School of Computing and Communications

SCC.130 Information Systems (2021-2022)

Home Work 3: Electronic Data Communication, Bit rate requirements of digital signals, Bandwidth and Throughput

Q1: A digitized voice channel is processed by digitizing a 4-kHz bandwidth analogue voice signal. The voice channel needs to be sampled at twice the highest frequency (two samples per hertz). If we assume that each sample requires 8 bits. What is the bit rate required for this system to process all the data?

Solutions:
Since the 4 kHz voice channel needs to be sampled at twice the highest frequency, the sampling frequency needs to be 8000 Hz. Subsequently, we would require 8000 samples/second.

If each sample is represented by 8 bits, the total bit rate required to process all the data is **64 kpbs**.

Q2: How many bits per sample would be required for the same voice channel, if the bit rate required for the same system to process all the data is 96 kbps and 128 kbps respectively?

Solutions:
If the required bit rate to process the same voice signal is 96 kbps, we calculate 96 000/8000 (the sampling frequency) = **12 bits per sample.**
To check this result: 4000 Hz requires 8000 samples/second. 8000 samples/second x 12 bits/sample = 96 kbps.

If the required bit rate to process the same voice signal is 128 kbps, we calculate 128 000/8000 (the sampling frequency) = **16 bits per sample.**
To check this result: 4000 Hz requires 8000 samples/second. 8000 samples/second x 16 bits/sample = 128 kbps

Q3: Consider the path from source to destination in Figure 1 below. What is the throughput of the whole path?

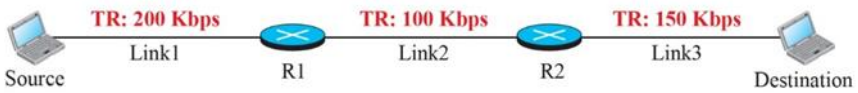

Figure 1: Throughput in a path with three links

Solutions:
In the figure above, the data can flow at a rate of 200 kbps in Link 1. When the data arrives at Router 1, it cannot pass at this rate. Data needs to be queued at the router and sent at 100 kbps. When data arrives at Router 2, it could be sent at the rate of 150 kbps, but there is not enough data to be sent. We can conclude that the average data rate and throughout for this path is 100 kbps, the

minimum of the three data rates. So, the throughput of the whole path is determined by the bottleneck in Link 2.

Q4: Assume that the link between R1 and R2 in Figure 1 above is upgraded to 170 kbps and the link between the source host and R1 is now downgraded to 140 kbps. What is the throughput between the source and destination after these changes? Which link is the bottle neck now?

Solutions:
The throughput is the smallest transmission rate, or 140 Kbps. The bottleneck is now the link between the **source host** and **R1**.

Q5: Suppose two users A and B need to exchange data between two ends of the system shown in Figure 3 below. Assuming the direction of data transfer is from User A to User B, and the user at Host A sends data over a medium that supports a bit rate = 500 kpbs:

- How long does it take for User A to transmit 10 bits over that medium?
- If the connection between Link 2 and Host B is 200 kbps, what is the throughput of the whole path from A to B?

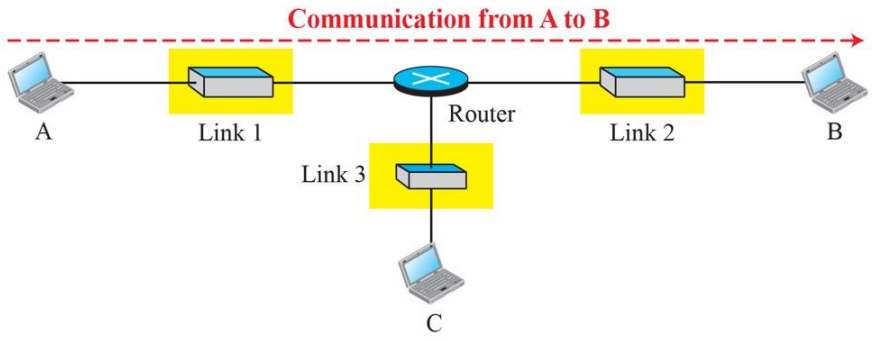

Figure 3: Two-user communication in a network-based information system

Solutions:

- How long does it take to transmit 10 bits? 10/500 000= 1/50 000 = 0.00002 sec = 20 µs.
- If the connection between Link 2 and B is 200 kbps, the throughput of the whole path between A and B = 200 kbps.

Q6: This question requires you to conduct some research and answer the following question:

- The audio bit rate for Red Book CD is approximately 1.411 Mbps. Explain how this bit rate is attained?

Solutions:

- The audio bandwidth = 20 kHz, the sample rate = 44,100 Hz. This means 44,100 samples per second.
- Each sample is represented by 16 bits, 2 x channels are used for stereo. As a result, the total bit rate = 44100 x 16 x 2 = 1,411,200 bps