Computer Network

Lecture-11

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Bandwidth

One characteristic that measures network performance is bandwidth. However, the term can be used in two different contexts with two different measuring values: bandwidth in hertz and bandwidth in bits per second.

Bandwidth in Hertz

Bandwidth in hertz is the range of frequencies contained in a composite signal or the range of frequencies a channel can pass. For example, we can say the bandwidth of a subscriber telephone line is 4 kHz.

Bandwidth in Bits per Seconds

The term bandwidth can also refer to the number of bits per second that a channel, a link, or even a network can transmit. For example, one can say the bandwidth of a Fast Ethernet network (or the links in this network) is a maximum of 100 Mbps. This means that this network can send 100 Mbps.

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Throughput

- The throughput is a measure of how fast we can actually send data through a network.
- For example, we may have a link with a bandwidth of 1 Mbps, but the devices connected to the end of the link may handle only 200 kbps. This means that we cannot send more than 200 kbps through this link.
- 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 be reduced to 100 cars per minute. The bandwidth is 1000 cars per minute; the throughput is 100 cars per minute.

Note: The bandwidth is a potential measurement of a link; the throughput is an actual measurement of how fast we can send data.

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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?

Solution:

We can calculate the throughput as

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

The throughput is almost one-fifth of the bandwidth in this case.

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Latency (Delay)

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

Latency is made of four components: propagation time, transmission time, queuing time and processing time.

$$\text{Latency} = \text{propagation time} + \text{transmission time} + \text{queuing time} + \text{processing time}$$

Propagation Time

Propagation time measures the time required for a bit to travel from the source to the destination.

$$\text{Propagation time} = \frac{\text{Distance}}{\text{Propagation speed}}$$

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Example:

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

Solution:

We can calculate the propagation time as

$$\text{Propagation time} = \frac{12000 \text{ x } 1000}{2.4 \text{ x } 108} = 50 \text{ ms}$$

Transmission time

The time required for transmission of a message depends on the size of the message and the bandwidth of the channel.

$$\text{Transmission time} = \frac{\text{Message size}}{\text{Bandwidth}}$$

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Example:

What are the propagation time and the transmission time for a 2.5-kbyte 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.

Solution:

We can calculate the propagation and transmission time as

$$\text{Propagation time} = \frac{12000 \times 1000}{2.4 \times 108} = 50 \text{ ms}$$

$$\text{Transmission time} = \frac{2.5 \times 1000 \times 8}{10^9} = 0.020 \text{ ms}$$

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Queuing Time

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

- 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 intermediate device, such as a router, queues the arrived messages and processes them one by one. If there are many messages, each message will have to wait.

Processing time

It is the time taken by intermediate or end devices to process the arrived message.

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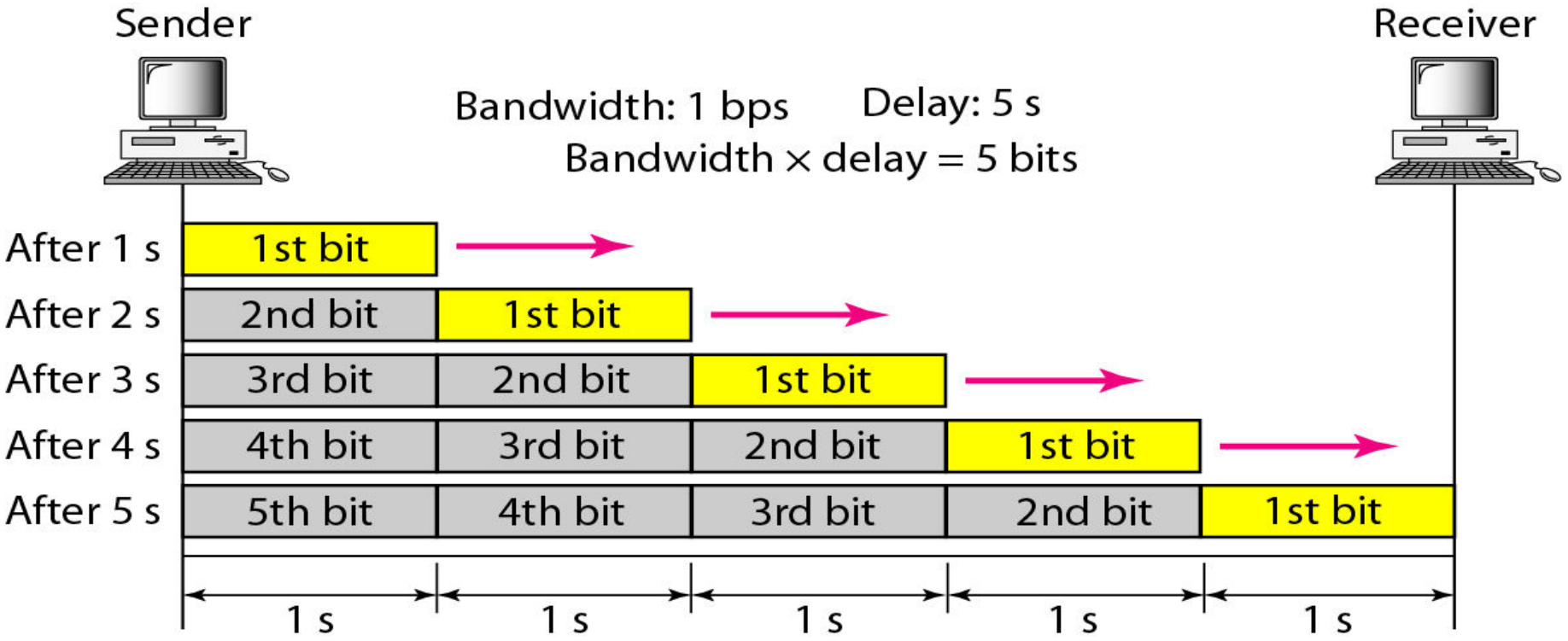
Bandwidth-delay product

