# Problem solving

# Circuit and Packet Switching

3. A path in a digital circuit-switched network has a data rate of I Mbps. The exchange of 1.000 bits is required for the setup and teardown phases. The distance between two parties is 3.000 km. Answer the following questions if the propagataion speed is $2x10^8$ m/s:

   a. What is the total delay if 1.000 bits of data are exchanged during the data transfer phase?

   b. What is the total delay if 100.000 bits of data are exchanged during the data transfer phase?

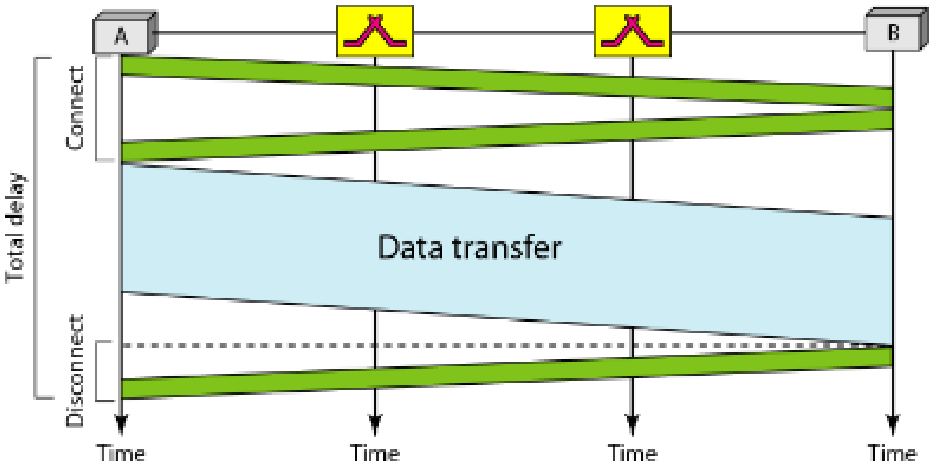
   c. What is the total delay if 1.000.000 bits of data are exchanged during the data transfer phase?

   d. Find the delay per 1.000 bits of data for each of the above cases and compare them. What can you infer?

# Solution

## Circuit and Packet Switching

- Total delay (t) = delay of setup and tear down (d1) + delay of data transfer (d2)




- Delay of setup and tear down (d1) = ( 3 * propagation delay) + (3 * transmission delay)
- Delay of data transfer = propagation delay + transmission delay

# Circuit and Packet Switching

3. Delay of Setup and tear down (d1)

   = (3*propagation delay) + (3*transmission delay)

   = 3 (3.000 km / (2*$10^8$ m/s)) + 3 ((1.000 bits / 1 Mbps))

   = (3X15) ms + (3X1) ms

   = 48 ms

   Lets assume the data transmission is in one direction:

   a. Total delay (t) = d1 + d2

      = 48 ms + propagation delay + transmission delay

      = 48 ms + 15 ms + 1 ms = 64 ms

   b. Total delay (t) = d1 + d2

      = 48 ms + propagation delay + transmission delay

      = 48 ms + 15 ms + 100 ms = 163 ms

   c. Total delay (t) = d1 + d2

      = 48 ms + propagation delay + transmission delay

      = 48 ms + 15 ms + 1000 ms = 1.053 ms

   d. For a, we have 64 ms, for b, we have, = 163 ms, for c, we have, = 1.053 ms. The ratio for the case of 3 is the smallest because of using one setup and tear down phase for sending more data

# Circuit and Packet Switching

4. Five equal-size datagrams belonging to the same message leave for the destination one after another. However, they travel through different paths as shown in the following table

| Datagram | Path Length | Visited Switches |
|---|---|---|
| 1 | 3200 Km | 1,3,5 |
| 2 | 11,700 Km | 1,2,5 |
| 3 | 12,200 Km | 1,2,3,5 |
| 4 | 10,200 Km | 1,4,5 |
| 5 | 10,700 Km | 1,4,3,5 |

| Switch | Delay (ms) |
|---|---|
| 1 | 3 |
| 2 | 10 |
| 3 | 20 |
| 4 | 7 |
| 5 | 20 |

We assume that the delay for each switch (including waiting and processing) is 3, 10, 20, 7, and 20 ms respectively. Assuming that the propagation speed is $2 \times 10^8$ m/s, find the order the datagrams arrive at the destination and the delay for each. Ignore any other delays in transmission.

