CS2105 Lecture 4
Reliable Protocols

3 February, 2014

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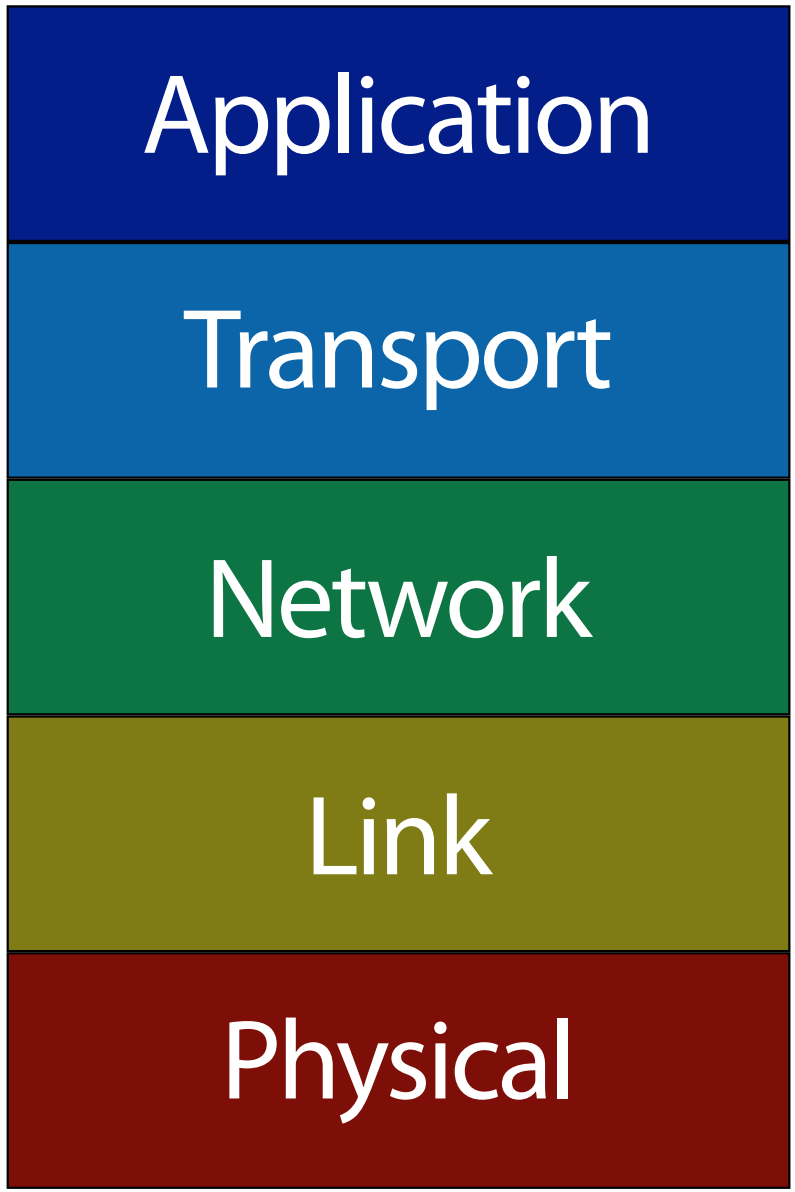
After this class, you are expected to:

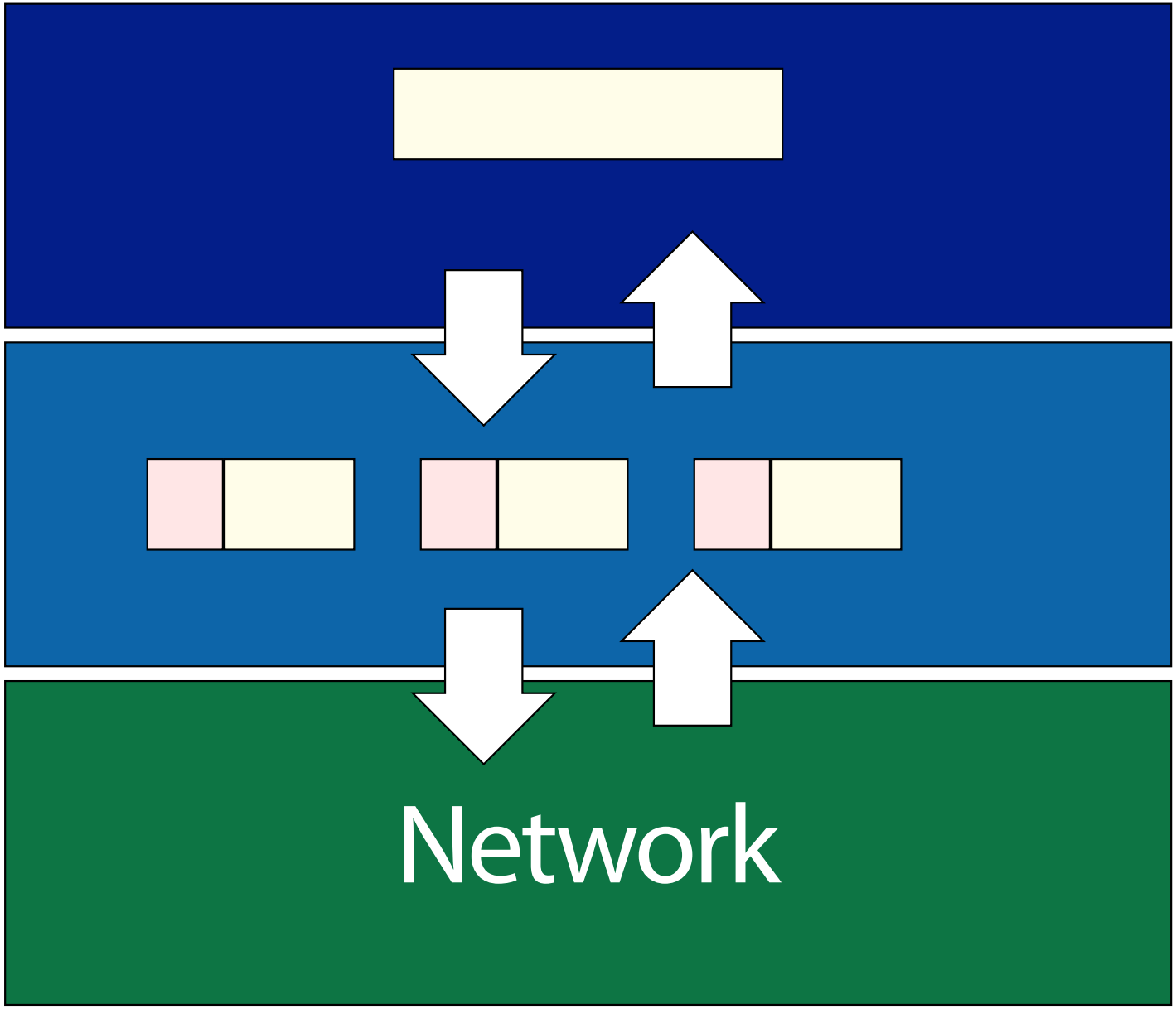
- understand the interface between the transport layer and the network layer
- be able to design your own reliable protocols with ACK, NAK, sequence numbers, timeout, and retransmission.
- know how to calculate the utilization of a channel.
- understand the working of Go-Back-N and Selective Repeat protocols

``Sending Data Reliably Over the Internet is Harder Than You Think. The Intricacy Involved in Ensuring Reliability Will Make Your Head Explode."


Application
Transport
Network
Link
Physical

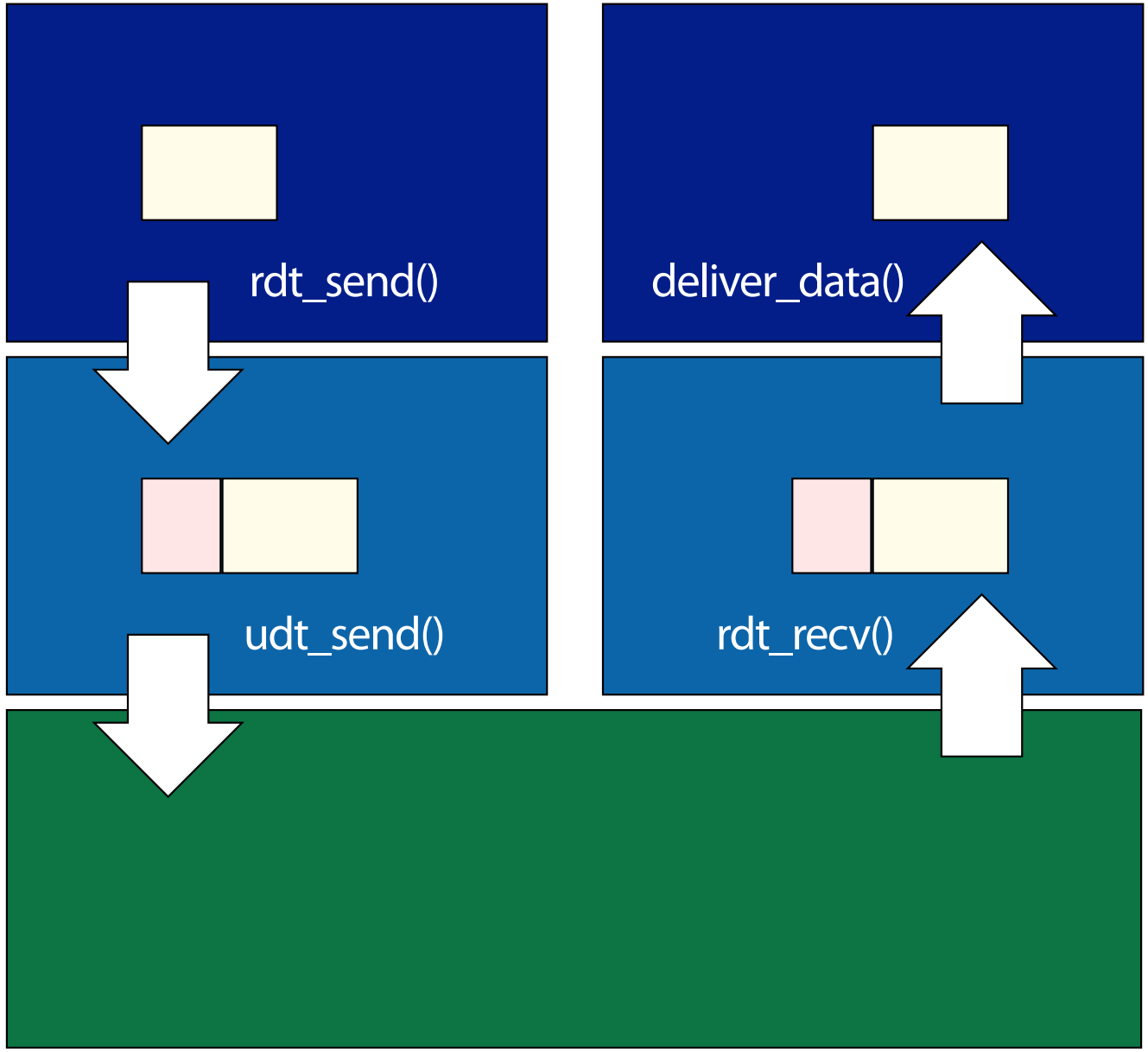
Transport layer resides **on end hosts** and provides **process-to-process** communication.

