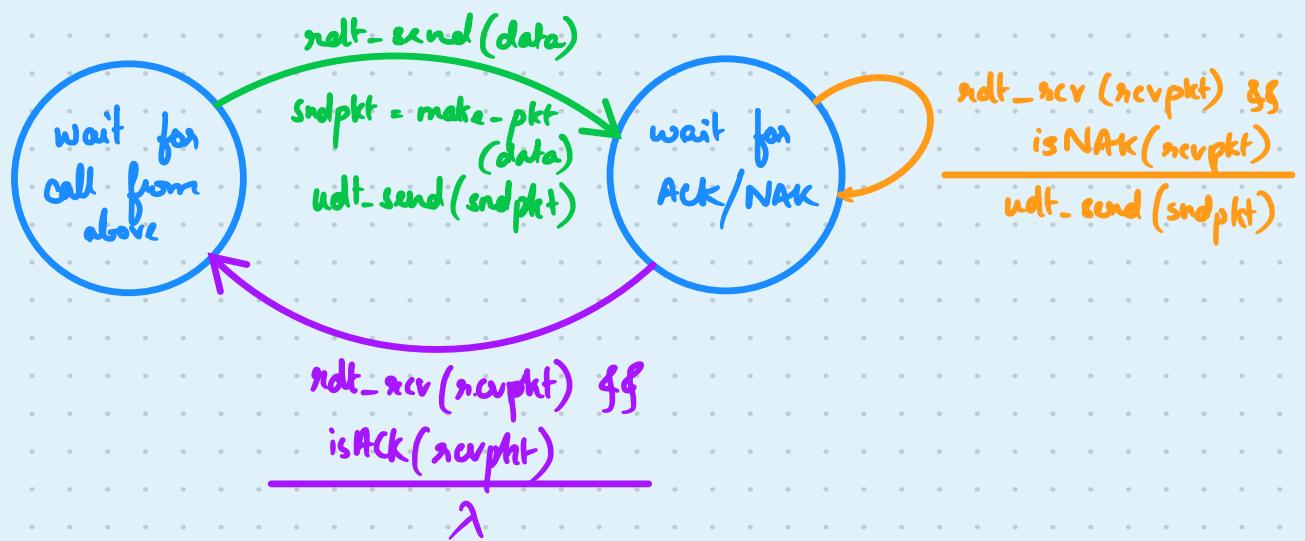
rdt 2.0

Links can have bit errors. To check for errors, we add

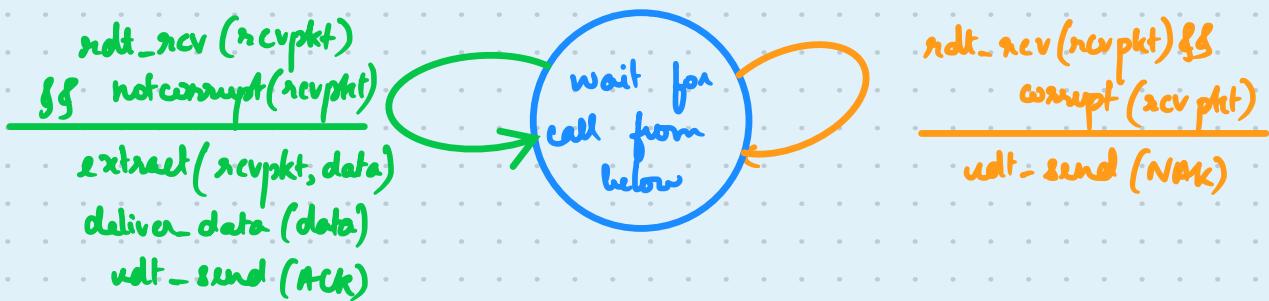
ACKs and NACKs → sender retransmits