# Solution

## Circuit and Packet Switching

Assuming a negligible transmission time (i.e. all datagrams start at time 0). The arrival times are calculated as:

First: (3.200 km / 2 x $10^8$ m/s) + 3 + 20 + 20 = 59 ms

Second: (11.700 km / 2 x $10^8$ m/s) + 3 + 10 + 20 = 91,5 ms

Third: (12.200 km / 2 x $10^8$ m/s) + 3 + 10 + 20 + 20 = 114 ms

Fourth: (10.200 km / 2 x $10^8$ m/s) + 3 + 7 + 20 = 81 ms

Fifth: (10.700 km / 2 x $10^8$ m/s) + 3 + 7 + 20 + 20 = 103,5 ms

The order of arrival is 3 -> 5 -> 2 -> 4 -> 1

| Switch | Delay (ms) |
|---|---|
| 1 | 3 |
| 2 | 10 |
| 3 | 20 |
| 4 | 7 |
| 5 | 20 |

# Q.No.3

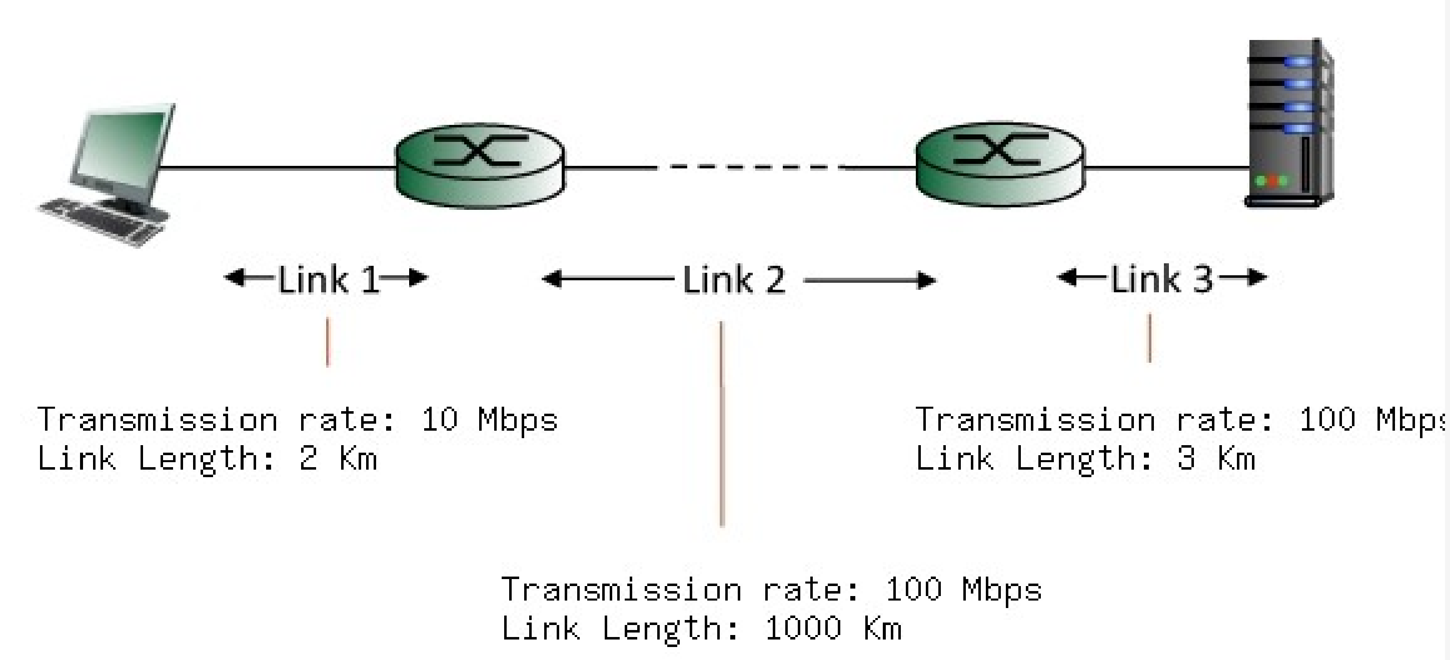
**Suppose a 128 kbps p2p link is set up between earth and a rover on mars. The distance from the earth to mars (when they are the closest together) is approximately 55Gm, and data travels over the link at the speed of light $3X10^8$ m/s**

**a) Calculate the minimum RTT for the link**
**b) Calculate the delay X bandwidth product of the link**
**c) A camera on the rover takes pictures of its surroundings and sends these to the earth. How quickly can it reach Mission Control on Earth? Assume that each image is 5Mb in size**

Solution:
a) Propagation Delay of the link is $55X10^9$ / $(3X10^8)$ = 184 secs, Thus RTT = 368 secs
b) The delay X bandwidth product for the link is the RTT X bandwidth = 23.5Mb
c) After a picture is taken, it must be transmitted on the link and completely propagated, before Mission Control can interpret it. Transmit delay for 5Mb of data is 29 secs