Network layer provides
host-to-host,
best-effort,
unreliable
communication.

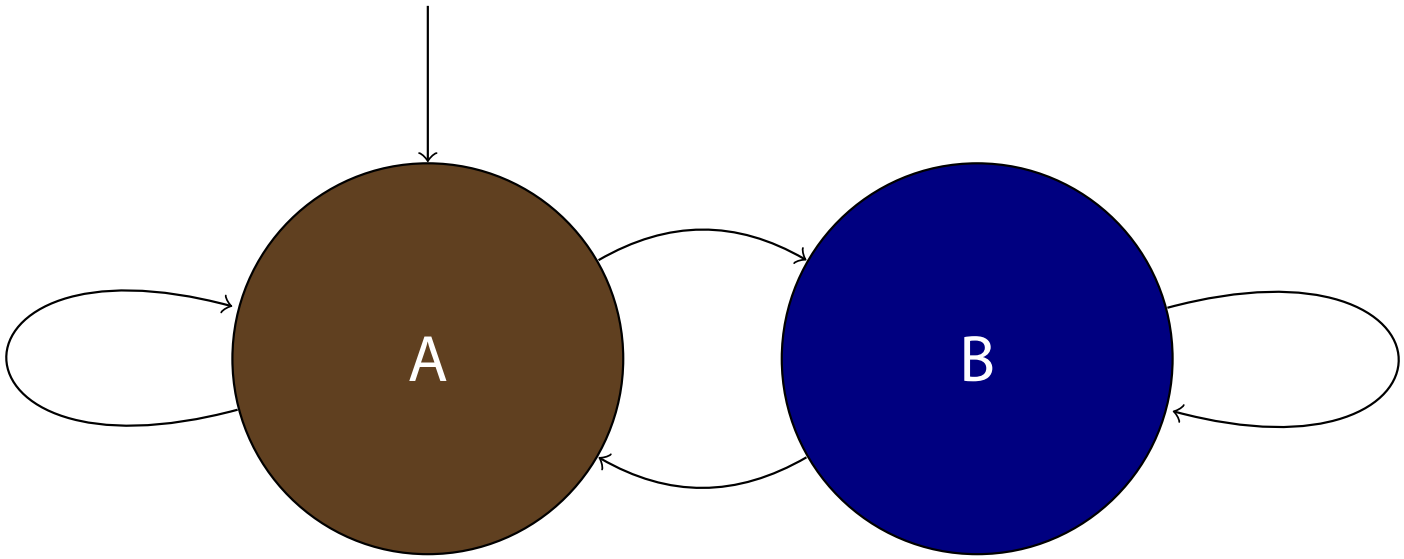

Network

How to build a **reliable transfer protocol** on top of unreliable communication?

Unreliable: may not deliver at all or deliver with error


rdt_send()
deliver_data()
udt_send()
rdt_recv()

