ITS323 – Performance Examples

1 Delay

In the following cases we will calculate the total delay, d_{path} across the link or path. Unless otherwise stated, we assume:

- Transmission speed is 2.8×10^8m/s
- Processing and queuing delay is negligible (i.e. 0)

1.1 Case 1

Two devices are connected via a single link 10km in length. The link data rate is 1Mb/s. What is the total delay for sending a 100 Byte packet?

We need to consider the transmission delay (d_t) and propagation delay (d_p) of the link:

$$
\begin{aligned}
d_t &= \frac{\text{datasize}}{\text{datarate}} \\
&= \frac{100 \times 8 \text{ bits}}{1 \times 10^6 \text{ b/s}} \\
&= 0.8 \text{ ms}
\end{aligned}
$$

$$
\begin{aligned}
d_p &= \frac{\text{distance}}{\text{speed}} \\
&= \frac{10 \times 10^3 \text{ m}}{2.8 \times 10^8 \text{ m/s}} \\
&= 0.036 \text{ ms}
\end{aligned}
$$

Therefore the total delay is:

$$
\begin{aligned}
d_{path} &= d_t + d_p \\
&= 0.8 + 0.036 \\
&= 0.836 \text{ ms}
\end{aligned}
$$

1.2 Case 2

The same conditions as Case 1, except the link length is now 1000km.

The transmission delay will not change (the data size and data rate are the same as Case 1), whereas the propagation delay will be increased by a factor of 100 (the link in this case is 100 times longer than that in Case 1). Hence it is easy to calculate the total delay to be:

$$\begin{aligned} d_{path} &= d_t + d_p \\ &= 0.8 + 3.571 \\ &= 4.371 \text{ ms} \end{aligned}$$

1.3 Case 3

A GEO satellite is about 36000km above the earth. The speed of transmission to/from the satellite to ground stations is the speed of light (3×10^8m/s). The link data rate is 1Mb/s. The satellite operates in a bent-pipe mode: one ground station sends a packet up to the satellite, which then repeats the packet down to the other ground station. The packet processing time (d_s) on the satellite is 4ms. What is the total delay for sending a 1000 Byte packet from one ground station to the other?

The path has two links: uplink and downlink. The links are identical (distance, rate, speed). Transmission delay of a link is:

$$\begin{aligned} d_t &= \frac{\text{datasize}}{\text{datarate}} \\ &= \frac{1000 \times 8 \text{ bits}}{1 \times 10^6 \text{ b/s}} \\ &= 8 \text{ ms} \end{aligned}$$

Propagation delay of a link is:

$$\begin{aligned} d_p &= \frac{\text{distance}}{\text{speed}} \\ &= \frac{36000 \times 10^3 \text{ m}}{3 \times 10^8 \text{ m/s}} \\ &= 120 \text{ ms} \end{aligned}$$

Remembering the satellite processing delay, the total delay (ground station to ground station) is:

$$\begin{aligned} d_{path} &= d_t + d_p + d_s + d_t + d_p \\ &= 8 + 120 + 4 + 8 + 120 \\ &= 260 \text{ ms} \end{aligned}$$

2 Throughput

Consider the TCP/IP encapsulation example in the lecture on Protocol Architectures and Internet Applications. The user data (e.g. a web page from a web server) is encapsulated in a HTTP application message and eventually transmitted as bits. Lets assume the size of the headers as follows:

- HTTP: 48 Bytes
- TCP: 20 Bytes
- IP: 20 Bytes
- Ethernet header: 14 Bytes
- Ethernet trailer: 4 Bytes
- Physical header: 16 bits

If the web server computer is connected via a single 1Mb/s, 1m link to the web browser computer, what throughput is acheived when sending a 10KB web page?

In this simple example we ignore any other protocol messages (e.g. TCP acknowledgements). The user data is the 10KB web page. But with encapsulation, the total number of bits (b_{total}) to be sent across the link is the user data plus all the headers and trailers:

$$\begin{aligned} b_{total} &= 10 \times 10^3 \times 8 + (48 + 20 + 20 + 14 + 4) \times 8 + 16 \\ &= 80864 \text{ bits} \end{aligned}$$

In other words, to deliver 80000 bits of user data, 80864 bits must actually be transmitted. The extra 864 bits are overhead incurred due to the protocols.

We can say the efficiency, η, at which we use the link for transmitting user data is:

$$\begin{aligned} \eta &= \frac{\text{userdata}}{\text{totaldata}} \\ &= \frac{80000}{80864} \\ &= 0.989315 \end{aligned}$$

The efficiency is 98.9%.

Throughput is the rate at which user data is delivered to the destination. In this case the amount of user data is 80000 bits. The time to deliver is the transmission time for all 80864 bits at 1Mb/s, i.e. 80.864ms. Therefore the throughput is:

$$\frac{80000 \text{ bits}}{80.864 \text{ ms}} = 989315 \text{ b/s}$$

Note that throughput analysis is usually not this simple: often multiple packets in both directions need to be considered. This will be illustrated in the topic on Data Link Control Protocols.