Network Performance

One important issue in networking is the performance of the network – how good is it?

Network performance is measured in following fundamental ways

- ★ Bandwidth
- ★ Throughput
- ★ Latency (Delay)

Bandwidth

Informal: Maximum amount of data that can be transmitted per second.

Formal: The bandwidth of a network is given by the number of bits that can be transmitted over the network in a certain period of time.

Bandwidth in bps

Bandwidth = Capability.

Example: Gigabit Ethernet can provide a bandwidth of 1 Gbps.

Bandwidth in Hertz

A range of frequencies used to transmit signals which is measured in hertz.

Throughput

Informal: Actual amount of data that passes through the medium.

Formal: The throughput is a measure of how fast we can actually send data through a network.

Although bandwidth in bits per second and throughput seem the same,

they are different.

A link may have a bandwidth of 'B' bps, but we can only send 'T' bps through this link with T<B always.

Throughput

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.

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.

Components of latency (delay)

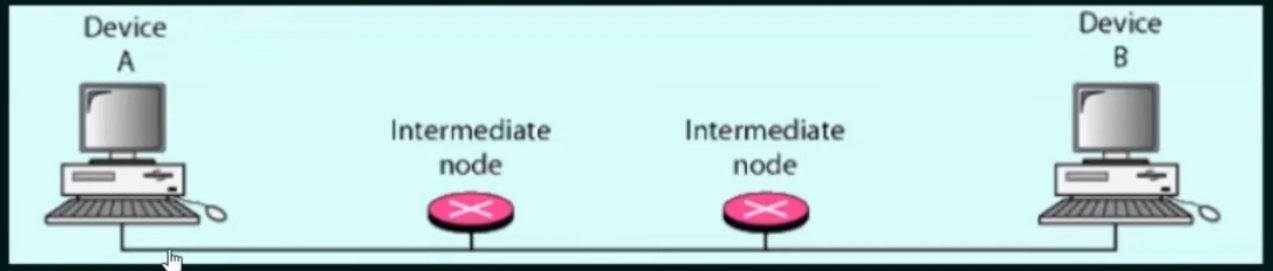
Latency is made of four components:

1. Transmission delay.
2. Propagation delay.
3. Queueing delay.
4. Processing delay.

Latency = Transmission delay + Propagation delay + Queuing delay + Processing delay.

Transmission delay

Time it takes to place the complete data packet on the transmission medium.



Transmission delay

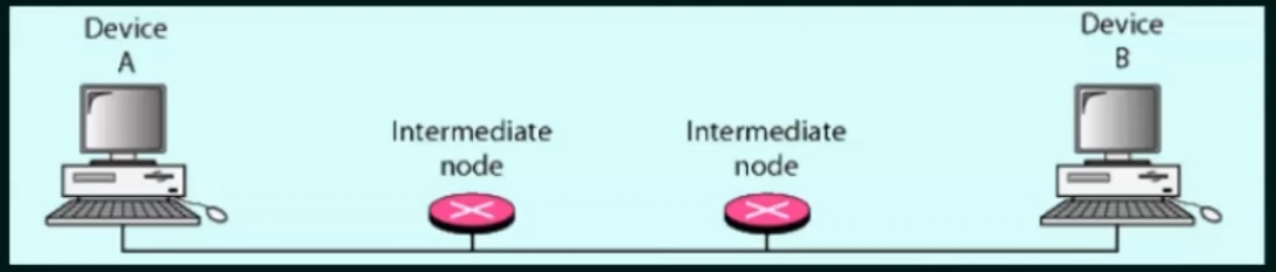
Time it takes to place the complete data packet on the transmission medium.

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

Propagation delay

Time it takes for a bit to go from device A to device B.

The propagation time is calculated by dividing the distance by the propagation speed.