Finite State Machine

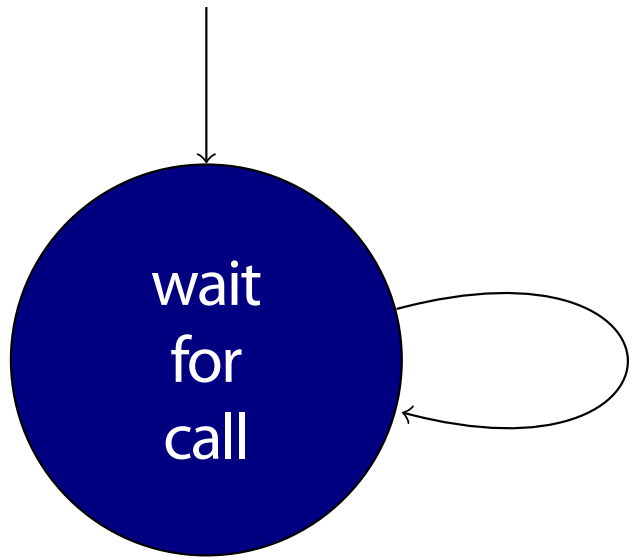


Event
Action

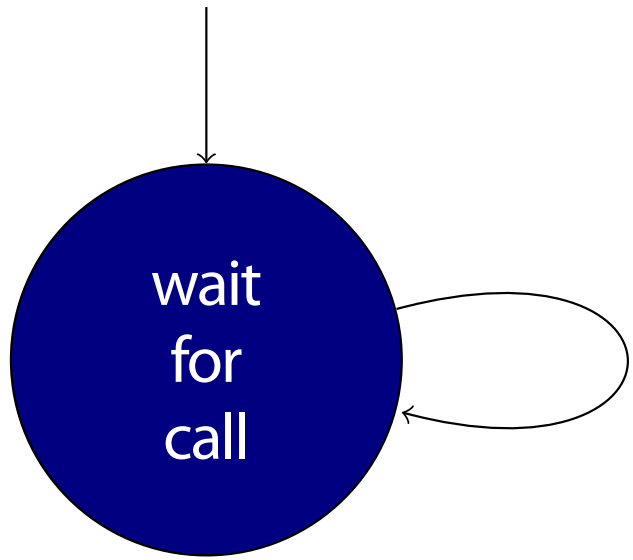
rdt 1.0

Assume underlying channel is reliable

rdt 1.0 sender



rdt 1.0 receiver



rdt 2.0

Underlying channel may introduce bit errors

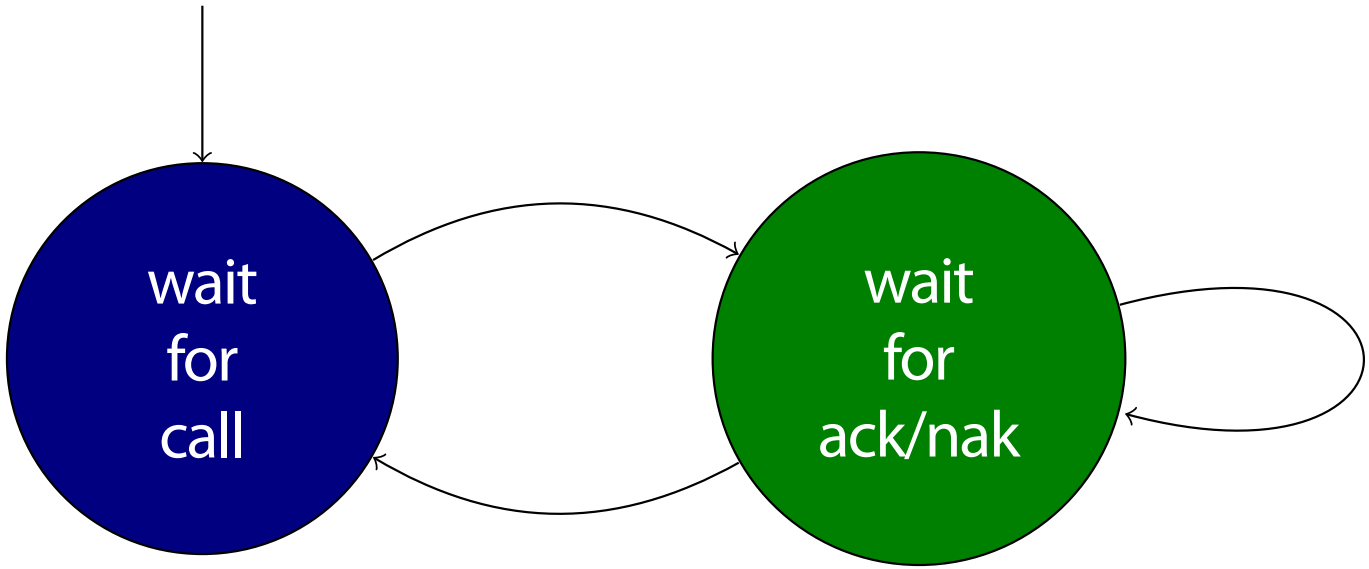
ARQ
Automated Repeat reQuest

Receiver detects errors
Receiver feeds back to sender
Sender retransmits

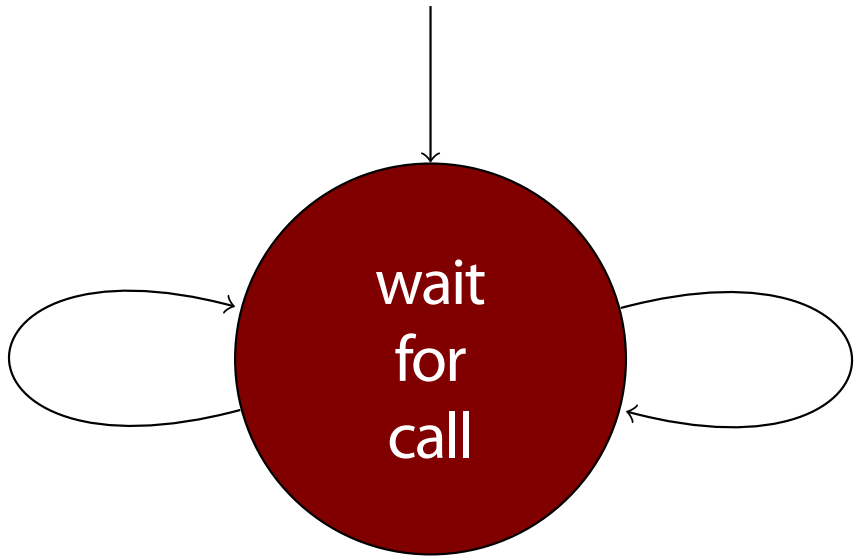
Receiver detects errors
Receiver feeds back to sender
Sender retransmits

We will talk about checksum, the technique to detect errors, in more detail in the subsequent lectures.

rdt 2.0 sender



rdt 2.0 receiver

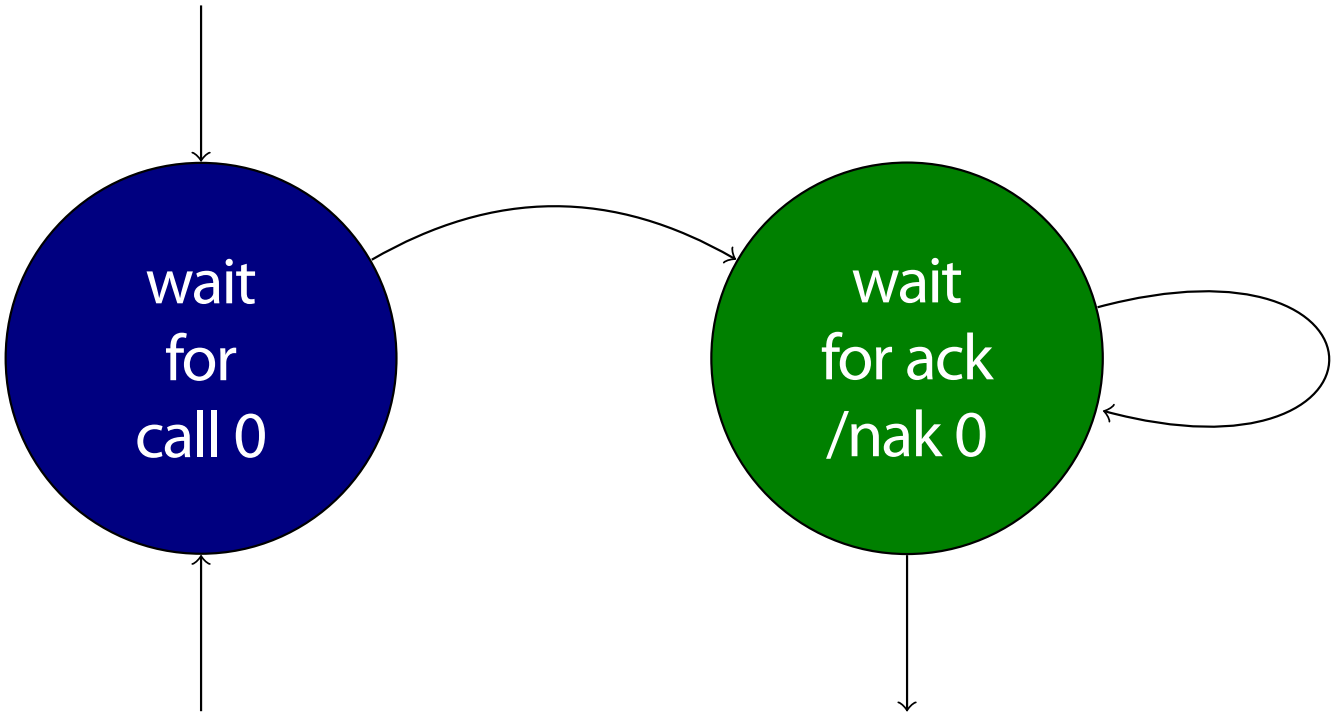


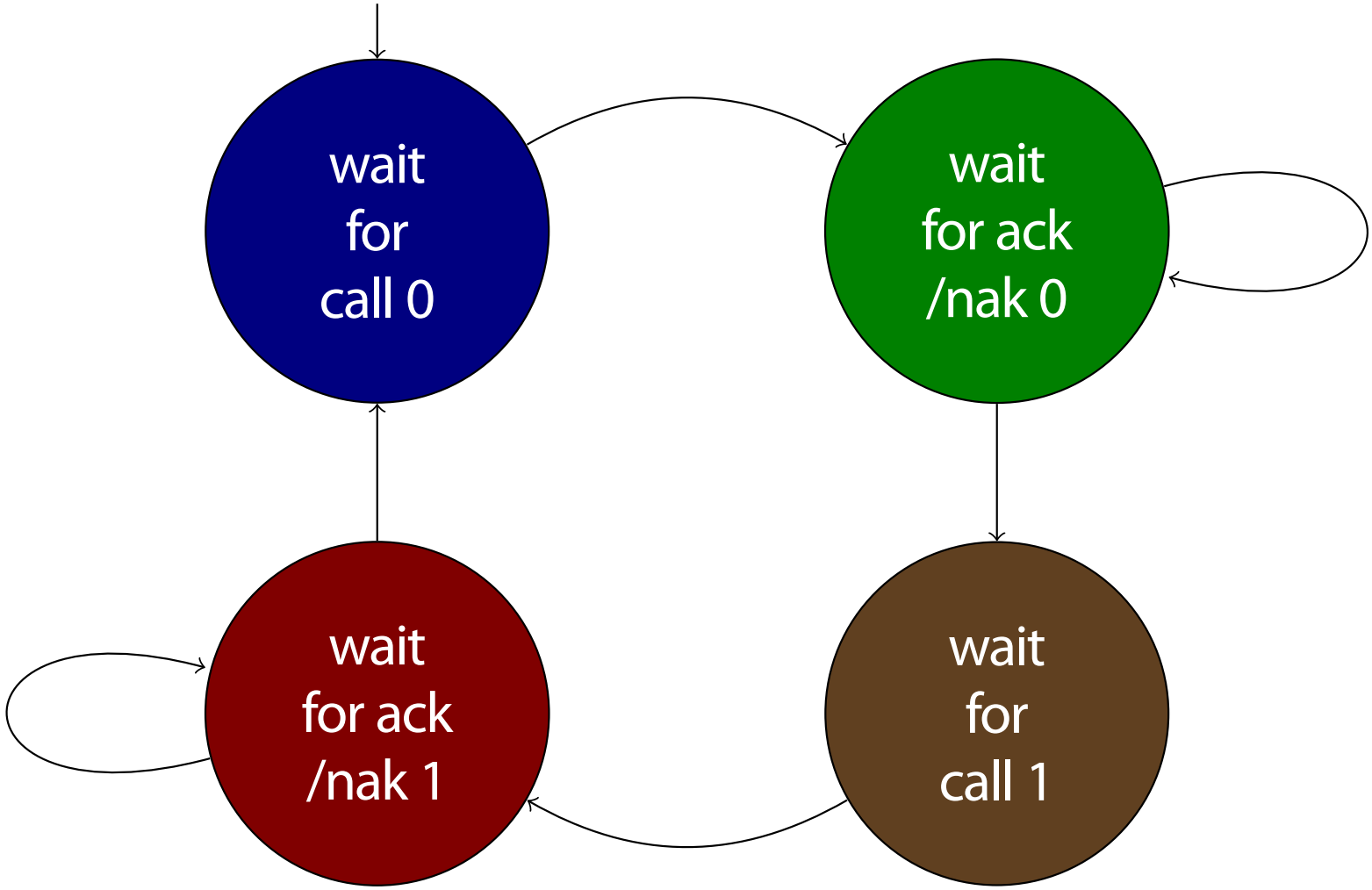
Stop-and-Wait Protocol

Bug:
What if ACK/NAK is corrupted?

