Week 2 Calculation Examples

1. Given a link with a maximum transmission rate of 5.2 Mbps. Only two computers, X and Y, wish to transmit starting at time t = 0 seconds. Computer X sends FileX (3 MiB) and computer Y sends FileY (165 KiB), both starting at time t = 0.
   Statistical multiplexing is used, with details as follows

   Packet Payload Size = 1000 Bytes

   Packet Header Size = 24 Bytes (overhead)

   Ignore Processing and Queuing delays.
   Assume partial packets (packets consisting of less than 1000 Bytes of data) are padded so that they are the same size as full packets.
   Assume continuous alternating-packet transmission.
   Computer X gets the transmission medium first.
   At what time (t = ?) would FileX finish transmitting?
   At what time (t = ?) would FileY finish transmitting?
   Give answer in seconds, without units, rounded to two decimal places.

   Solution:

   First, find the number of packets that will need to be sent to transmit FileX.

   Convert the size of the file from MiB to bits.

$$3\ MiB * \left(\frac{1{,}024\ KiB}{1\ MiB}\right) * \left(\frac{1{,}024\ bytes}{1\ KiB}\right) * \left(\frac{8\ bits}{1\ byte}\right) = 25{,}165{,}824\ bits$$

   Convert the packet payload size from bytes to bits.

$$1{,}000\ bytes * \left(\frac{8\ bits}{1\ byte}\right) = 8{,}000\ bits$$

   Divide the size of the file by the number of bits in a packet.

$$\frac{25{,}165{,}824\ bits}{8{,}000\ bits\ per\ packet} = 3{,}145.728\ packets$$

It is assumed in the problem statement that packets consisting of less than 1,000 bytes of data are padded so that they are the same size as full packets, thus the previous value is rounded up.

$$3{,}145.728\ packets = 3{,}146\ packets$$

Use the same steps to find the number of packets that will need to be sent to transmit FileY.

$$165\ KiB * \left(\frac{1{,}024\ bytes}{1\ KiB}\right) * \left(\frac{8\ bits}{1\ byte}\right) = 1{,}351{,}680\ bits$$

$$\frac{1{,}351{,}680\ bits}{8{,}000\ bits\ per\ packet} = 168.96\ packets = 169\ packets$$

Since continuous alternating-packet transmission is assumed with FileX getting the transmission medium first, the pattern for packet transmission can be visualized as follows.

<u>X, Y, X, Y, X, Y, X, **Y**,</u> <u>X, X, X, X, X, X</u>

Notice, since FileY is smaller, that all the packets transmitted by computer Y will be sent before computer X is finished transmitting all the packets for FileX.

Once again, since they're alternating, the total number of packets sent when FileY finishes transmitting can be thought of as twice the total number of packets used for transmitting FileY. Of course, half of those packets were for FileX.

$$\text{Total \# of packets when } \textbf{FileY} \text{ finishes transmitting} =$$

$$169\, packets * 2 = 338\, packets$$

The total number of packets sent when FileX finishes transmitting is the total number of packets used for transmitting FileY and the total number of packets used for transmitting FileX.

$$\text{Total \# of packets when } \textbf{FileX} \text{ finishes transmitting} =$$

$$3{,}146\, packets + 169\, packets = 3{,}315\, packets$$

Now, since a 24-byte packet header is also sent with each packet, the time it takes to send each file must account for this data to be sent as well.

First compute the size, in bits, of each packet header and payload.

$$(1{,}000\, bytes + 24\, bytes) * \left(\frac{8\, bits}{1\, byte}\right) = 8{,}192\, bits$$

Finally, calculate the time for each file to finish transmitting.

For the smaller file, FileY:

$$\left(\frac{8{,}192\, bits * 338\, packets}{5{,}200{,}000\, bits\ per\ second}\right) = \left(\frac{2{,}768{,}896\, bits}{5{,}200{,}000\, bits\ per\ second}\right) = 0.53\, seconds$$

For the larger file, FileX:

$$\left(\frac{8{,}192\, bits * 3{,}315\, packets}{5{,}200{,}000\, bits\ per\ second}\right) = \left(\frac{27{,}156{,}480\, bits}{5{,}200{,}000\, bits\ per\ second}\right) = 5.22\, seconds$$

Note: The maximum transmission rate of the link given in the problem statement was converted from Mbps to bits per second to align the units before performing the above calculations, but this hasn't been written out since it was learned during Week 1.