Hence, total time = transmit delay + propagation delay = 223 secs

# Q.No.4



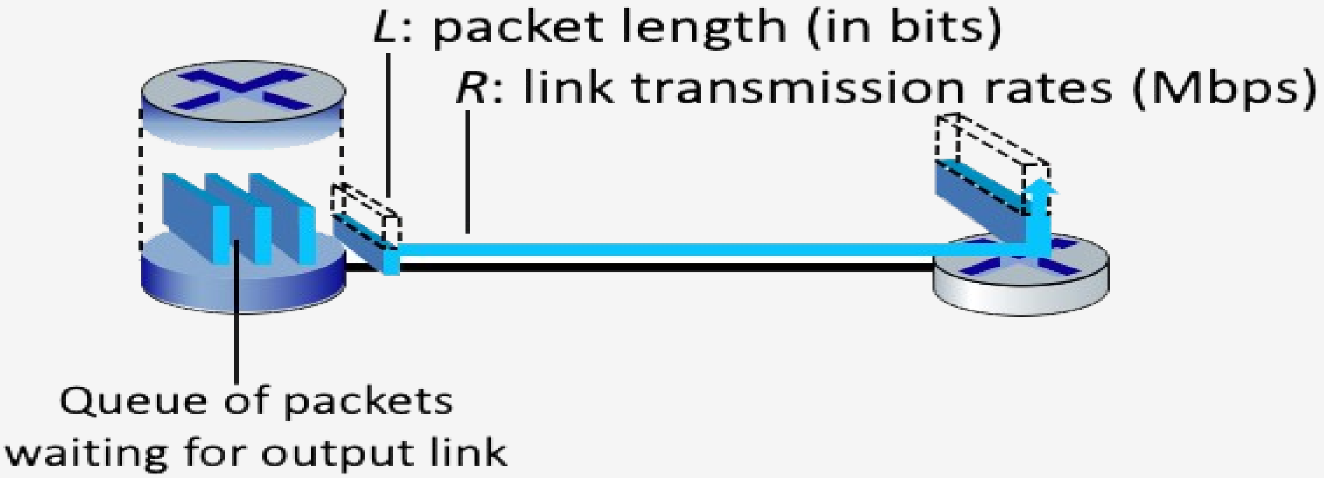

Find the end-to-end delay (including the transmission delays and propagation delays on each of the three links, but ignoring queueing delays and processing delays) from when the left host begins transmitting the first bit of a packet to the time when the last bit of that packet is received at the server at the right. The speed of light propagation delay on each link is 3x10**8 m/sec. Note that the transmission rates are in Mbps and the link distances are in Km. Assume a packet length of **16000** bits. Give your answer in milliseconds.

**Solution:**

Link 1 transmission delay = L/R = 16000 bits / 10 Mbps = 1.600000 msec.
Link 1 propagation delay = d/s = 2 Km / 3*10**8 m/sec = 0.006667 msec.
Link 2 transmission delay = L/R = 16000 bits / 100 Mbps = 0.160000 msec.
Link 2 propagation delay = d/s = 1000 Km / 3*10**8 m/sec = 3.333333 msec.
Link 3 transmission delay = L/R = 16000 bits / 100 Mbps = 0.160000 msec.
Link 3 propagation delay = d/s = 3 Km / 3*10**8 m/sec = 0.010000 msec.

Thus, the total end-to-end delay is the sum of these six delays: 5.270000 msecs.

# Q.No.5




Q1. Suppose that the packet length is *L* = 8000 bits, and that the link transmission rate along the link to router on the right is *R* = 1 Mbps. . What is the transmission delay?
What is the maximum number of packets per second that can be transmitted by this link?

The transmission delay = L/R = 8000 bits / 1000000 bps = 0.008 seconds

The number of packets that can be transmitted in a second into the link = R / L = 1000000 bps / 8000 bits = 125 packets

Q6.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?

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

Q7.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 × 108 m/s.

Solution

Propagation Delay = Distance/Propagation speed

Transmission Delay = Message size/bandwidth bps

Latency = Propagation delay + Transmission delay + Queueing time + Processing time

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

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

Q8. 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

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

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

Suppose a signal travels through a transmission medium and its power is reduced to one-half. This means that P2 is (1/2)P1. In this case, the attenuation (loss of power) can be calculated as

$$\boxed{10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5 = 10(-0.3) = -3 \text{ dB}}$$

A loss of 3 dB (–3 dB) is equivalent to losing one-half the power.