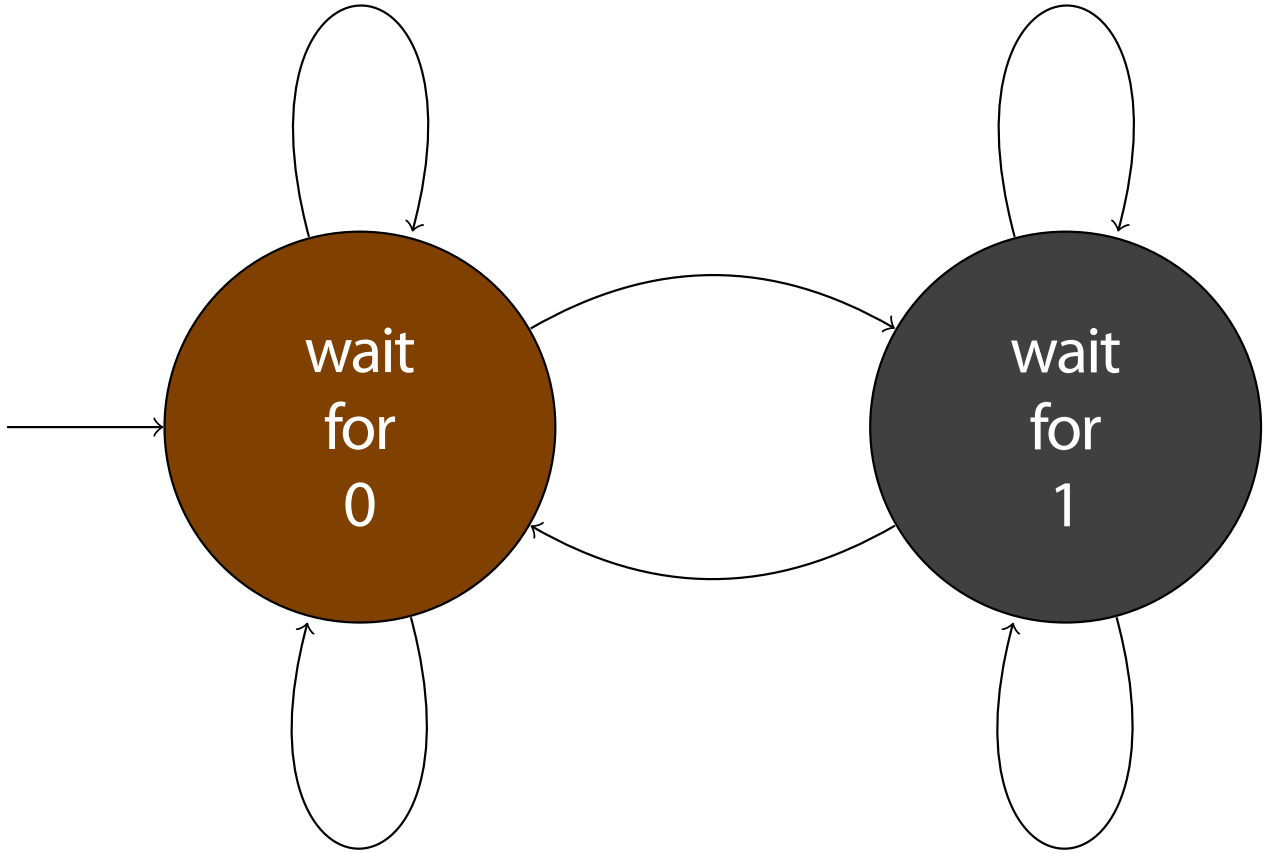
Bug Fix:
Add a sequence number

rdt 2.1 sender




wait
for
call 0
wait
for ack
/nak 0
wait
for ack
/nak 1
wait
for
call 1

rdt 2.1 receiver



rdt 2.2

Replace NAK with ACK of the last correctly received packet.

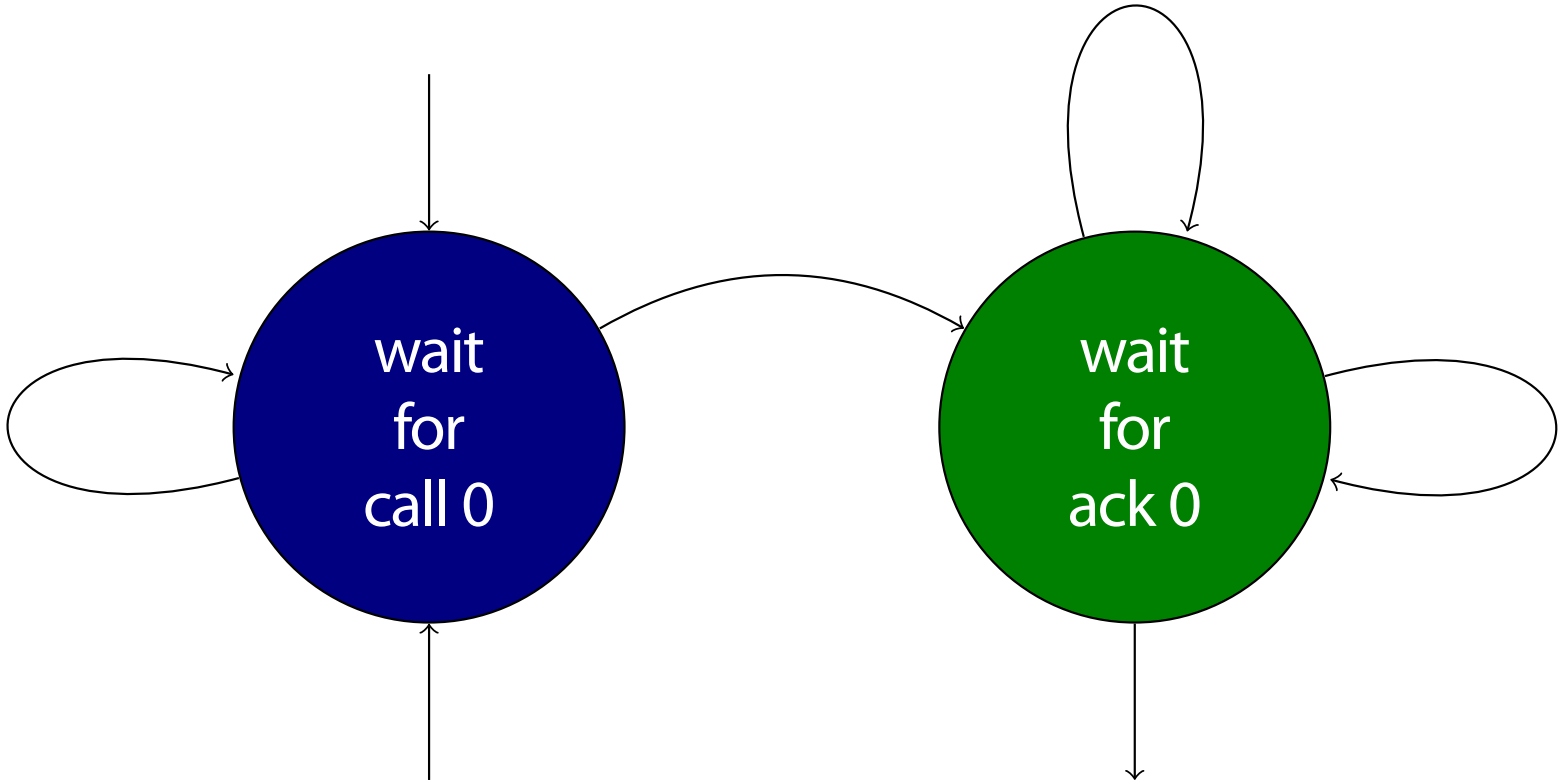
rdt 3.0

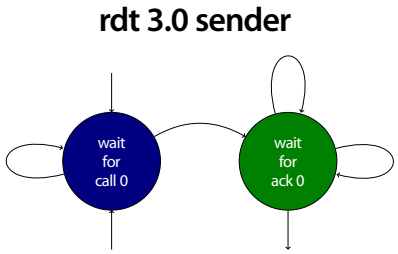
Packet can be loss or corrupted

Challenge: If ACK is lost, how to tell if the packet has been received?

Resend after timeout
(may lead to dups, but OK since we have seq numbers).

rdt 3.0 sender





The state diagram for the receiver in rdt 3.0 is given as an exercise.

