

# CSE-3215

## Data Communication

### Lecture-16

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*Note*

**The Shannon capacity gives us the upper limit; the Nyquist formula tells us how many signal levels we need.**

# PERFORMANCE

One important issue in networking is the **performance** of the network—how good is it? We discuss quality of service, an overall measurement of network performance, in greater detail in Chapter 24. In this section, we introduce terms that we need in future.

## Topics discussed in this section:

Bandwidth

Throughput (System output per unit time)

Latency (Delay)

Bandwidth-Delay Product

# Bandwidth vs Throughput vs Latency

- Bandwidth is the **maximum amount of data** that can travel through a 'channel'.
  - Throughput is **how much data** actually does travel through the 'channel' successfully.
  - Latency is a function of **how long** it takes the data to get sent all the way from the start point to the end
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## *Note*

*In networking, we use the term bandwidth in two contexts.*

- ❑ The first, bandwidth in hertz, refers to the range of frequencies in a composite signal or the range of frequencies that a channel can pass.
- ❑ The second, bandwidth in bits per second, refers to the speed of bit transmission in a channel or link.

### Example #1

The bandwidth of a subscriber line is 4 kHz for voice or data. The bandwidth of this line for data transmission can be up to 56,000 bps using a sophisticated modem to change the digital signal to analog.

### Example #2

If the telephone company improves the quality of the line and increases the bandwidth to 8 kHz, we can send 112,000 bps by using the same technology as mentioned in Example 1.

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

### Solution

We can calculate the propagation time as

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



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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  $2.4 \times 10^8$  m/s.

### Solution

We can calculate the propagation and transmission time as shown on the next slide:

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

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

Note that in this case, because the message is short and the bandwidth is high, the dominant factor is the propagation time, not the transmission time. The transmission time can be ignored.

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What are the propagation time and the transmission time for a 5-Mbyte message (an image) if the bandwidth of the network is 1 Mbps? Assume that the distance between the sender and the receiver is 12,000 km and that light travels at  $2.4 \times 10^8$  m/s.

### Solution

We can calculate the propagation and transmission times as shown on the next slide.

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

$$\text{Transmission time} = \frac{5,000,000 \times 8}{10^6} = 40 \text{ s}$$

Note that in this case, because the message is very long and the bandwidth is not very high, the dominant factor is the transmission time, not the propagation time. The propagation time can be ignored.



Low Bandwidth



High Bandwidth

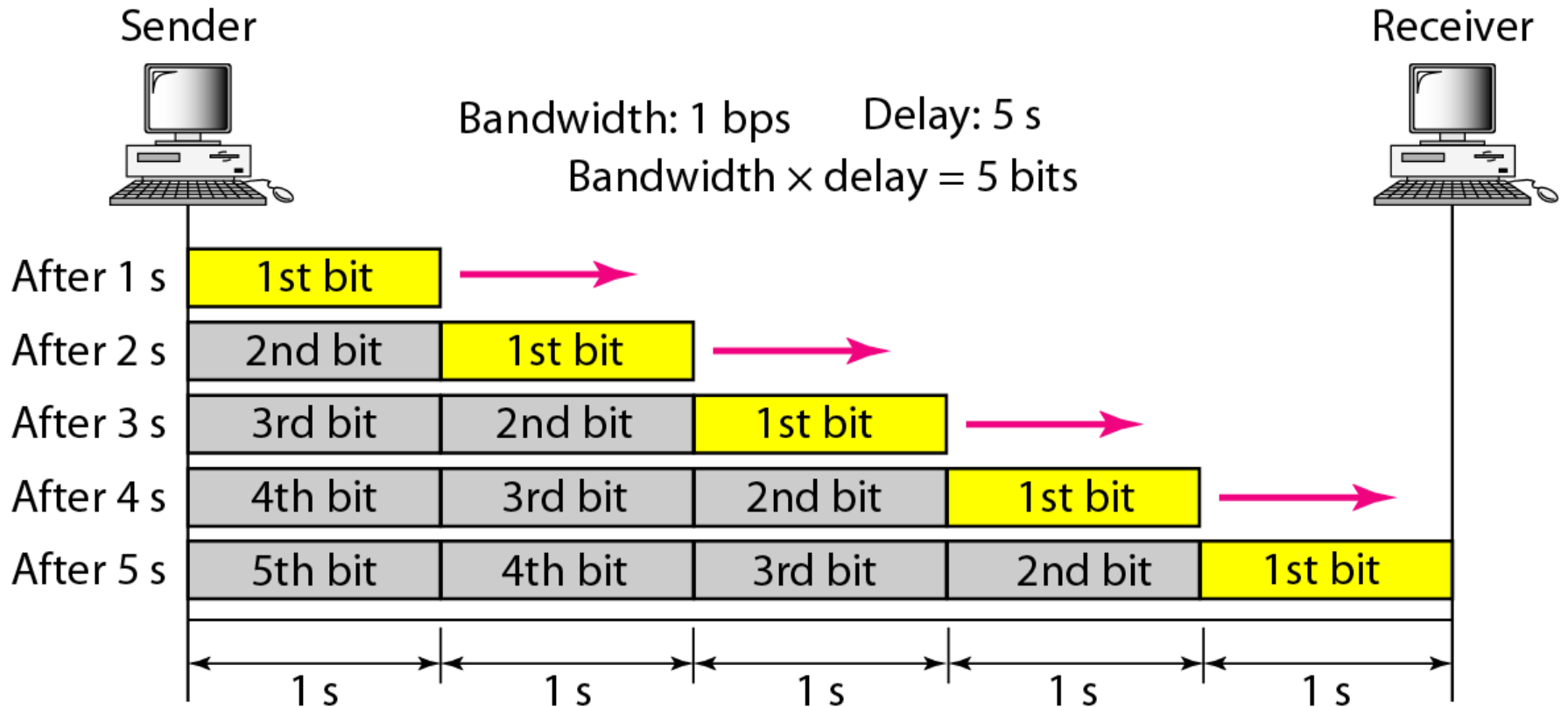


Low Latency



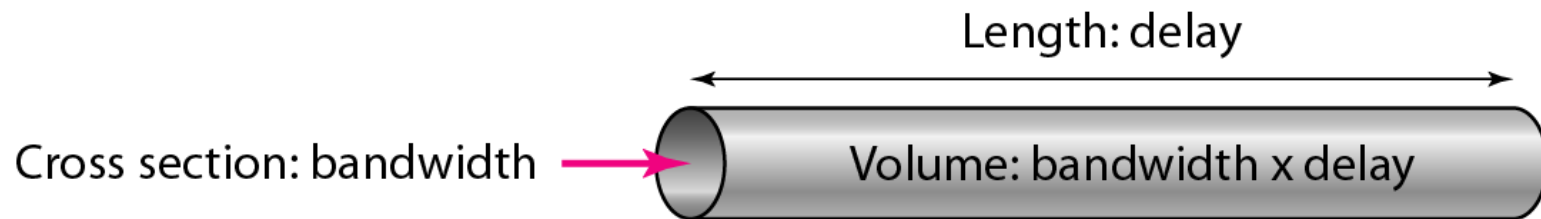
High Latency

**Figure 1:** *Simple Illustration of Bandwidth and Latency  
(Just for understanding)*



**Figure 2:** *Filling the link with bits*

We can think about the link between two points as a pipe. The cross section of the pipe represents the bandwidth, and the length of the pipe represents the delay. We can say the volume of the pipe defines the bandwidth-delay product, as shown in Figure 3.



**Figure 3:** *Concept of bandwidth-delay product*

*That's all for today*

**Thank You**