Network Delays

The Idea

We need to be able to measure the performance of our ability to communicate. We do this by understanding the different delays that occur in network communication.

Delay Type	Description	Formula
Propagation Delay	The time it takes for a signal to travel from point A to point B over a network medium. It is influenced by the type of medium, the distance between the points, and typically the speed of the signal, which is often close to c, the speed of light (3×10^8 m/s) in vacuum.	$t_p = \frac{Distance}{Speed}$
Transmission Delay	The time required to transmit all the bits of a packet into the network medium. Packet size is denoted by L, and the bandwidth (data carrying capacity) is denoted by R.	$t_T = \frac{L}{R}$
Queuing Delay	The time a packet spends waiting in a queue before it can be transmitted over the network due to congestion or prior packet processing. If there is no space in the queue (i.e. not enough buffer in the router), that packet is dropped!	Depends on queue length and network traffic
Processing Delay	The time taken by a network device (e.g., router, switch) to process a packet.	Depends on device and packet complexity

Data Size vs Transfer Speed

It's also very important to note the difference between Data Size vs Transfer Speed when computing delays.

- When we talk about a file size, we are talking in terms of a binary scale. E.g. 10GB is $10 \times 1024 \times 1024 \times 1024\, Bytes$
- When we talk about transfer speed, we are using SI units. E.g. 10GB/s is $10 \times 1000 \times 1000 \times 1000\, Bytes/s$
- To convert $Bytes$ into $Bits$, we multiply by 8

Exercise 1

Which mode of data transfer has the higher propagation delay? (Assuming they are transferred over the same distance)

1. Pigeon
2. Network

Answer: The pigeon does, clearly. Network speeds reach up to the speed of light. Pigeons fly at about $80\frac{m}{h}$

Exercise 2

Which mode of data transfer has the higher transmission delay?

1. Pigeon
2. Network

Answer: The network does. Pigeons are capable of carrying much more information at once than a network is capable of. (At least mostly) They could carry some physical disk with hundreds of GB in a single communication. We should also consider how fast we can copy data onto the USB, which is often much quicker than it is to load it into a network.

Exercise 3

The NBN has potential speeds of 100 $\frac{Mb}{s}$ download and 40 $\frac{Mb}{s}$ upload. Is it faster to send a $4GB$ file on a USB using a pigeon?

Answer: Yes. The calculations in the table below clearly show that the network transmission speed is considerably slower.

Mode of Communication	Method	Calculation: $t_T = \frac{L}{R}$	Total Time
Pigeon	Copying data to the USB Drive, then attaching that USB Drive to the pigeons legs. Let's say the USB Drive has a write speed of 100 MB/s.	$= \frac{4 \times 1024 \times 1024 \times 1024\ Bytes}{100 \times 10^6\ Bytes/s}$	43 Seconds

Mode of Communication	Method	Calculation: $t_T = \frac{L}{R}$	Total Time
Network	Transmitting all the packets inside a bit to the network medium. i.e. Transmitting at 4GB at 40 $mbps$	$= \frac{4 \times 1024 \times 1024 \times 1024 \times 8\ bits}{40 \times 10^6\ bits/s}$	859 seconds

Ok, but what if we consider the propagation delay for the pigeon and the network? Assume its 0 for the network because c is so fast. A pigeon travels at 150 km/h.

Mode of Communication	Method	Calculation: $t_T = \frac{L}{R}$	Propagation Calculation	Total Time
Pigeon	Copying data to the USB Drive, then attaching that USB Drive to the pigeons legs. Let's say the USB Drive has a write speed of 100 MB/s. A pigeon travels at 150 km/h.	$= \frac{4 \times 1024 \times 1024 \times 1024\ Bytes}{100 \times 10^6\ Bytes/s}$	$= \frac{300\,km}{150\,km/h} = 7200\,seconds$	7243 Seconds
Network	Transmitting all the packets inside a bit to the network medium. i.e. Transmitting at 4GB at 40 $mbps$	$= \frac{4 \times 1024 \times 1024 \times 1024 \times 8\ bits}{40 \times 10^6\ bits/s}$	0 (Assumed negligible due to speed of light)	859 seconds

Exercise 4

You want to send 10GB of videos to a friend. You have a choice of burning to DVD and sending by express post, which will take 1 day (24 hours) for them to arrive or you can them by Internet on which you get an average upload data rate of 2MB/sec. Show which method will be faster. You must show your work, no marks for just guessing an answer.

Assumptions: DVD write speed is 7200KB/s

Answer: As seen in the image below, its considerably faster to send via the internet, than it is by mail.

Files = 10 GB Bandwidth = 2 mb/s

mail$_p$ = 24 hours = 1440 minutes

$$mail_t = \frac{\text{size}}{\text{write speed}}$$

$$= \frac{10\ GB}{7200\ kb/s} \rightarrow \text{Binary scale}$$

$$= \frac{10 \times 1024 \times 1024\ kb}{7200\ kb/s}$$

$$= 24 \text{ minutes}$$

$$mail_{Total} = mail_t + mail_p = 24 + 1440$$

$$= 1464 \text{ minutes}$$

net_p = 0 (speed of light)

$$net_t = \frac{10\ GB}{2\ Mb/s} \rightarrow \text{megabits}$$

$$= \frac{10 \times 1024 \times 8\ Mb}{2\ Mb/s}$$

$$= 40960 \text{ seconds}$$

$$= 683 \text{ minutes}$$

$net_{total} = net_t + net_p$