Alternating Bit Protocol

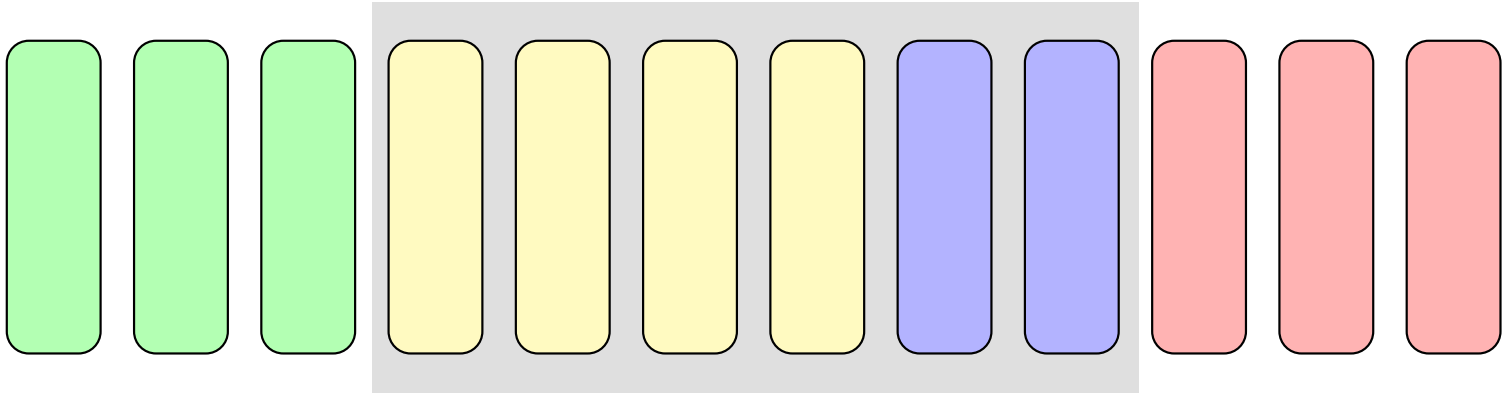
RTT = 30ms

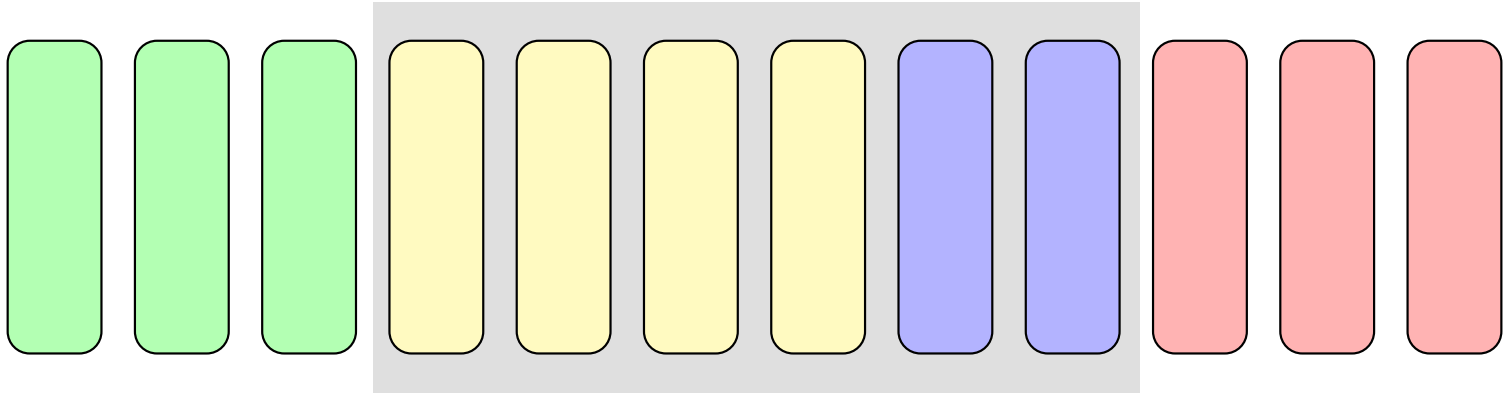
R = 1 Gbps

L = 1000 bytes

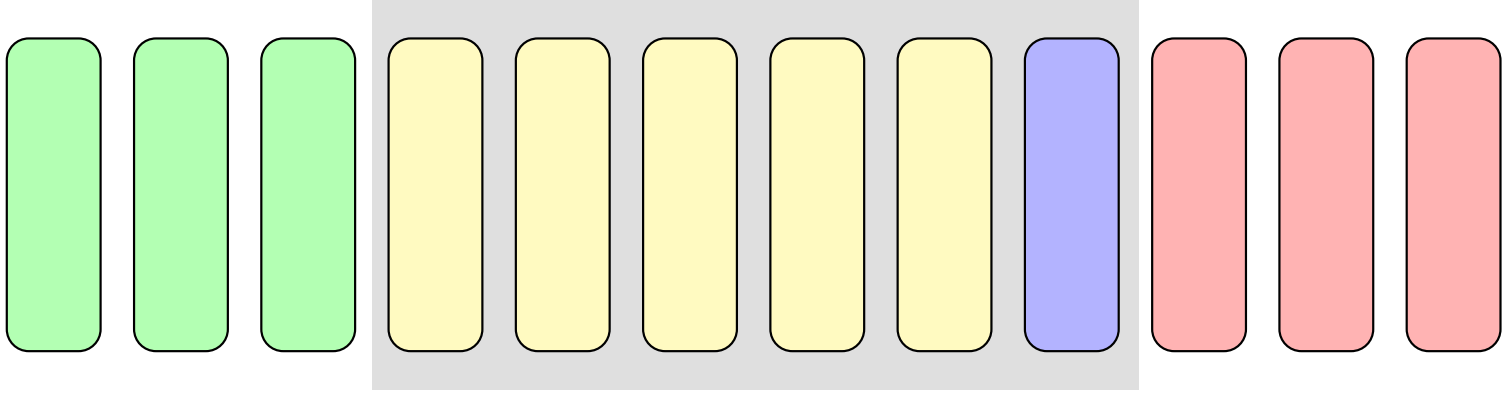
Pipelining:
need buffering and larger range of sequence numbers.

