The Lunar ~ Circuit ~

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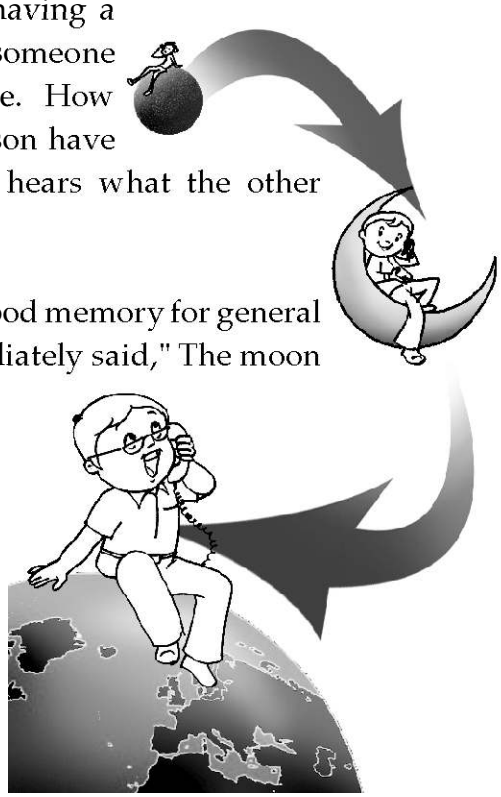
It was after dinner-time on a clear full moon night and many youngsters from Sarvodaya Nagar had assembled on the cricket ground. However, the topic of discussion was not cricket but astronomy. Uncle Pai had set up a telescope on the ground and was conducting a star-gazing session. After watching Orion and the other visible constellations, the major part of the session was devoted to the most predominant object in the night sky, the moon itself.

While watching the lunar craters, the talk inevitably turned to space shuttles, the possibility of human beings settling on the Moon and travel to distant stars. Uncle Pai said, "When we use a telephone, the signals travel over the wire at almost the speed of light, which is around 300,000 Kilometers/sec. So when you talk to your friend, you can hear each other almost instantaneously. Suppose you are having a conversation with someone on the lunar base. How long will each person have to wait before he hears what the other said?".



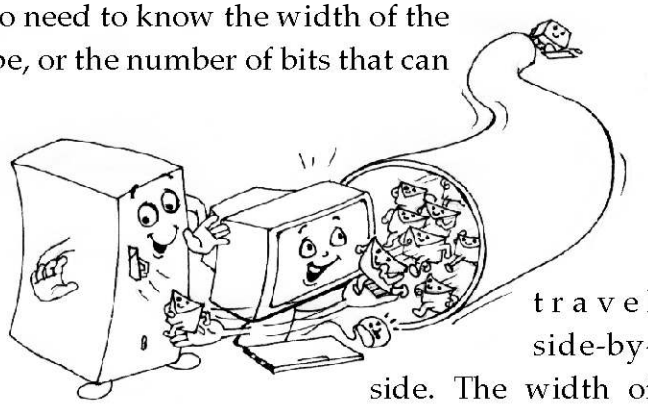
Sunil, who had a good memory for general knowledge, immediately said," The moon is around 385,000 Kilometers from the Earth. So, if we assume that the conversation data travels from the moon to the earth at the speed of light, it will take 385000/300000 seconds to reach." "That comes to about 1.28 seconds.", added Kiran, who was quick at maths.

