

## Reliable Data Transfer

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- Error Detection
- Sequence Numbering
- Feedback
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## Basic Tools Summary

### Error Detection

The data link and network layers have error detection for detecting bit errors in packets. However, error detection schemes can never detect all errors so it is helpful to have additional error detection in the transport layer to reduce the frequency of undetected errors.

Lower layer protocols with error detection usually have a simple policy for dealing with errors: discard the packet. A transport layer RDT protocol typically just does the same thing, letting its algorithm for dealing with missing packets deal with the problem. Since the lower layers may discard packets an RDT protocol must allow for the possibility that a receiver is not even aware of an attempted transmission.

### Sequence Numbering

Packets in the network layer are routed individually. This makes it possible that they are received in a different order than they are transmitted. Sequence numbering is essential for restoring the transmitted order.

### Feedback

Feedback involves information sent by the receiver back to the sender about reception of sent packets. This is essential for recovery of missing packets. The feedback takes the form of acknowledgments (ACKs) with one of three forms:

- Negative acknowledgment - "I did not receive the packet with sequence number *sn*."
- Positive individual acknowledgment - "I received the packet with sequence number *sn*."
- Positive cumulative acknowledgment - "I have received all packets with sequence numbers up to but not including *sn*."

Most reliable data transfer protocols use only one of these types of acknowledgment. Negative acknowledgments are useful in human communication, but only because the acknowledgment is not lost, though it may be garbled. Since negative acknowledgment packets can be lost in the internet, they are not useful. They will not be considered in this presentation.

Cumulative acknowledgments allow acknowledgment of numerous packets at a time. They can be useful in pipelined protocols.

### Timers

Packet loss in the network layer does not discriminate between data packets and acknowledgment packets. A sender in a reliable data transfer protocol needs to set a timer for transmitted packets. Generally the sender does one of two things:

- Resends a packet after a timer fires.
- Sends a new packet after an acknowledgment (positive) arrives.

If an acknowledgment arrives before the timer fires the sender stops the timer so that it will not fire.