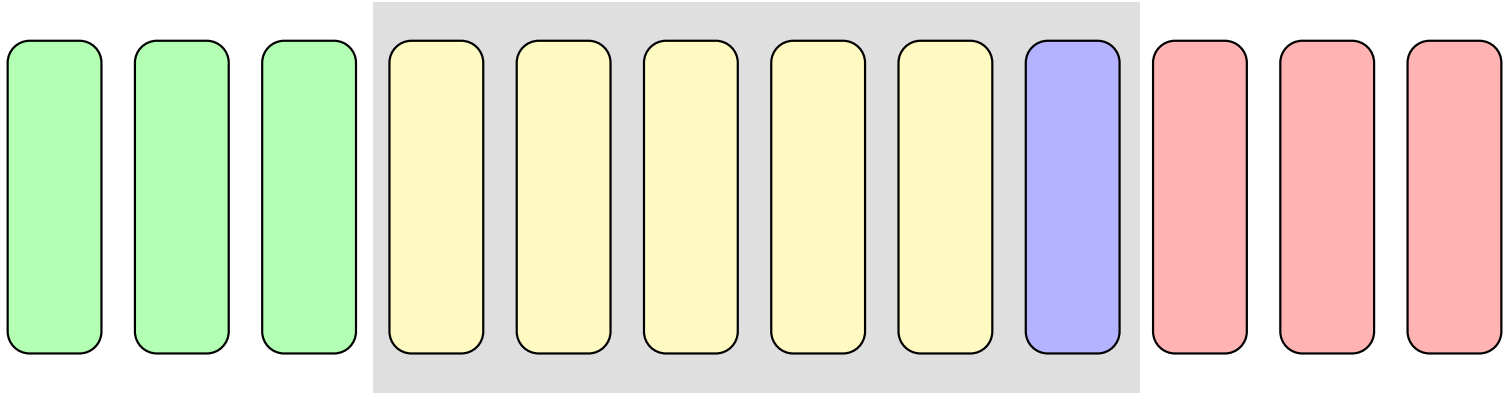
Go-Back-N



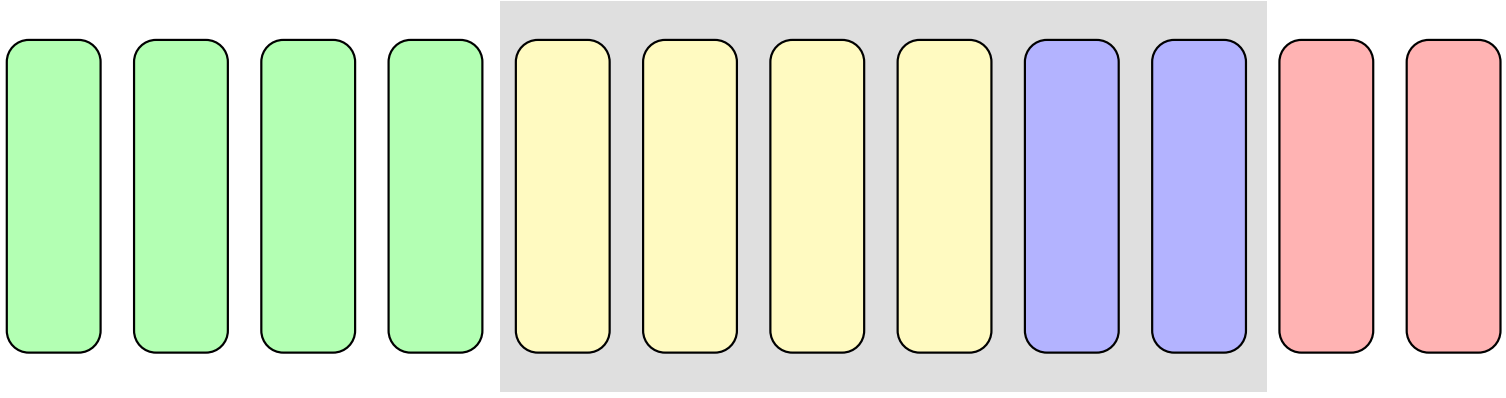


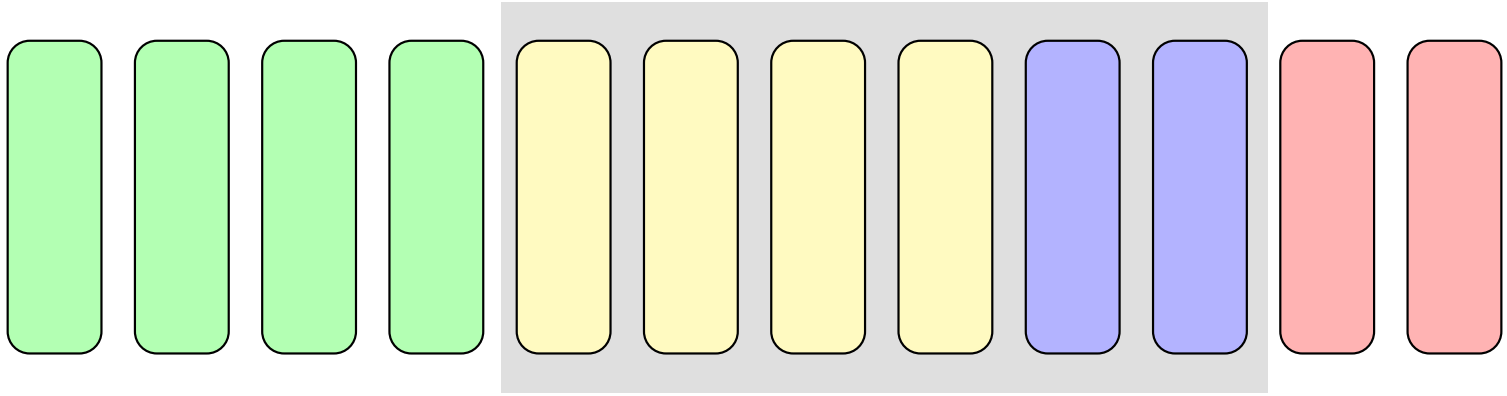
send a packet



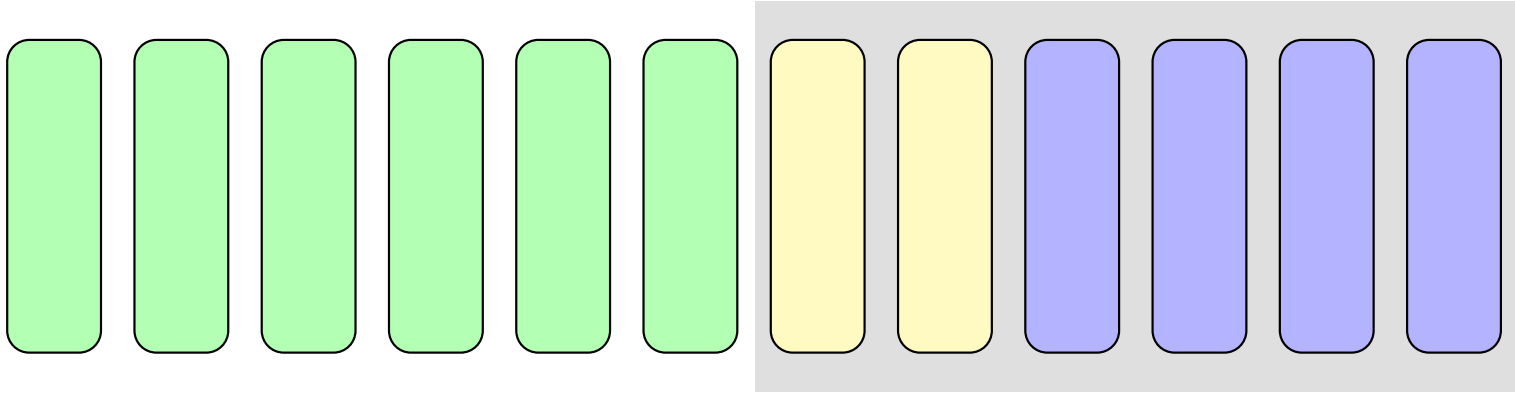


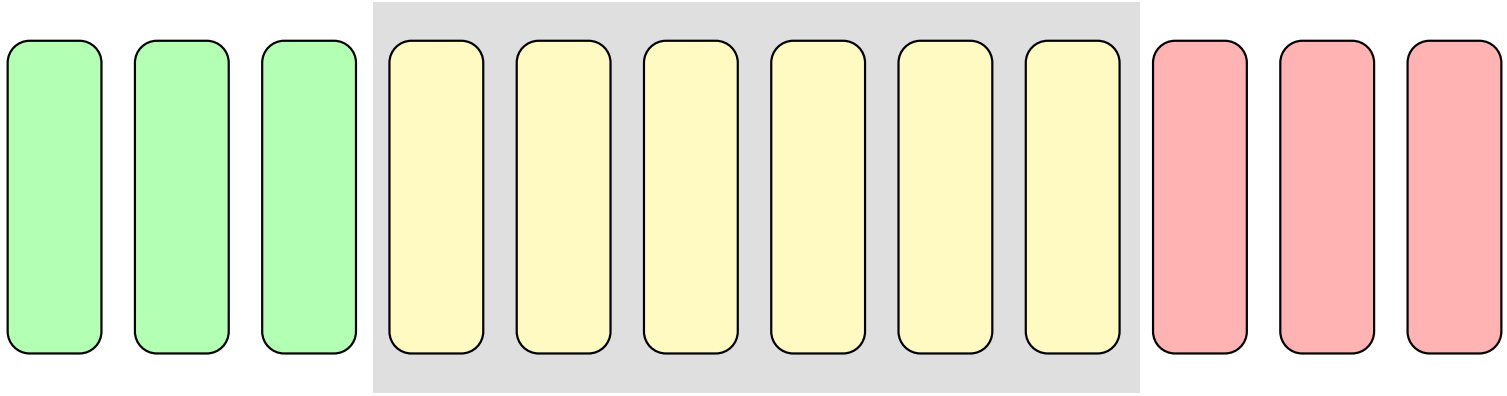
receive ACK 3



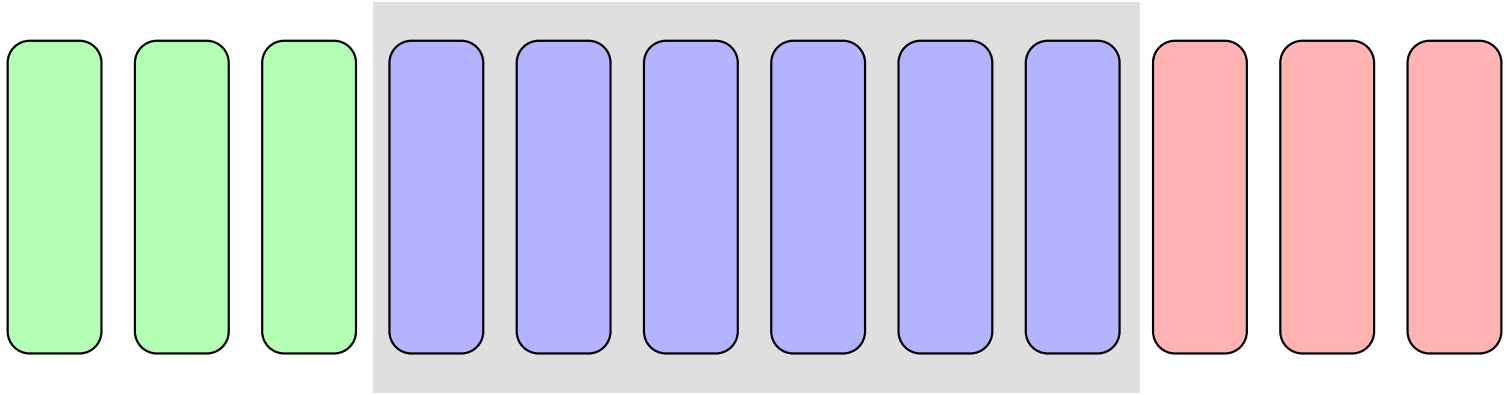


receive ACK 5





window is full