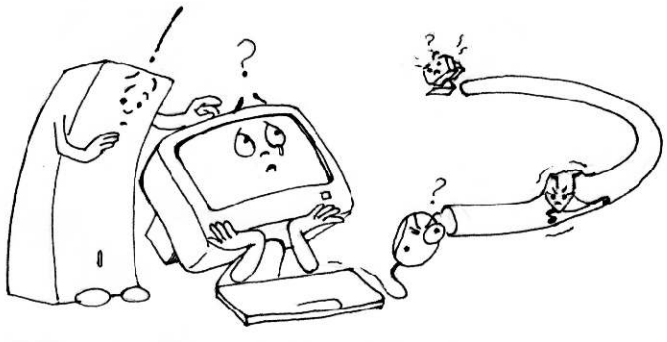
Sunil continued, "Suppose we were talking to someone on Saturn's moon, which is around 1,500,000,000 km away." "The delay would be 5000 seconds, or 1 hour 23 minutes." completed Kiran. "Wow, that would mean really long pauses in the conversation.", said Sheela, who was considered to be a chatter-box. Everyone laughed as she concluded, "Of course, there is no problem if each side keeps talking non-stop, without waiting for any reply."

Uncle Pai said, "Here is a puzzle: A camera on the lunar base takes pictures of the Earth. The pictures are stored in the form of bits in a computer and the size of each picture is 25 Mega bits (25,000,000 bits). Suppose you want to get the latest picture from the camera. What is the minimum amount of time that will elapse between the sending of the request from Earth until the picture is received completely?" "1.28 seconds.", said Sunil immediately. "No, 1.28 seconds is the one-way delay. We have to consider the time taken by the request to reach the moon and the time taken by the reply to return. So the round-trip delay would be twice, or 2.56 seconds.", added Kiran. "Ok. But it takes 2.56 seconds for receiving only the first bit of the picture. The total time taken for the picture to be received completely would also depend on the size of the picture.", said Sheela. "We know that the size of the picture is 25 Mega bits.", said Sunil. All of them were silent, trying to calculate the time taken. But they could not do so. Can you guess why?

After a while, Kiran said, "Hey, it is not enough to know just the size of the picture. In order to calculate the time, we also need to know how much of it is being sent in one second." "Very good", said Uncle Pai, "We do need to know how much data is being sent in one second, which is called the bandwidth of the connection." "Why is that?", asked Sunil. Uncle Pai explained, "Imagine

that the communication link (between the lunar base and the Earth) is like a pipe. Now the length of the pipe corresponds to the delay for each bit, since each bit has to travel this distance. But to calculate the total time taken for all the bits, we also need to know the width of the pipe, or the number of bits that can travel side-by-side. The width of the pipe corresponds to the bandwidth." "Yes, that makes sense", said Sunil, "The total time taken will be lesser if we have a fatter pipe as compared to a thinner one." "Right", said Uncle Pai, "Suppose the bandwidth of the communication link between the lunar base and Earth is 100 Mega bits per second (100 Mbps). Now the size of the picture is 25 Mega bits, so it will take 25/100 or 0.25 seconds to be transferred. So the total time taken will be the round-trip delay (2.56 seconds) plus the transfer time (0.25 seconds), which comes to 2.81 seconds." Interestingly, bandwidth and delay are important considerations in everyday computer networking also.





When you connect to the Internet from your home computer using a dial-up telephone line, you find that sometimes the responses come "fast", while at other times it is very "slow". One reason for this is that the bandwidth at the service provider is limited and is shared between many users. If there are many users accessing the Internet simultaneously, each user gets only a small share of the bandwidth and the transfer time increases, leading to the perception that the "Internet is slow".

Bit: This is a short form for binary digit, the smallest unit of information on a computer. A single bit can hold only one of two values: 0 or 1. More meaningful information is obtained by combining consecutive bits into larger units. For example, a byte is composed of 8 consecutive bits.
Bandwidth: The amount of data that can be passed along a communications channel in a given period of time.
This is typically measured in bits per second (bps).
Delay: The interval of time between two events. In this case, it is the time interval between the sending of a message and its receipt.
Round-Trip-Time (RTT): The time required for a network communication (message) to travel from the source to the destination and back.

Some interesting related websites are:
http://www.kidsastronomy.com/
http://astroplace.com/
http://www.freeprogrammingresources.com/tcp.html

Illustrations: Mrs. Kaumudi Sahasrabudhe