Stop and wait: Sender sends one packet, then waits for receiver's response

ARQ: Automatic Repeat reQuest



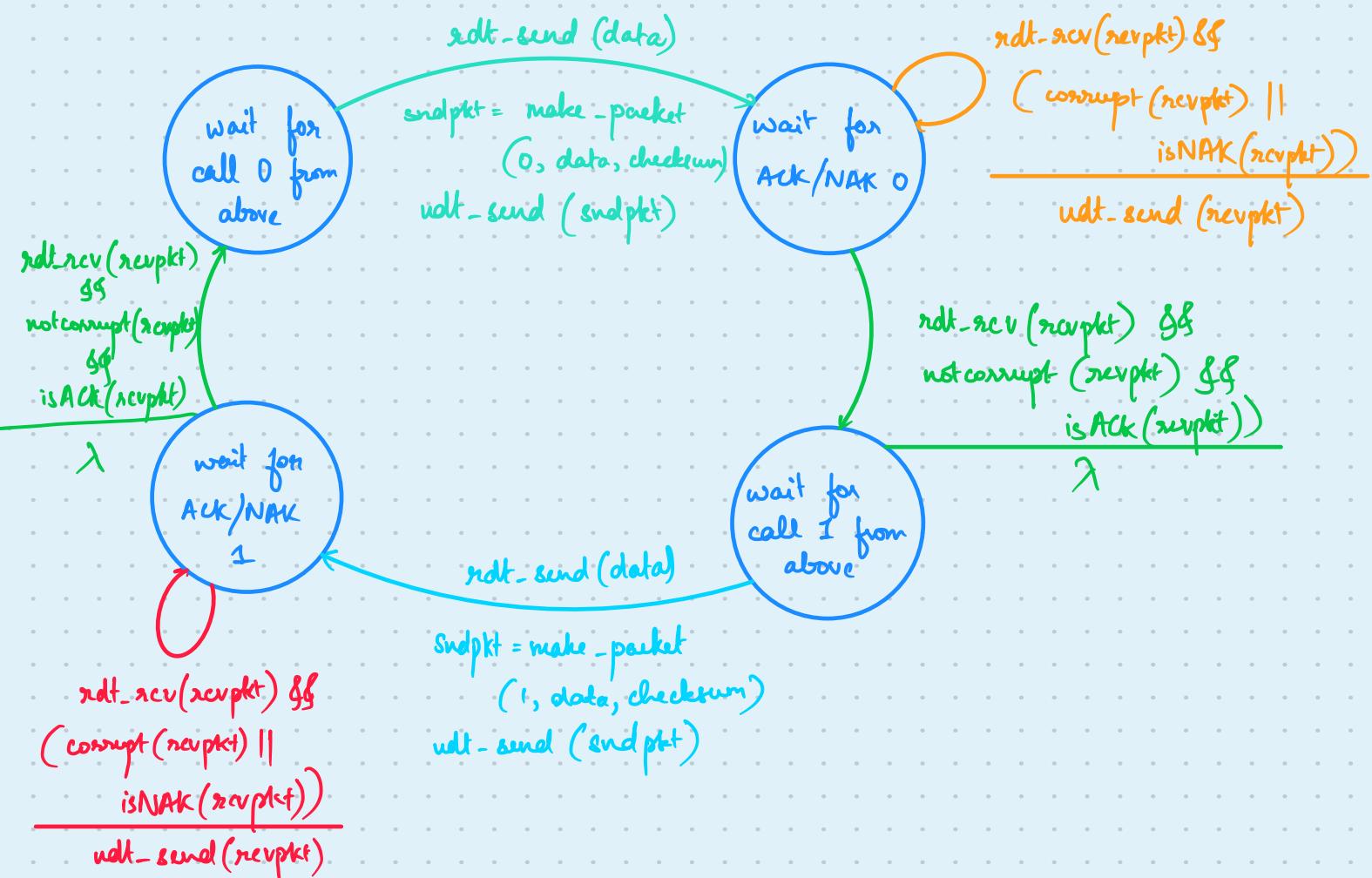
Sender's FSM



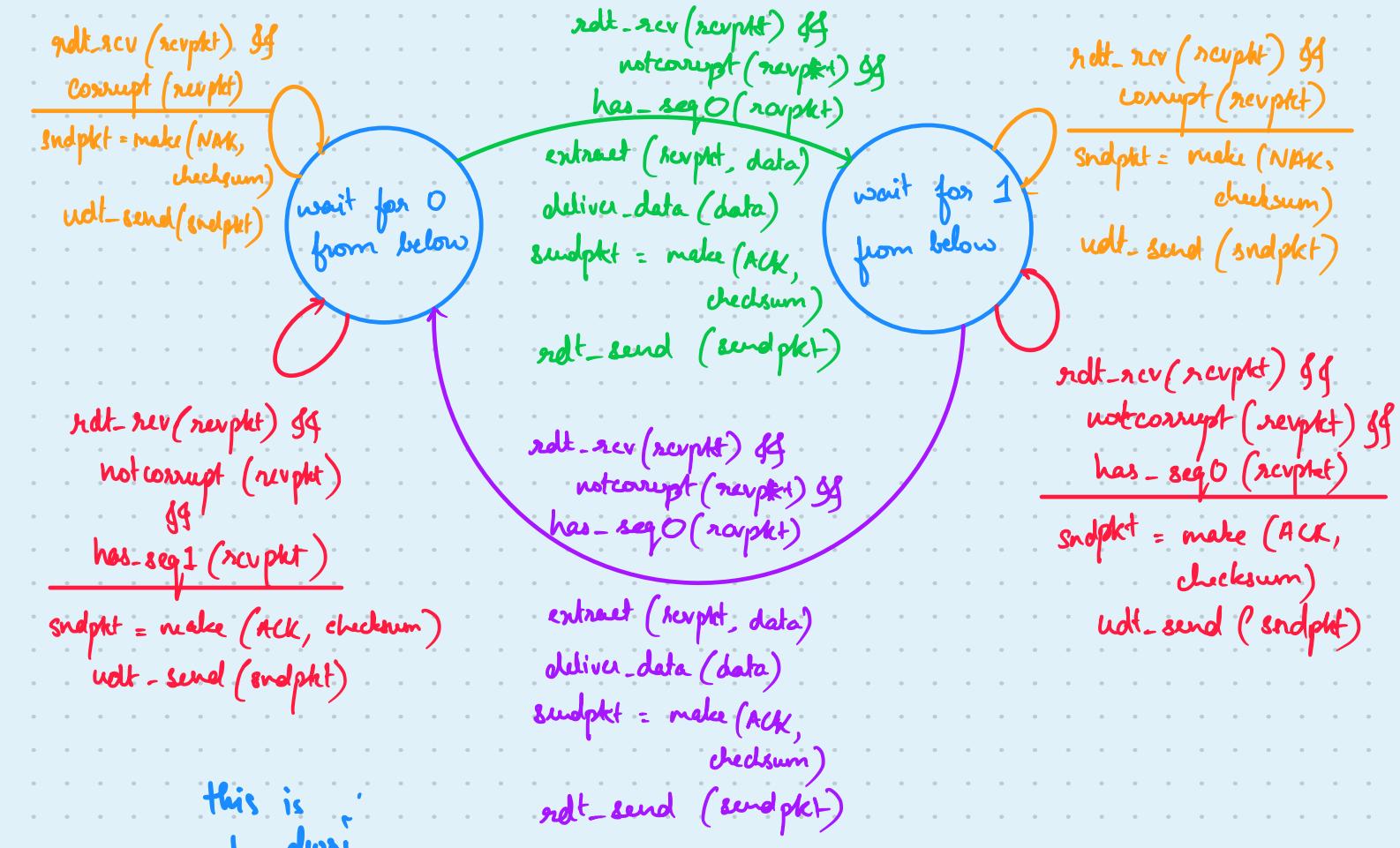
rdt 2.1

ACK/NAK itself corrupted \rightarrow sender does not know whether to retransmit

Solution: sender will retransmit if ACK/NAK corrupted,
and adds sequence no to each pkt
receiver checks seq no and discards duplicates



