Performance Of Network

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Performance of the network _____ how good is it?

Performance metrics

- Bandwidth
- Throughput
- Latency
- Bandwidth - Delay product

Bandwidth in two contexts

Bandwidth in hertz: refers to the range of frequencies in a composite signal or the range of frequencies that a channel can pass.

Bandwidth in bits per second: refers to the speed of bit transmission in a channel or link.

Throughput

It is a measure of how fast data can be sent through a network.

an insight

- both bandwidth and throughput are in bits per second
- the bandwidth is a potential measurement of a link; the throughput is an actual measurement of how fast data can be sent
- a link may have a bandwidth of B bps, but only T bps can be sent through this link with $T \leq B$

Throughput: A visualization

- A link may have a bandwidth of 1Mbps, but the device connected to the end of the link may handle only 200 Kbps. This means that more than 200 Kbps can not be sent through this link. So, **throughput** of the network is 200 Kbps.

- Imagine a highway designed to transmit 1000 cars per minute from one point to another. However, if there is congestion on the road, this figure may reduced to 100 cars per minute. So, the **bandwidth** is 1000 cars per minute; the **throughput** is 100 cars per minute.

Example

- A network with bandwidth of 10 Mbps can pass only an average of 12,000 frames per minute with each frame carrying an average of 10,000 bits. What is the throughput of this network?

$$\text{Throughput} = \frac{12{,}000 \times 10{,}000}{60} = 2\text{Mbps}$$

- Consider a point-to-point link $12,000$ km in length and signal propagates at 2.4×10^8 m/s through the link. Calculate the throughput of the network if a message 5 KB is transmitted form one to another. Assume the bandwidth of the link is 1 Kbps.

$$\text{Propagation time}(T_p) = \frac{12{,}000 \times 1000}{2.4 \times 10^8} = 0.05\text{s}$$
$$\text{Transmission time}(T_f) = \frac{5 \times 2^{10} \times 8}{10^3} = 40.96\text{s}$$
$$\text{So, Throughput} = \frac{\text{size of message}}{\text{Total time}} = \frac{5 \times 2^{10} \times 8}{T_f + T_p} \text{ bps}$$

Latency (Delay)

The latency or delay defines how long it takes for an entire message (data) to completely arrive at the destination from the first bit sent out from the source.

Latency = Propagation time (delay) + Transmission time (delay) + Queuing time (delay) + Processing time (delay)

for simplicity we are not considering queuing time (delay) and processing time (delay)

Delay Measure

$$\text{Transmission time}(T_f) = \frac{\text{Message Size}}{\text{Bandwidth}}$$

$$\text{Propagation time}(T_p) = \frac{\text{Distance}}{\text{Propagation speed}}$$

T_f and T_p Examples

- What is the propagation time if the distance between the two points is $12,000$ km? Assume the propagation speed to be 2.4×10^8 m/s in cable.

$$T_p = \frac{12,000 \times 1000}{2.4 \times 10^8} = 50\text{ms}$$

- What are the propagation time and the transmission time for a 2.5-Bbyte message (an e-mail) if the bandwidth of the network is 1 Gbps? Assume that the distance between the sender and the receiver is $12,000$ km and that light travels at 2.4×10^8 m/s.