Propagation delay

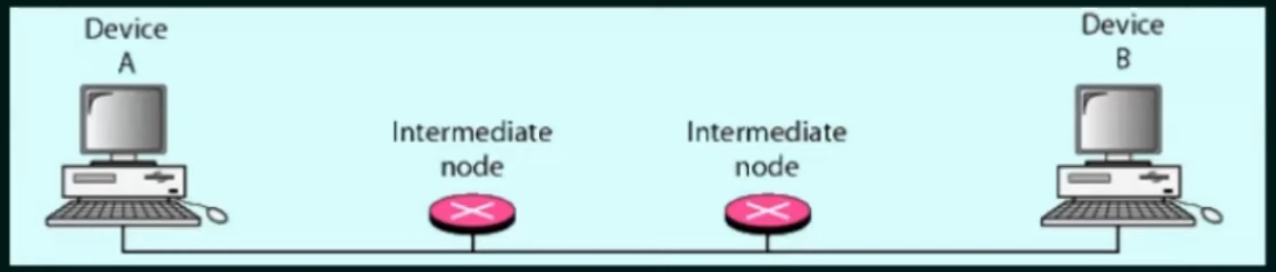
Time it takes for a bit to go from device A to device B.

The propagation time is calculated by dividing the distance by the propagation speed.

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

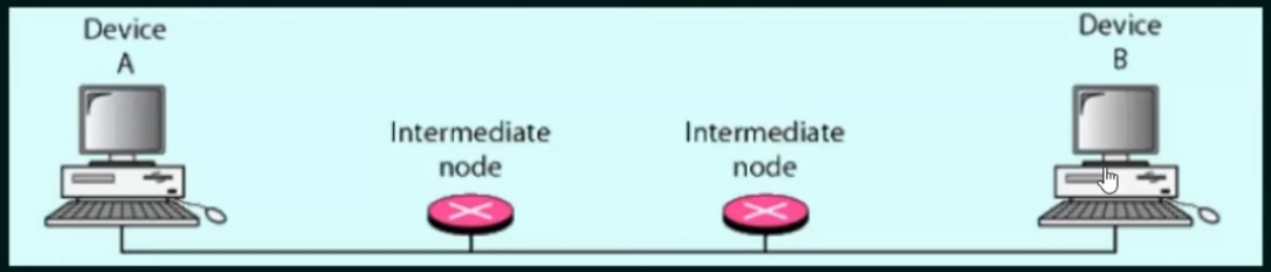
Queuing delay

- ★ The third component in latency is the queuing time, 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.



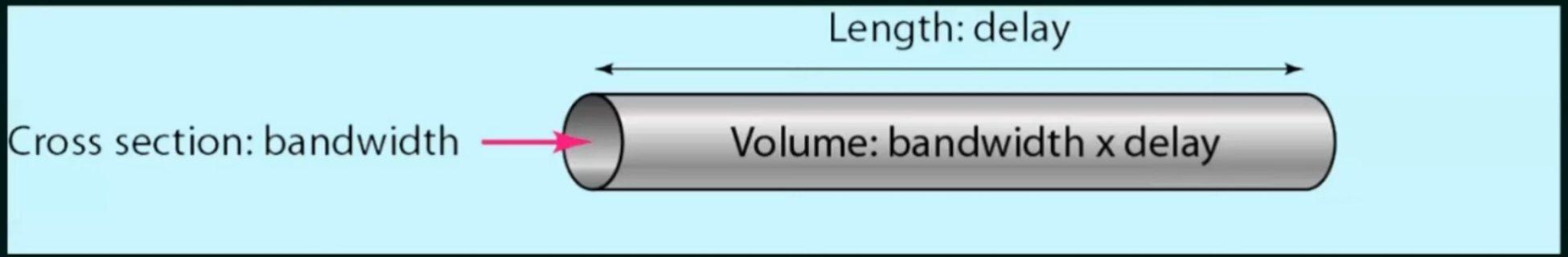
Processing Delay

★ How much time the node takes to process the message?