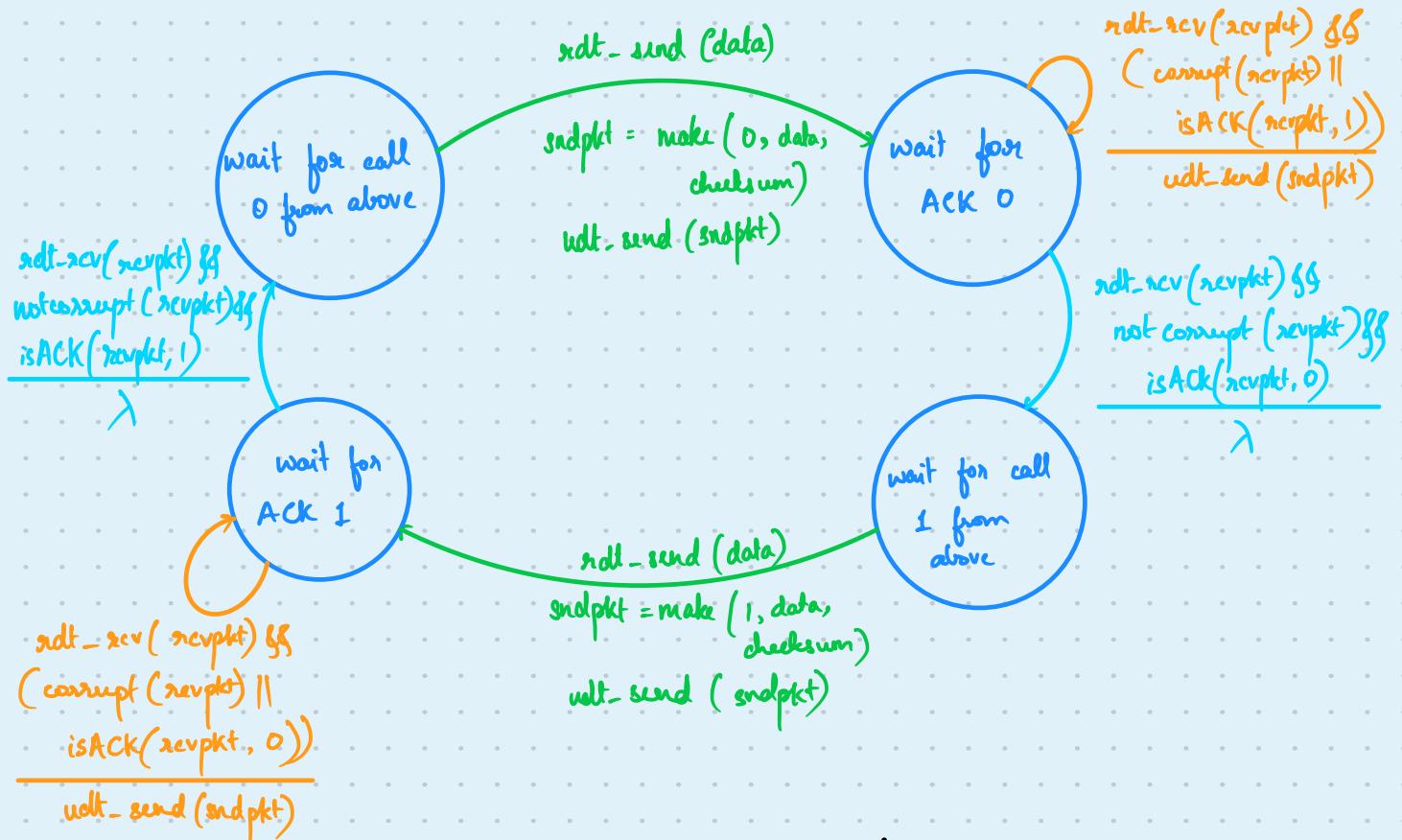
Sender's FSM



Receiver's FSM

rdt 2.2

- No need for both ACK and NAK signals
- Receiver sends ACK for last packet received OK, must include sequence number
- Duplicate ACK = NAK → retransmission of current packet



