4.8 Link Utilization and Efficiency:

Link utilization is simply the average traffic over a particular link expressed as a percentage of the total link capacity. Link efficiency is a less commonly used term that is defined as the ratio of the time taken to transmit a frame (or frames) of data to the total time it takes to transmit and acknowledge the frame or frames:

Utilization (U) or Efficiency=(Time taken to transmit frame)/(Total transmission time)

The efficiency of a link with stop-and-wait ARQ can be determined as follows:

If the time taken to transmit a frame or block of data is t_f, the propagation delay for both frame and acknowledgement is t_d, the time taken to transmit an acknowledgement is t_a and the total processing time is t_p, then:

$$U = (t_f) / (t_f + t_a + t_p + 2t_d)$$

In many situations the acknowledgement transmission time and processing times can be ignored, giving:

$$U = (t_f) / (t_f + 2t_d) = (1) / (1 + 2a) \quad ; \text{where } a = t_d / t_f$$

Example 4.7:

A point-to-point satellite transmission link connecting two computers uses a stop-and waits ARQ strategy and has the following characteristics:

Data transmission rate = 64 kbps

Frame size, n = 2048 bytes

Information bytes per frame, k = 2043 bytes

Propagation delay, t_d *= 180 ms*

Acknowledgement size, t_a *= 10 bytes*

Round-trip processing delay, t_p *= 50 ms*

Determine the throughput and link efficiency.

Solution:

Frame transmission time t_f = (2048 x 8) / (64000) = 0.256 sec.

Acknowledgement transmission time t_a = (10 x 8) / (64000) = 1.25 msec.

Total time to transmit frame and receive an acknowledgement is:

$t_f + t_a + t_p + 2t_d$ = 0.256 + 0.00125 + 0.05 + 0.36 = 0.66725 sec.

Throughput k = (2043 x 8) / (0.66725) = 24.494 Kbps.

Note that the resulting throughput is considerably less than the transmission rate of 64 kbps.

The link efficiency (Utilization)can now be calculated, neglecting t_a and t_p, as follows:

a = (t_d) / (t_f) = (0.18) / (0.256) = 0.7

U = (1) / (1 + 2a) = (1) / (1 + 1.4) = 41.67 %.

4.9 Effect of Errors on Throughput:

From the principles of networking and communications, the number of errors present in a link is expressed as a BER. If a link has a BER of (0.000001) which is equal to (10^{-6}), this means that there is a probability of 0.000001 that any bit is in error. The frame error rate, *P*, can be obtained from the bit error rate, *E*, as follows:

If the probability of a bit being error free is *(1 – E)* and the probability of a block of length *n* being error free is $(1 - E)^n$. The frame error probability is therefore:

$$P = 1 - (1 - E)^n$$

Example 4.8:

A frame of data of length 2048 bits is transmitted over a link with a BER of 10^{-4}. Determine the probability that a frame will be received erroneously.

Solution:

Since the BER, E = 0.0001, then Probability of a bit being error free = (1 – E) = (1 − 0.0001) = 0.9999. Since the frame length, *n*, is 2048 bits then the probability of the frame being error free is (1 – E) = $(0.9999)^{2048}$ = 0.815.
The probability of a frame being in error is given by:
P = 1 − 0.815 = 0.185.

is reduced under these circumstances.