ARQ and Flow Control

Automatic Repeat reQuest (ARQ) is a technique to ensure reliable delivery of data by retransmitting frames that are received with errors or not at all. Flow control is the term for various techniques to stop or slow down transmissions to match the rate at which a receiver can accept data.
After this lecture you should be able to: explain how ACK frames ensure error-free transmissions; select an appropriate type of ARQ (from stop-and-wait, go-back-N and selective repeat) based on channel error rate and delay; and select appropriate flow-control method(s) to avoid over-flows.

Retransmission Protocols

Many frame-oriented data communication protocols require that the receiver acknowledge correct reception of each frame to ensure that no data is lost.

When a message is received without errors the receiver sends an "ACK" (acknowledgment) packet back to the sender to confirm correct reception.

If the transmitter does not receive the appropriate ACK frame within a certain amount of time (the timeout) it knows the frame (or ACK) was not correctly received and retransmits the original frame. This technique is called ARQ (for Automatic Repeat reQuest).

This type of ARQ is called **Stop and Wait ARQ**. The transmitter must wait after each frame until it receives the ACK or timeout.

This is the simplest type of ARQ since the transmitter only has to store one frame (in case a retransmission is required). It is also the least efficient variant, particularly if there is a long delay between transmitter and receiver.

Efficiency can be improved by allowing the transmitter to send more than one frame without waiting for each one to be acknowledged. The transmitter also adds a serial number (or byte count) to each frame. The transmitter must store all unacknowledged frames which increases memory requirements.

There are two ways that retransmissions can be handled:

The first, **Go Back N ARQ**, requires the transmitter to transmit all frames starting at the first unacknowledged frame.

The second, **Selective Repeat ARQ**, allows the receiver to acknowledge individual frames (or ranges of byte counts) received. The transmitter then retransmits the lost frames. This requires that the receiver store all frames received since the first missing frame so the frames can be output in the right order.

In many protocols ACKs can be appended as "piggyback" information on data frames being sent in the reverse direction. This reduces the overhead of sending ACKs.

Some protocols allow the use of a negative acknowledgment (NACK) that allows a receiver to ask for a retransmission if it knows that a frame was lost. This can be faster than waiting for a timeout.

Exercise 1: Create a table summarizing the different types of ARQ. Include: throughput, transmitter memory, receiver memory and relative complexity.

Exercise 2: A data communication system operates at 1 Mb/s and uses 10000-bit data frames and 100-bit ACK frames. What are the frame durations? What is the throughput if there is no channel delay and no errors? If the round-trip channel delay is a 0.5s (typical for satellite links)? If go-back-N ARQ is used, assuming the transmitter can store all unacknowledged frames?

Exercise 3: A communication system loses every 10th frame (e.g. due to periodic noise bursts). Ignoring ACK overhead, what is the throughput using go-back-N ARQ? Using Selective ARQ?

Flow Control

It is possible for the data to overflow the buffers available in a receiver.

To avoid overflows we can use "flow control" signals. For example, on serial interfaces a "clear-to-send" signal output by the receiver can tell the transmitter when the receiver is ready to accept data. This is often called "hardware" flow control.

To avoid the need for a dedicated flow-control signal line the receiver can send special characters to the

transmitted to tell it when to stop and start sending data. This is called "software" flow control. The XON (start sending, also control-Q) and XOFF (stop sending, also control-S) ASCII control characters are often used for this. However, this means that these characters cannot be used for other purposes.

Another flow control method is to use stop-and-wait ARQ. The sink can output an ACK for the previous frame only when there is room for another frame.

Exercise 4: Which of the above flow control methods can be used with frame-oriented protocols? On unidirectional links?