## Question:11

4. Consider sending voice from host A to host B over a packet-switched network (for example, Internet phone). Host A converts analog voice to a digital 64 Kbps bit stream on the fly. Host A then groups the bits into 48-byte packets. There is one link between host A and B; its transmission rate is 1 Mbps and its propagation delay is 2 ms. As soon as host A gathers a packet, it sends it to host B. As soon as host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at host A) until the bit is decoded (as part of the analog signal at host B)

**Solution:**

Before the first bit of a packet can be transmitted, all the other bits belonging to the same packet need to be generated. This requires: 48x8 / 64x10^3 = 7.6 ms

The time to transmit this packet is: 48x8 / 10^6 =0.384 ms

The propagation delay = 2 ms

**Therefore, the delay until decoding is: 6ms + 0.384ms + 2ms = 8.384 ms**

12.

**Packet Switching Problems**

Five equal-size datagrams belonging to the same message leave for the destination one after another. However, they travel through different paths as shown in the following table:

| Datagram | Path Length | Visited Switches |
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| 5 | 10,700 Km | 1,4,3,5 |

We assume that the delay for each switch (including waiting and processing) is 3, 10, 20, 7, and 20 ms respectively. Assuming that the propagation speed is 2x108 m/s, find the order the datagrams arrive at the destination and the delay for each. Ignore any other delays in transmission.

**Solution:**

Assuming a negligible transmission time (i.e. all datagrams start at time 0). The arrival times are calculated as:

First: (3.200 km / 2 x $10^8$ m/s) + 3 + 20 + 20 = 59 ms

Second: (11.700 km / 2 x $10^8$ m/s) + 3 + 10 + 20 = 91,5 ms

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The order of arrival is 3 -> 5 -> 2 -> 4 -> 1

| Switch | Delay (ms) |
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13.The loss in a cable is usually defined in decibels per kilometer (dB/km). If the signal at the beginning of a cable with −0.3 dB/km has a power of 2 mW, what is the power of the signal at 5 km?

Solution

The loss in the cable in decibels is 5 × (−0.3) = −1.5 dB. We can calculate the power as

$$\text{dB} = 10 \log_{10} \frac{P_2}{P_1} = -1.5$$

$$\frac{P_2}{P_1} = 10^{-0.15} = 0.71$$

$$P_2 = 0.71 P_1 = 0.7 \times 2 = 1.4 \text{ mW}$$

14.Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What is the maximum bit rate

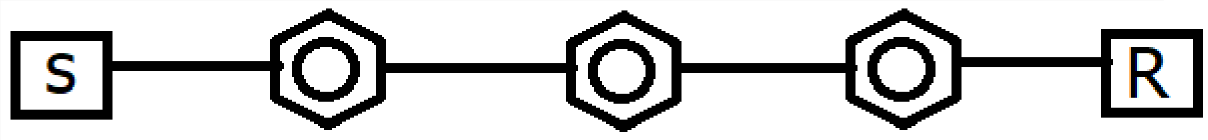
$$\boxed{\text{BitRate} = 2 \times 3000 \times \log_2 2 = 6000 \text{ bps}}$$

**Q15)** Assume there is a network that transfers data using circuit switching. There are three switches between end-users (sender and receiver) on this network, with a channel capacity (bandwidth) of 10 Mbps. Calculate the total time it takes to send a 100-byte message from sender to recipient using the information below (Consider the given parameters according to the requirement).

The propagation speed is estimated to be 2.4 * 10^8 m/s.
The hop distance between two nodes is 12,000 kilometres.
The header is 100 bytes long.
The circuit setup time is 10 seconds, and the circuit disconnect time is half that of the setup time.

**Answer q1**:

There are three switches between end-users (sender and receiver)




Number of hops=4
Bandwidth (BW)=10Mbps=$10\times10^{6}$bits/sec =$10^{7}$bits/sec
Message Size (M)=100bytes=10×8=800 bits
speed (S)= 2.4 * 10^8 m/s.
Distance (D)= 12,000 kilometres= 12000×1000 meters
Circuit Connection set up time=10 sec
Circuit disconnect/termination time= 5sec
Transmission delay= M/BW=*Tt*=MBw
*Tt*=800 bits$10^{7}$ Bits/sec=$8\times10^{-5}$ sec
Propagation delay *Tp*=DistanceSpeed
*Tp*=12000*103 *meters*2.54*103*mesters/sec*=$5\times10^{-2}$ sec
Total time= Connection set up time + Transmission delay + (Propagation delay * Number of hops) + Tear down time
Total time= 10+$8\times10^{-5}$ +($5\times10^{-2}\times4$)+5= 15.20008 sec =15200.08 ms=15200080 micro sec