$$T_p = \frac{12,000 \times 1000}{2.4 \times 10^8} = 50\text{ms}$$

$$T_f = \frac{2500 \times 8}{10^9} = 0.020\text{ms}$$

Queuing time

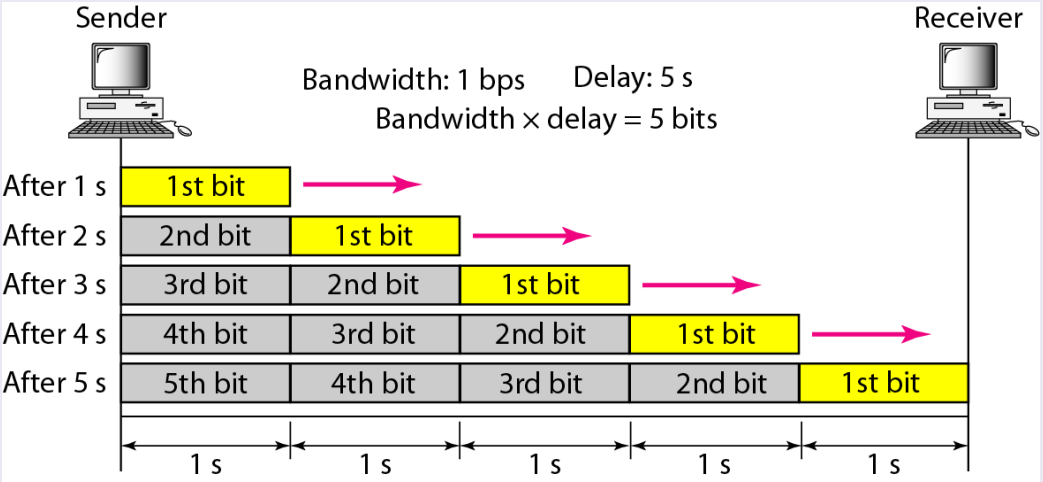
The time needed for each intermediate or end device to hold the message before it can be processed.

Note: The queuing time is not a fixed factor; it changes with the load imposed on the network. When there is heavy traffic on the network, the queuing time increases. An intermidiate device, such as a router, queues the arrived messages and process them one by one. If there are many messages, each message will have to wait.

Bandwidth-Delay Product

Bandwidth and delay are two performance metrices of a link

Filling the link with bits

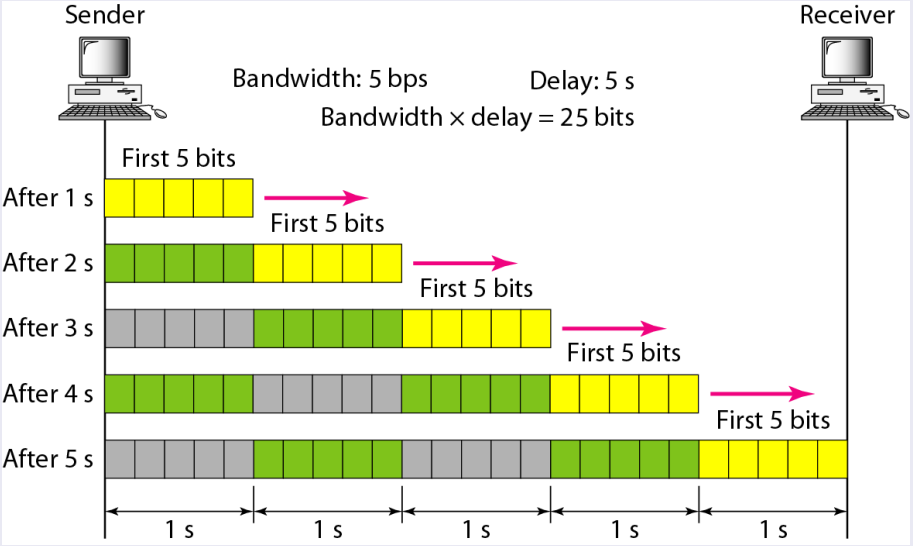


We can say that this product 1×5 is the maximum number of bits that can fill the link. There can be no more than 5 bits at any time on the link.

Bandwidth-Delay Product Contd...

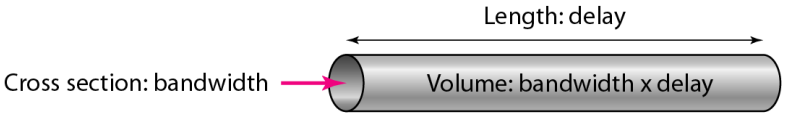
Assume bandwidth of 5 bps and propagation delay 5 sec

Filling the link with bits



We can say that this product 5×5 is the maximum number of bits that can fill the link. There can be no more than 25 bits at any time on the link.

Concept of bandwidth-delay product



The bandwidth-delay product defines the number of bits that can fill the link