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

Bandwidth-delay product = Bandwidth * Delay



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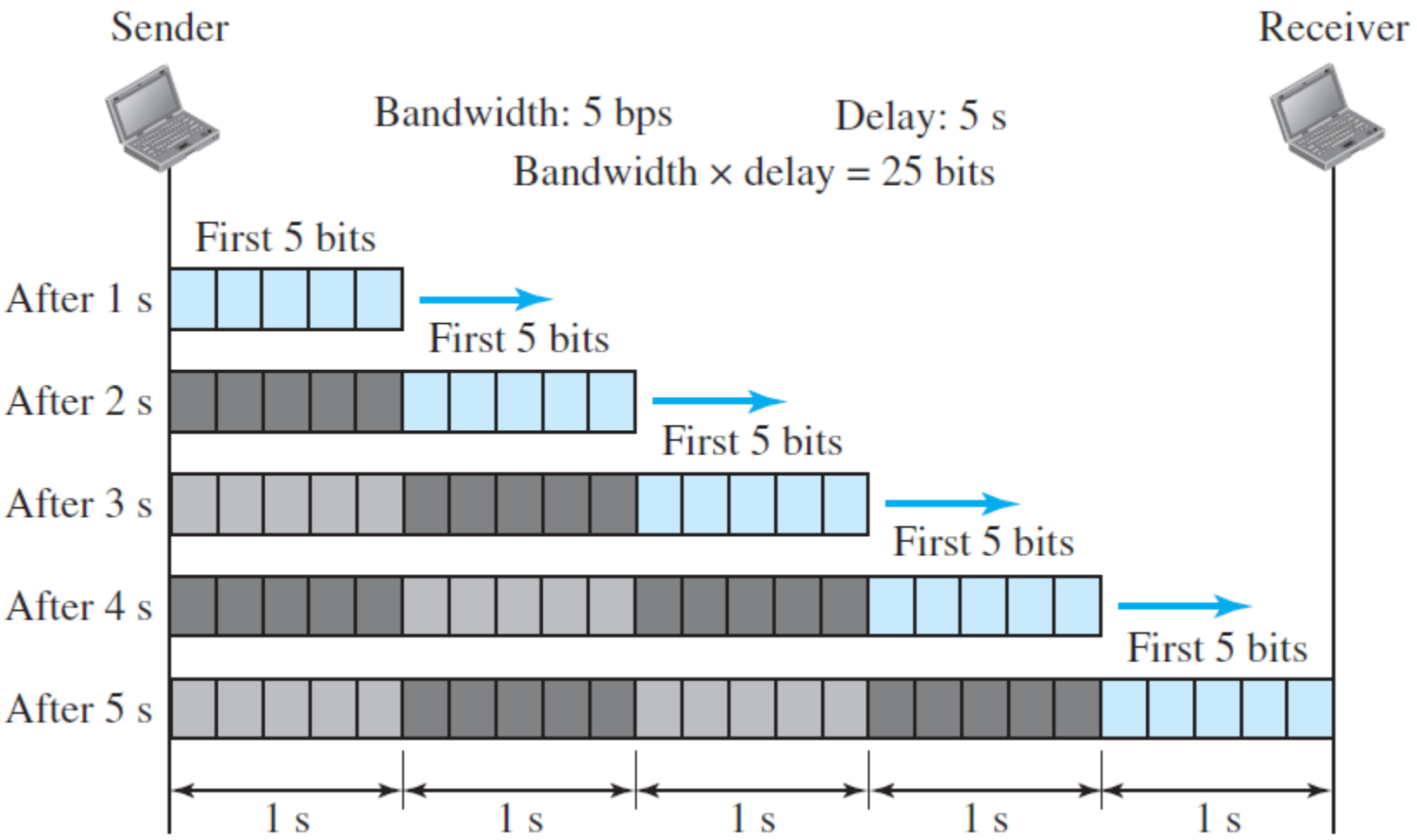
Bandwidth-delay product



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Question: A device is sending out data at the rate of 1000 bps.

a. How long does it take to send out 10 bits?

b. How long does it take to send out a single character (8 bits)?

c. How long does it take to send a file of 100,000 characters?

Question: A file contains 2 million bytes. How long does it take to download this file using a 56-Kbps channel? 1-Mbps channel?

Question: How many bits can fit on a link with a 2 ms delay if the bandwidth of the link is

a. 1 Mbps?

h. 10 Mbps?

c. 100 Mbps?

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Question: We are sending a 30 Mbits MP3 file from a source host to a destination host. All links in the path between source and destination have a transmission rate of 10 Mbps. Assume that the propagation speed is $2*10^8$ meters/sec, and the distance of the each link is 10,000 km, the processing time of the router is 0.01 sec.

a) Suppose there is only one link between source and destination. Find the latency?

b) Suppose there is three links between source and destination. The router is found between each two links Find the latency?

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Question: What is the total delay (latency) for a frame of size 5 million bits that is being sent on a link with 10 routers each having a queuing time of 2 μs and a processing time of 1 μs. The length of the link is 2000 Km. The speed of light inside the link is 2×10^8 m/s. The link has a bandwidth of 5 Mbps. Which component of the total delay is dominant? Which one is negligible?