Network Performance

For a given physical layer, how does it perform:

- For changes in network length.
- Changes in data rate.
- Changes in message overhead.
- Changes in load (demands for data transfer).

Some possible criteria are:

- Throughput
- Response time
- Utilization
- Error rates

Utilization

$$U = \frac{throughput}{capacity} = \frac{DataUnits}{Capacity}$$

You can also use:

$$U = \frac{DataTime}{TotalTime}$$

Examples:

A network with a capacity of 100,000 b/s sends an average of 40,000 data bits per second.

$$U = \frac{40{,}000b/s}{100{,}000b/s} = 0.40$$

A network sends data for 8 seconds out of every 10:

$$U = \frac{8s}{10s} = 0.80$$

A General Formulation

Let,

- R = the channel data rate in bits per second
- V = the propogation rate of the signal
- D = the maximum distance between nodes
- L = the frame length in bits
- τ = the expected propogation time of one bit

The first bit of a message takes $\frac{D}{V}$ seconds to arrive (maximum).
The messages takes $\frac{L}{R}$ seconds to transmit.

$$\tau = \frac{D}{V}$$

The total time to receive a message is $\frac{D}{V} + \frac{L}{R}$:

The ratio of propogation time to time spent moving data bits is:

$$a = \frac{D/V}{L/R} = \frac{RD}{VL}$$

$$U = \frac{datatime}{totaltime} = \frac{L/R}{L/R + D/V} = \frac{1}{1 + RD/VL} = \frac{1}{1 + a}$$

Which says that the utilization, assuming a perfect MAC protocol, is inversely related to the proportion of time wasted in propogation delay.

Also note that the other formulation of utilization also works:

$$U = \frac{throughput}{capacity} = \frac{L}{L + DR/V} = \frac{1}{1 + RD/VL} = \frac{1}{1 + a}$$

This model allows us to draw some conclusions about network performance:

$$U = \frac{1}{1 + RD/VL}$$

- As D goes up, U goes down.
- As R goes up, U goes down.
- As L goes up, U goes up.

However, you need to remember that any model is an approximation to the real world and this only tells part of the story. It ignores load on the network and the access algorithm.

Utilization for Round Robin

- N = the number of nodes
- k = the number of nodes sending in a round

The data time is the number of nodes that send times the frame length for a given round, or the time is:

$$datatime = k * L/R$$

and the total time is simply N times the time for a frame:

$$capacity = N * (L/R + D/V)$$

The utilization is:

$$U = datatime/totaltime = \frac{kL/R}{N(L/R+D/V)}$$

$$U = \frac{k}{N}\frac{1}{1+a}$$