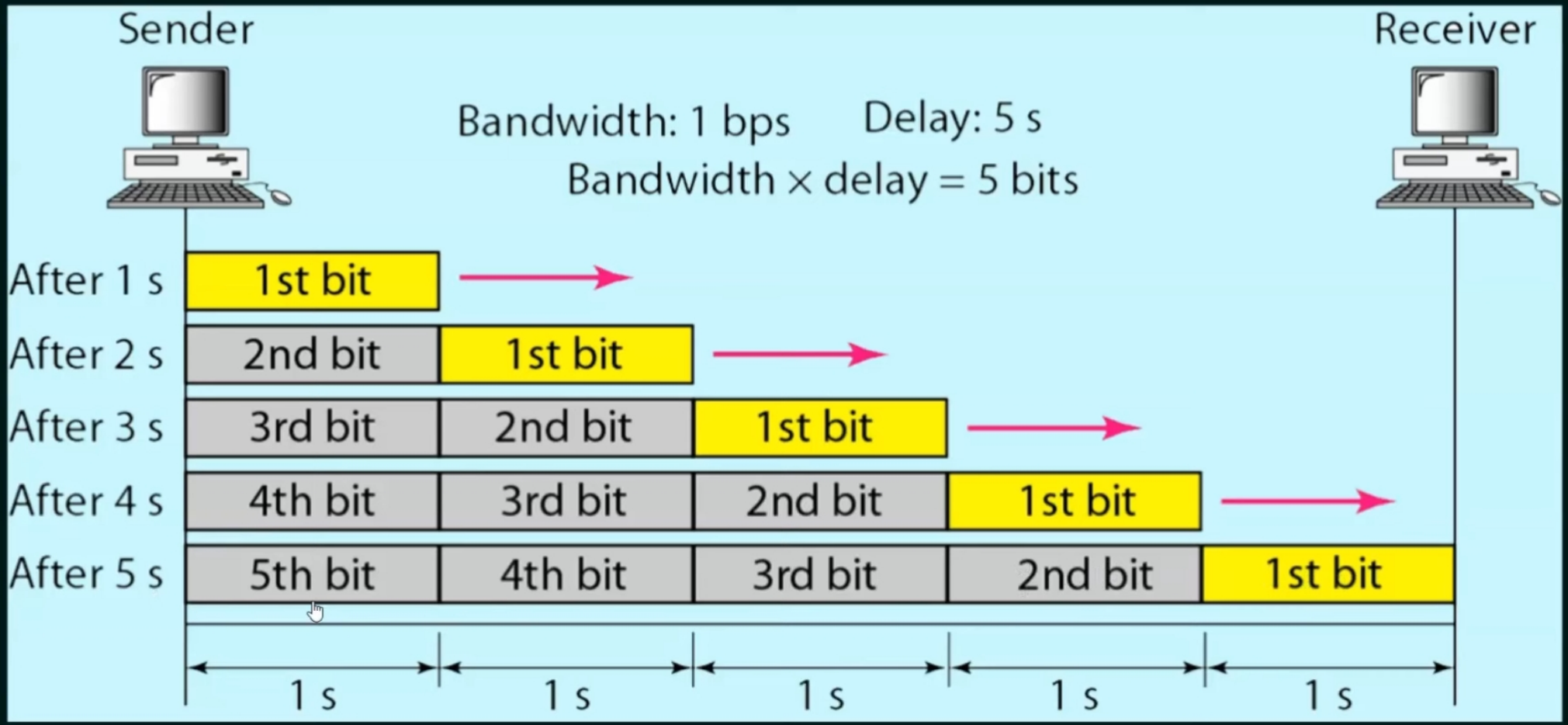


Bandwidth-Delay product

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



Bandwidth-Delay product – Example



Bandwidth-Delay product – Solved Example

Consider that the link capacity of a channel is 512 Kbps and round – trip delay time is 1000ms.

Solution:

The bandwidth delay product $= 512 \text{ Kbps} \times 1000 \text{ ms}$

$= 512 \times 1000 \text{ bits/sec} \times 1000 \times 10^{-3} \text{ sec}$

$= 512{,}000 \text{ bits}$

$= 64{,}000 \text{ bytes}$

$= 62.5 \text{ KB}$

QUESTION

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.

Given

Distance = 12000 Km

Propagation speed = 2.4×10^8 m/s

To Find

Propagation Time

Solution

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

$$\text{Propagation Time} = \frac{12000 \times 1000}{2.4 \times 10^8} \text{ sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \text{ sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{10^{-3}}{10^{-3}} \text{ sec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{1}{10^{-3}} \text{ millisec}$$

$$\text{Propagation Time} = \frac{5000 \times 1000}{10^8} \times \frac{10^3}{1} \text{ millisec}$$

$$\text{Propagation Time} = \frac{50 \times 100 \times 1000}{10^8} \times \frac{10^3}{1} \text{ millisec}$$

Propagation Time = 50 millisec OR 50 ms

Question 4

The data rate of 10Base5 is 10 Mbps. How long does it take to create the smallest frame? Show the calculation.