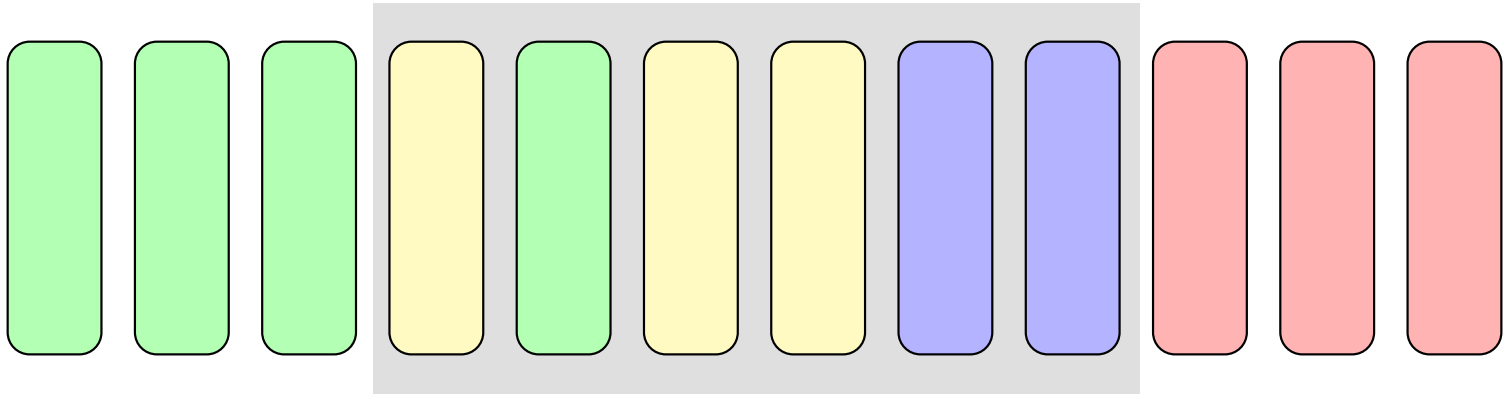


window is empty

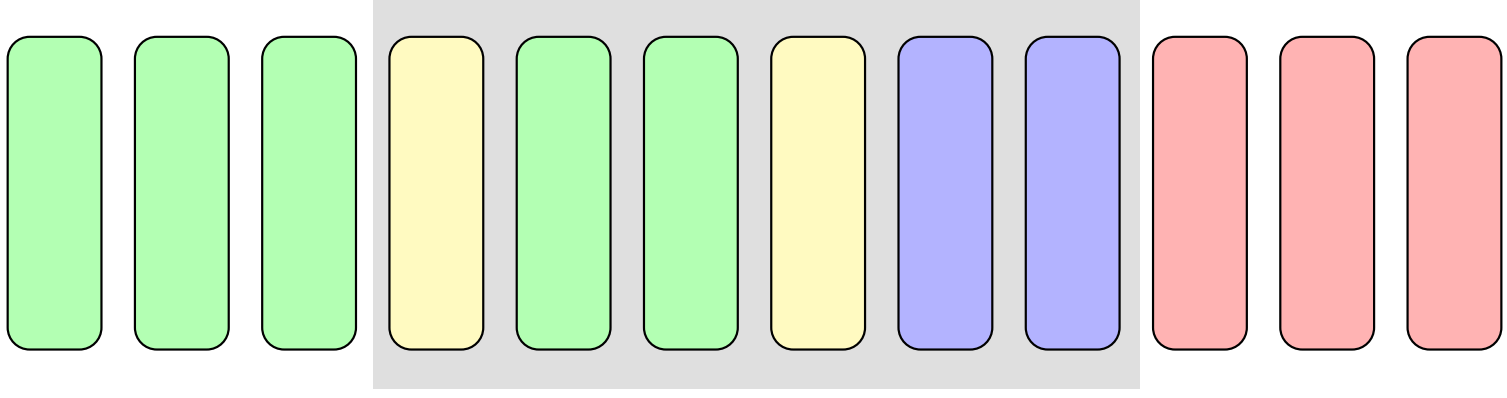
Selective Repeat

1. one timer per packet
2. receiver needs buffer

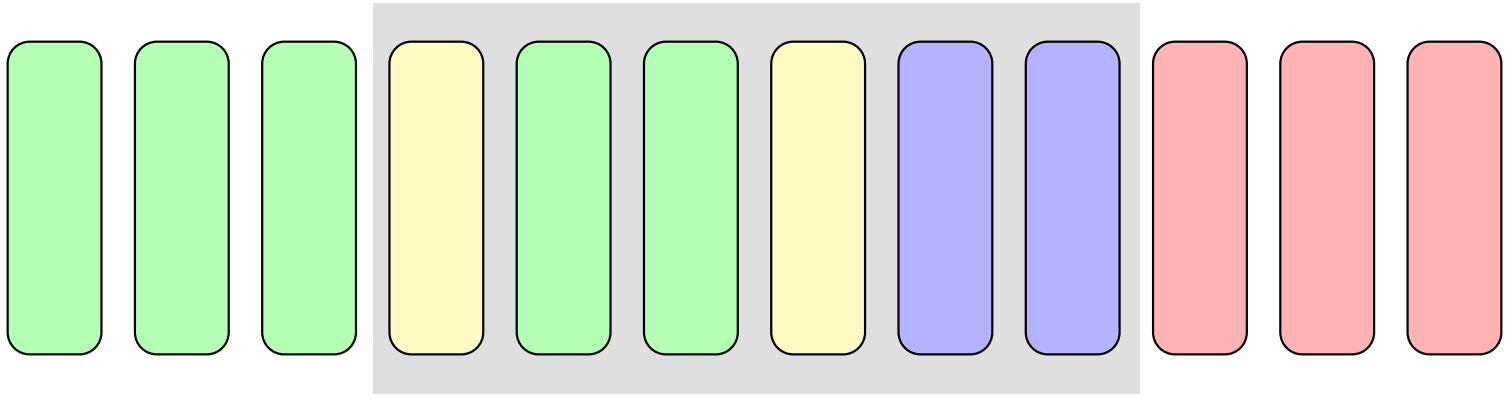
at sender:



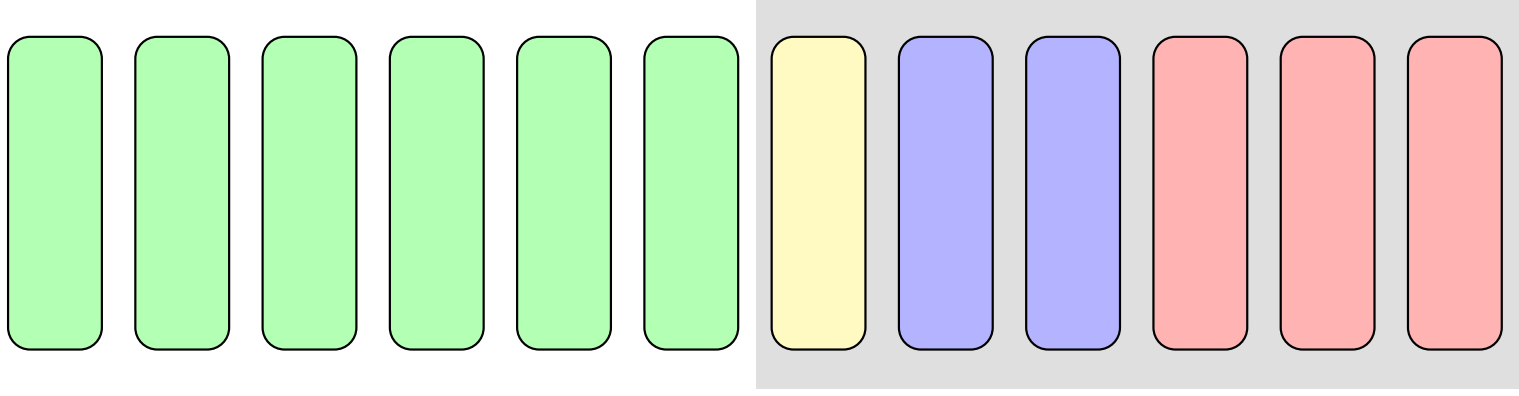
receive ACK 5



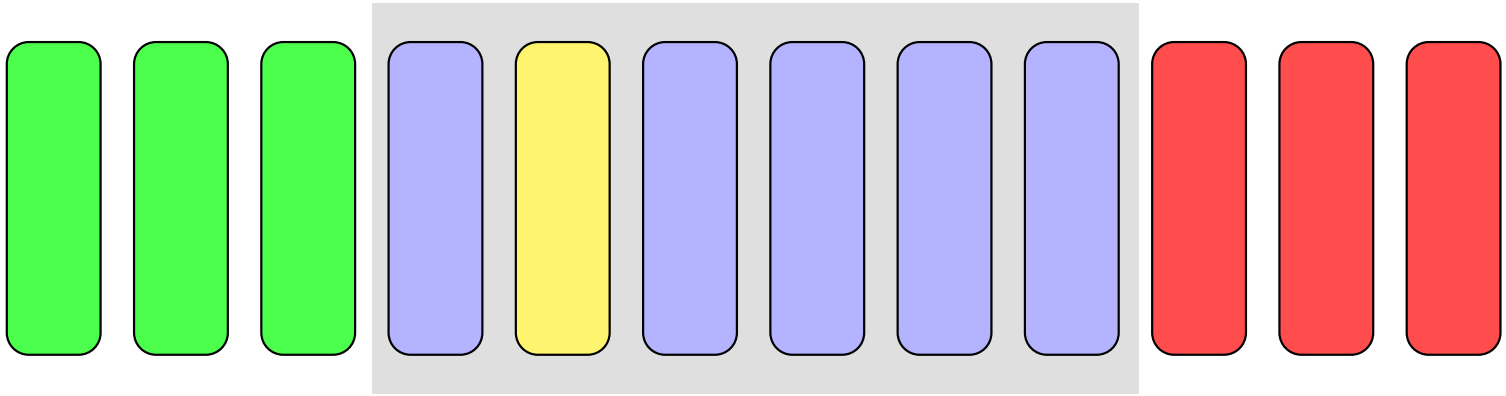
at sender:



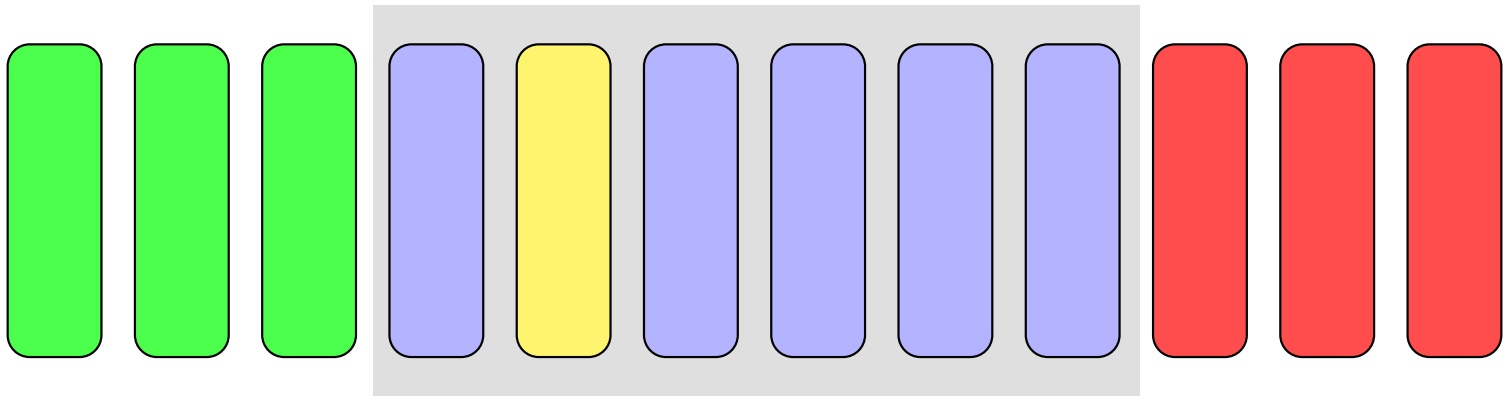
receive ACK 3



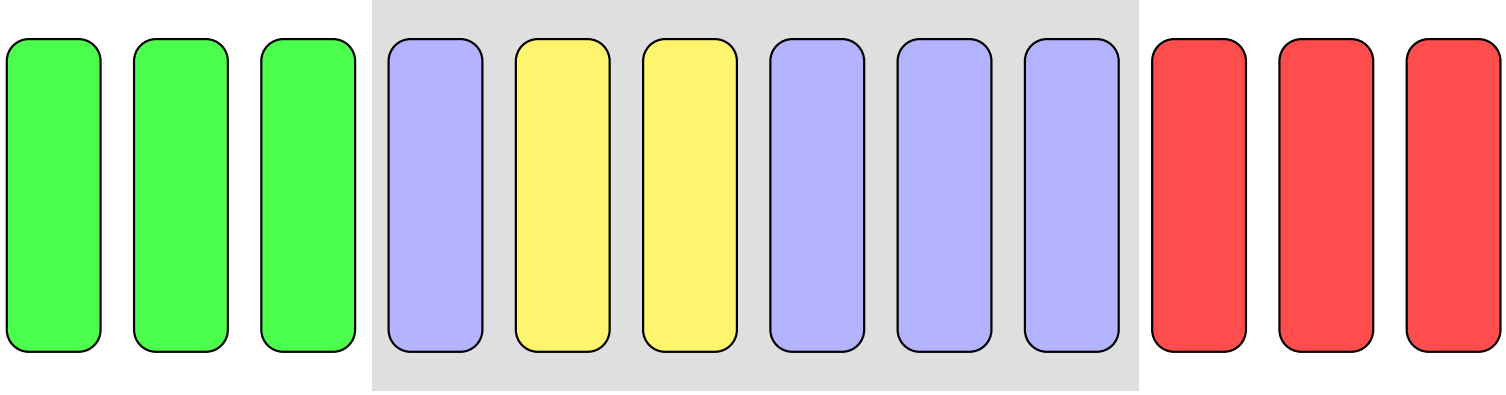
at receiver:



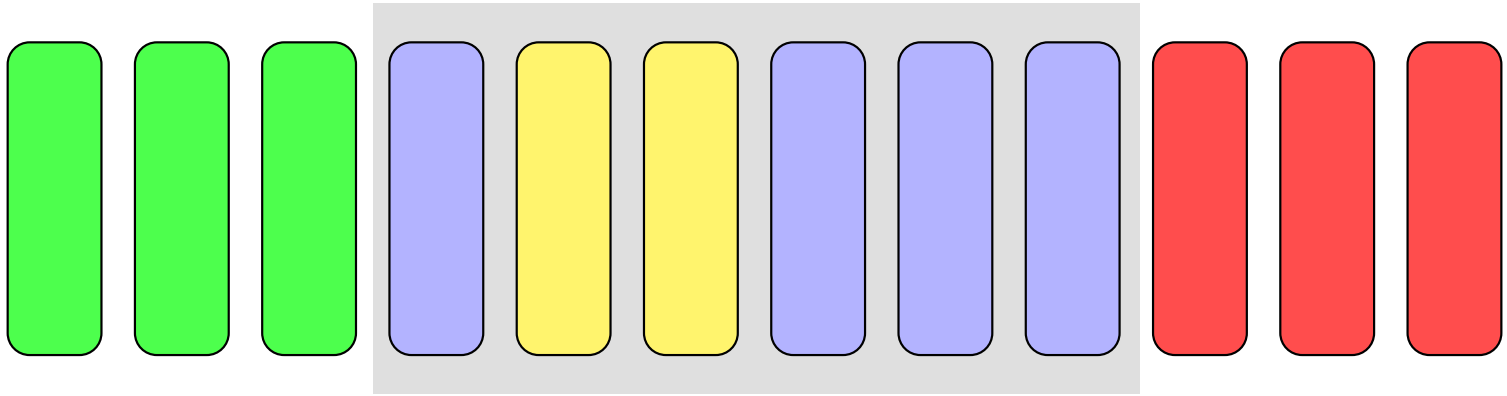
at receiver:



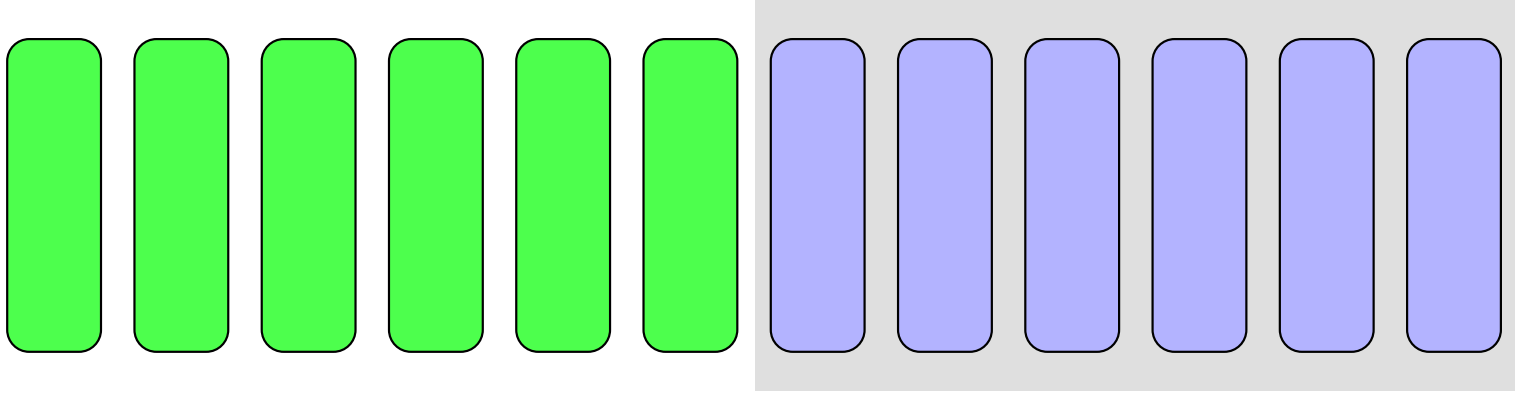
receive packet 5

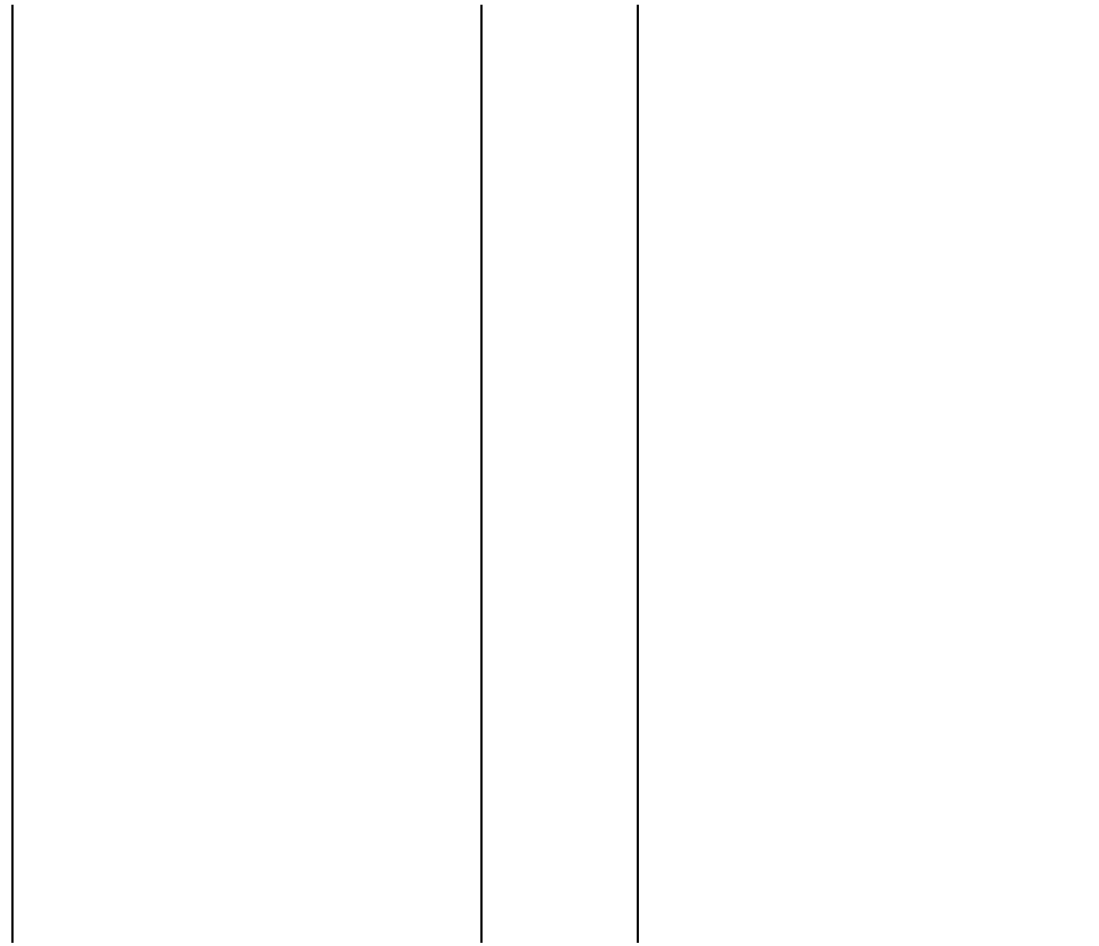


at receiver:



receive packet 3





	GBN	SR
ACK	cumulative	selective
out-of-order	ignore	keep
retransmit	all unack	one unack
timer	earliest unack	one per unack

How to build a **reliable protocol** on top of unreliable communication?

How to build a **reliable protocol** on top of unreliable communication?

The same techniques can be used in other layers, such as in an application layer protocol over UDP, or in a link-layer protocol.

error detection
retransmission
timers
sequence numbers
ACK/NAK
window and pipelining