Sender's FSM



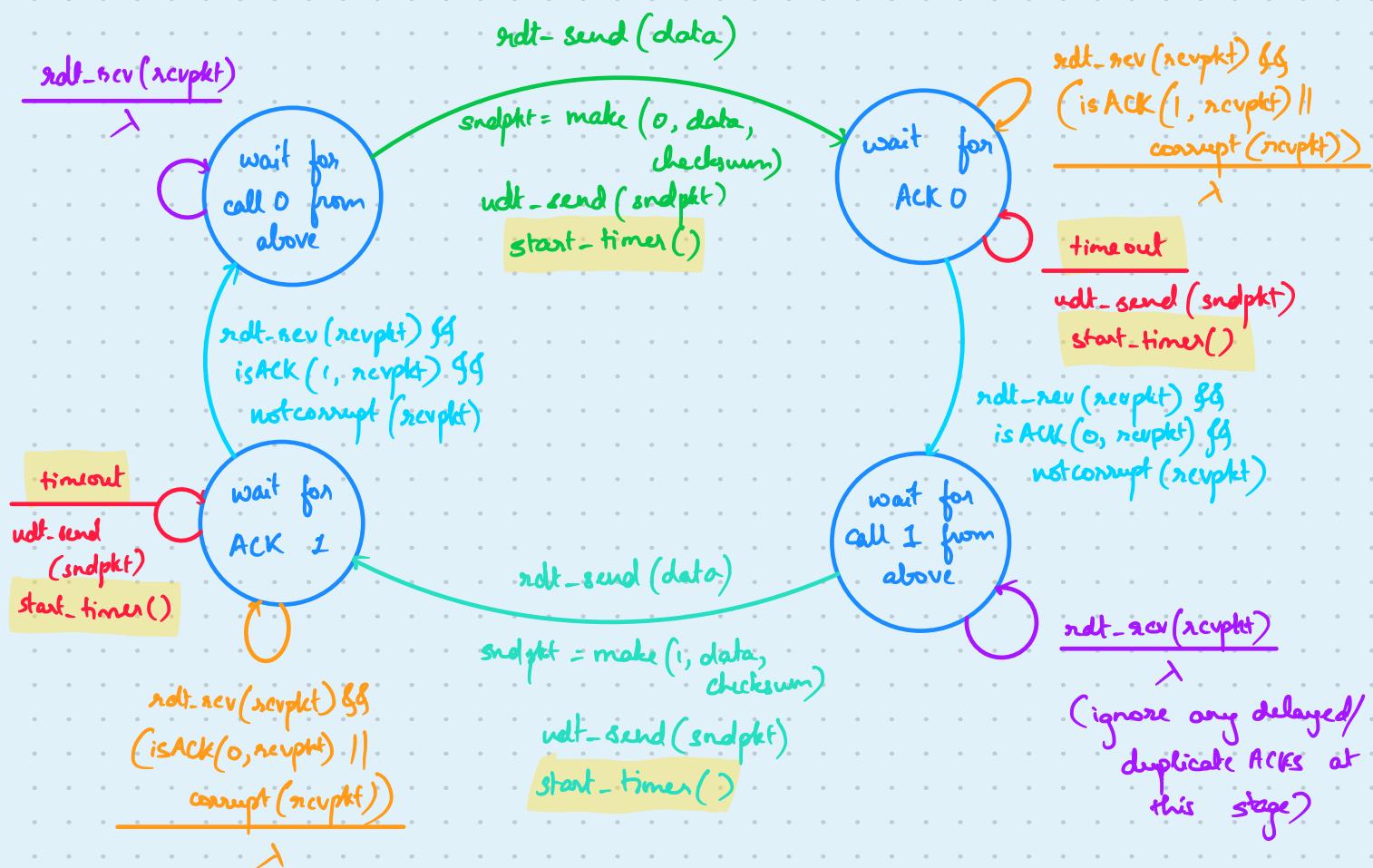
Receiver's FSM

rdt 3.0

Channel with bit errors as well as packet delay/loss

Solution: Sender sets a timer → does not get ACK within time limit
 ↓
 retransmits

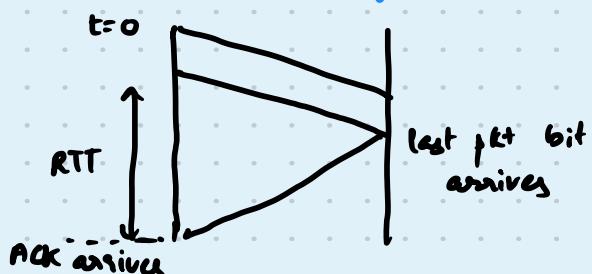
NOTE: Retransmission only depends on timeout, not getting the wrong ACK



Performance of rdt 3.0

Utilization: fraction of time sender is busy sending

$$U_{\text{sender}} = \frac{L/R}{RTT + L/R}$$



pipelining: sender allows multiple pkts in flight
(not ACKed)

↳ range of seq. nos increase

$$V_{\text{sender}} = \frac{3 L/R}{L/R + RTT} \rightarrow 3 \text{ times better utilisation}$$