ANSWER:

The smallest frame is 64 bytes or 512 bits. With a data rate of 10 Mbps, we have

$$\text{Transmission Delay} = \frac{\text{Message Size}}{\text{Bandwidth}}$$

$$\text{Transmission Delay} = \frac{512 \text{ bits}}{10 \text{ Mbps}}$$

$$\text{Transmission Delay} = \frac{512 \text{ bits}}{10 \times 1000 \times 1000 \text{ bps}}$$

$$\text{Transmission Delay} = 51.2 \ \mu s$$

QUESTION

Determine the maximum length of the cable (in km) for transmitting data at a rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits. Assume the signal speed in the cable to be 2,00,000 km/s.

[GATE CS 2013]

(A) 1

(B) 2

(C) 2.5

(D) 5

Solution

Given Data:

Rate of transmission = 500 Mbps

Size = 10^4 bits

Signal speed = 2×10^5 km/sec

Solution:

Transmission time $\geq$ round trip time of 1 bit

Transmission time $\geq 2 \times$ propagation time

Solution

Transmission time $\geq$ 2 x propagation time

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

$$\text{Propagation time} = \frac{\text{Length}}{\text{Propagation Speed}}$$

$$\frac{\text{Message Size}}{\text{Bandwidth}} = \frac{2 \times \text{Length}}{\text{Propagation Speed}}$$

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{2 \times \text{Length}}{2 \times 10^5 \text{ Km/sec}}$$

Solution

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{2 \times L}{2 \times 10^5 \text{ Km/sec}}$$

$$\frac{10^4 \text{ bits}}{500 \text{ Mbps}} \geq \frac{L}{10^5 \text{ Km/sec}}$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \text{ Mbps}} \geq L$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \text{ Mbps}} \geq L$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \times 10^6 \text{ bps}} \geq L$$

$$\frac{10^4 \text{ bits} \times 10^5 \text{ Km/sec}}{500 \times 10^6 \text{ bps}} \geq L$$

$$\frac{10^4 \text{ Km/sec}}{500 \times 10} \geq L$$

$$2 \text{ Km} \geq L$$

Question

A network with CSMA/CD protocol in the MAC layer is running at 1 Gbps over a 1 km cable with no repeaters. The signal speed in the cable is 2×10^8 m/sec. The minimum frame size for this network should be

[GATE CS 2005]

(A) 10000 bits ✓

(B) 10000 bytes

(C) 5000 bits

(D) 5000 bytes

Solution

Given Data:

Rate of transmission = 1 Gbps

Length = 1 Km

Signal speed = 2×10^8 m/sec

Solution:

Transmission time $\geq$ round trip time of 1 bit

Transmission time $\geq 2 \times$ propagation time

Solution

$$\text{Transmission time} \geq 2 \times \text{propagation time}$$

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

$$\text{Propagation time} = \frac{\text{Length}}{\text{Propagation Speed}}$$

$$\frac{\text{Message Size}}{\text{Bandwidth}} \geq \frac{2 \times \text{Length}}{\text{Propagation Speed}}$$

$$\frac{\text{Message Size}}{1\,\text{Gbps}} \geq \frac{2 \times 1\,\text{Km}}{2 \times 10^8\ \text{m/sec}}$$

Solution

$$\text{Message Size} \geq \frac{2 \times 1\,\text{Km} \times 10^9\,\text{bps}}{2 \times 10^8\,\text{m/sec}}$$

$$\text{Message Size} \geq \frac{2 \times 1 \times 10^3\,\text{m} \times 10^9\,\text{bps}}{2 \times 10^8\,\text{m/sec}}$$

$$\text{Message Size} \geq \frac{2 \times 1 \times 10^3 \times 10^9\,\text{bits}}{2 \times 10^8}$$

$$\text{Message Size} \geq 10^4\,\text{bits}$$

$$\text{Message Size} \geq 10000\ \text{bits}$$