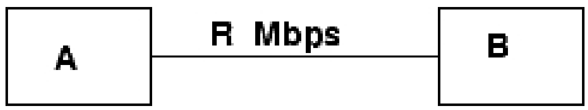
Module 2 – Sample delay calculations



1. This is Problem 8 at the end of Chapter 1 in the book, Page 70.

Consider two hosts A and B, connected by a single link of transmission rate R bps. Suppose that the two hosts are separated by m meters and that the propagation speed along the link is s meters/sec. Host A needs to send a single packet of size L bits to host B.

a)What is the propagation delay, d_{prop} ?

Ans: $d_{\text{prop}} = \frac{m \text{ meters}}{s \text{ meteres / sec}} = \frac{m}{s} \text{ sec}$

b) The transmission time of the packet, d_{trans} is:

Ans: $d_{\text{trans}} = \frac{L \text{ bits}}{R \text{ bits / sec}} = \frac{L}{R} \text{ sec}$

c) Ignoring processing and queuing delays, obtain an expression for end-to-end delay:

Ans: The last bit gets pushed out of A's interface in $\frac{L}{R}$ sec; this bit takes $\frac{m}{s}$ secto reach B. So the total end-to-end delay is : $\frac{L}{R} + \frac{m}{s}$ sec.

d) If A begins transmission at $t = 0$, at $t = d_{\text{trans}}$, where is the last bit of the packet?

Ans: The last bit has already reached host B, assuming $\frac{m}{s}(= d_{\text{trans}})$ is much less than $\frac{L}{R}(= d_{\text{prop}})$.

2. In the netwok above, the transmission delay for a single 54Kbyte packet that A needs to transmit to B is:

Ans: $\frac{L}{R} \times 54 \times 10^3 \times 8 \text{ sec}$

3. Suppose two hosts A and B are separated by 10,000 kilometers and connected by a single direct link with $R = 1 \text{ Mbps}$. Assume the propagation speed is 2.5×10^8 meters / sec.

a) The "Bandwidth-delay product" of a link is defined as $R \times d_{\text{prop}}$. Caculate the bandwidth-delay product for this link:

Ans: $d_{\text{prop}} = \frac{10{,}000 \text{ km} \times 1000 \text{ meters / km}}{2.5 \times 10^8 \text{ meters / sec}} = \frac{1}{25}$ sec; $R = 1 \text{ Mbps}$; So

Bandwidth-delay product=$\frac{1}{25} \text{ sec} \times 10^6 \text{ bits / sec} = 4 \times 10^4 \text{ bits}$

b)What is the maximum number of bits on the link at any given time?

A first bit takes $\frac{1}{25}$ sec to reach B once it leaves A. During this time, how many bits have been injected into the wire by A? $\frac{1}{25} \times 10^6 \frac{\text{bits}}{\text{sec}} = 4 \times 10^4 = 40,000\,\text{bits}$. So the maximum number of bits on the link at any given time is 40,000. Thus Bandwidth-delay product is the *maximum* number of bits on the link at any given time.

4. Consider a router that has a finite buffer it its outbound link. Suppose that the link has $R = 1.5\,\text{Mbps}$ transmission rate and that a packet contains 6400 bits. If 1000 such packet arrive simultaneously at the router, what is the average queuing delay for the 1000 packets?

Ans: The queuing delay for the first packet is 0; the second packet has to wait till the first one is completely transmitted, which takes $\frac{6400}{1.5\times10^6}$ sec. The waiting time for the third packet will be $2 \times \frac{6400}{1.5\times10^6}$ sec, since it gets sent only after the first two are sent. Arguing similarly, the last packet has to wait $999 \times \frac{6400}{1.5\times10^6}$ sec. So the average delay is the average of these delays:

$$\frac{\left(\frac{6400}{1.5\times10^6} + 2\times\frac{6400}{1.5\times10^6} + 3\times\frac{6400}{1.5\times10^6} + \ldots + 999\times\frac{6400}{1.5\times10^6}\right)}{999}\,\text{sec} = \frac{1+2+3+\ldots+999}{999} \times \frac{6400}{1.5\times10^6} = 500 \times \frac{6400}{1.5\times10^6} \simeq 2.13\,\text{sec}\,.$$