Automatic Repeat reQuest (ARQ)

Automatic Repeat reQuest (ARQ)

- ARQ is a mechanism used in data link control and transport protocols.
- It relies on the use of error detection code.
- ARQ demands for bi-directional communication system.
- Which means that a reverse channel must be present where an **positive acknowledge** (ACK) can be transmitted if a correct message have been received.
- Or when an error is detected in a message the receiver asks for a retransmission of the message, negative acknowledge (NACK).

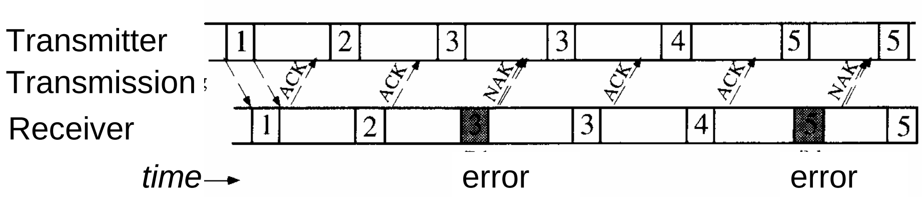
Automatic Repeat reQuest (ARQ)

There are three main versions of ARQ:

- Stop and wait (SW)
- Go Back-N (GBN)
- Selective repeat (SR)

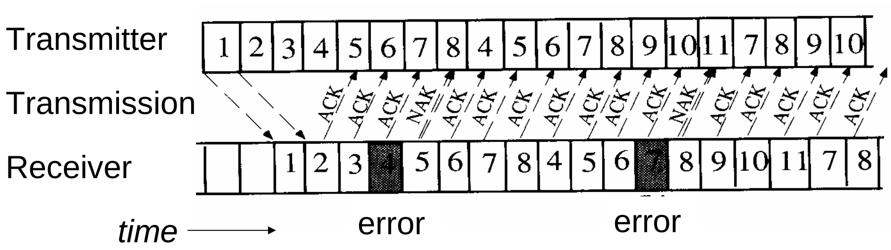
Stop and Wait (SW)

In **Stop and wait** the transmitter is waiting for an **ACK** from the receiver before it starts the next data transmission. When an erroneous code word is received, the receiver answers with an **NACK**.



Go Back-N (GBN)

In Go Back-N or sometimes called continuous ARQ, the transmitter transmits the code words in a stream and at received NACK it backs and starts again from that position and re-transmits all code words. Dependent on the delay in the system *N* code words will be repeated. The method allows for higher transmission speed and longer delay.



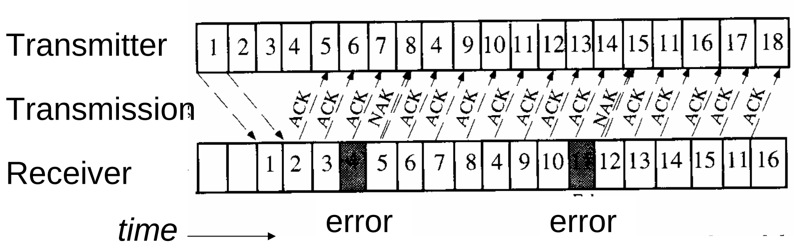
Selective repeat (SR)

In Selective Repeat the erroneous code word is only repeated.

When a erroneous code word is detected, it interrupts the data stream transmission.

It re-transmits the erroneous code word.

Then it goes back to the previous point in the message stream and continuous to transmit data from that point.



ARQ performance

A important measure of an ARQ system performance is how many code words *m*, that in average has to be transmitted for each accepted code word.

The probability for zero errors in a sequence of *n* bits is:

$$(1-P_s)^n$$

where P_s is the symbol error probability. The probability of one error is then:

$$1-(1-P_s)^n \approx nP_s$$

The approximation is based on the series

$$\left\{(1-P_s)^n = 1-nP_s+\frac{n(n-1)}{2}P_s^2+.....\right\}$$

ARQ performance

With the previous approximation the probability for re-transmission of a block:

$$P_{bl} \approx nP_s$$

The probability for zero errors in a received block is then (transmitted once):

$$P(1) = (1-P_{bl})$$

The probability that a block is transmitted twice is:

$$P(2) = (1-P_{bl})P_{bl}$$

ARQ performance

The probability for m + 1 transmissions, m erroneous reception followed by one correct block is:

$$P(m+1) = (1 - P_{bl})P_{bl}^{m}$$

The average of transmitted code words per correct received then becomes:

$$\bar{m} = \sum_{m=1}^{\infty} mP(m) = (1 - P_{bl}) + 2(1 - P_{bl})P_{bl} + 3(1 - P_{bl})P_{bl}^{2} + \ldots$$

$$= (1 - P_{bl})\left[1 + 2P_{bl} + 3P_{bl}^{2} \ldots\right] = \frac{1 - P_{bl}}{P_{bl}}\left[1 + 2P_{bl} + 3P_{bl}^{2} \ldots\right] = \frac{1}{1 - P_{bl}}$$

The last step is based on a geometric series approximation.

ARQ performance

To transport k information carrying symbols, the average number of transmitted symbols are $n\bar{m}$.

The coding rate (overhead) then becomes:

$$R_c = \frac{k}{n\bar{m}} = \frac{k}{n}(1 - P_{bl})$$

ARQ performance