The Scientific Concept/Data Packets and Data Transfer Speed

Title: The Mailman and the Five Packages

Welcome, everyone.

Our lesson today has four heroes: the Mailman, Nawaf, Shadi, and Shawqi.

To learn what happened to them, follow us.

First of all, allow me to introduce myself, I am Bader Ahmad Al-Hamidi, a lecturer at the King Fahad University of Petroleum and Minerals. It is my great pleasure to share this subject with you, which has been prepared by Professor Hanan Abdel-Rahman Al-Arfaj, Chief Supervisor, Computer Department, Educational Management Supervision in the Eastern Province of the Ministry of Education.

This topic aims at simplifying the concept of data transfer and its transfer speed via computer networks. Confusion has arisen since we have been confronted with puzzling situations when sending data via computer networks, such as variations in data transfer speed, where it is too slow sometimes and very fast at others. Other problems include non-completion of data transferred or loss of part of it, in addition to different speeds of data transfer from one network to another.

As a result of these inconsistencies, we face two questions:

1. How are data packets transferred through networks?
2. What are the factors that affect data transfer speed?

To find out the answers, we will introduce to you a problem which we call "The Mailman and the Five Packages."

What is the problem?

There are five packages of different sizes that should be delivered to different addresses. The first three of them are to be delivered to one address, while the remaining packages should be delivered to a different address.

While the mailman is on his mission to deliver the packages to the right addresses, he faces the following challenges:

1. The street that leads to the first address is too narrow for the vehicle to pass through.
2. The second street is very crowded in the afternoon.
3. The mailman is the only person who knows the addresses of senders and recipients.
4. The mailman needs assistants to carry the boxes.

What do you think? Would you like to help the mailman?

Well, we're going to divide you into groups, and we would like you to think about ways to overcome these challenges!

How can the mailman deliver the five packages on time before three o'clock?

Based on your suggestions for helping the mailman solve his delivery problem, the question is:

How is data transferred through networks?

Thank you for your creative attempts to answer the questions.

Notice the similarity between road networks and data transfer paths within computer networks; also note that the problems the mailman has faced during his mission will be similar to the problems facing data transfer.

Before we examine how data is transferred and the factors affecting its speed within the network, let's spend a moment to recall together how data is represented inside a computer.

A computer is an electronic device in which data is represented in the form of binary numbers. These binary numbers consist of zero and one. A combination of eight binary numbers (8 bits) is used to represent symbols, numbers and letters. For example, the letter H is represented by 01001000. Notice that we used 0 or 1 eight times to represent the single letter H.

Now, here are two problems that I'd like you to work on:

The first question:

How many bits are in the sentence "Hanan is happy to be with you?"

The second question:

How much time would it take for this sentence to be sent at a data transfer speed of 1000 bit/s?

Now, sit down in groups and work out the answers to these two questions.

Thank you for your great work in solving these two problems.

The sentence "Hanan is happy to be with you" contains 29 characters or 29 bytes. Since each byte consists of 8 bits, the sentence contains 29*8 = 232 bits as a result.

To send a sentence, it should be placed in a packet (via the protocol applied in the network). This packet consists of the following parts:

1. A head up to a maximum of 96 bytes, equivalent to 768 bits.
2. A maximum of 896 data bytes, equivalent to 7168 bits.
3. A tail up to a maximum of 32 bytes, equivalent to 256 bits.

The head contains the packet number if the data is divided into parts in addition to the addresses of both the sender and the recipients, and the tail contains the packet-ending signal and that it is free of errors.

As we have calculated earlier, the data size of the sentence "Hanan is happy to be with you" is 232 bits. In order to send this sentence, we need to put it in a packet as follows:

1. Packet size = 768 (head) + 232 (data)+ 256 (tail) = 1256 bits.
2. Since the data transfer speed is 1000 bits per second, then the time elapsed would be: 1256 ÷ 1000 = approximately 1.3 seconds.

Therefore, the data transfer speed is the rate of sending data measured in bits per second.

Now, compare this answer with the answer to the previous one. What is the difference between them?

Would you like to play "The Fastest Mailing"? This game will help us to simplify the concept of data packet and mailing speed.

Here's how the game goes:

We have six books that are about the same size, and there are three paths from the library that lead to the classroom, as shown in the diagram.

The books will be put into three bags. The first and second books will be put into the first bag, the third and fourth books will be put in the second bag, and the last two books will be put in the third one.

Three students will be selected to carry these books. Nawaf is going to carry the first bag following the first path, Shadi takes the second bag and

follow the second route, and finally Shawqi takes the third one going via the third route. The time will be measured for each student.

The first route is very crowded and contains two passages: Passage #1, which is 10 m long and passage #2, which is 3 m long. The combined length of the two passages is thus 13 m.

The second route is moderately crowded and contains three passages: Passage #3, which is 5 m long, Passage #4, which is 10 m long, and Passage #2, which is 3 m long. The combined length of these passages is 18 m.

The third route is not crowded and starts with Exit #1, three external passages measuring 8 m, 15 m, and 3 m respectively, passing through exit #2, and the entrance which measures 2 m, making a total of 28 m.

Now here is a description of the participating students: Nawaf is thin and small in size; Shadi is fast and large in size, while Shawqi is slow and large in size.

The questions to be answered are these:

Which bag will be delivered first?

What do you expect will happen?

Please do the previously described activity, my dear students, with assistance from your teacher who will provide you with the following information:

1. The desired folder from the library to be delivered to the classroom.
2. The route details from the library to the classroom.
3. The distance for each route.
4. How crowded each route is at the required time for delivery.
5. The number of bags in which the books are to be carried.

6. The students who will carry the books and their timing, taking into consideration their different physical nature in terms of size, weight and speed.
7. The student assigned to put each two or three books in each bag in order.
8. The student assigned to label each bag (e.g., from the library, to the classroom, the bag serial number).
9. The student assigned to collect the bags and arrange the books to be in one folder.
10. Finally, the guiding students who will give directions to the participating students depending on the route (e.g., the number of passages leading to the library).

Here, my dear students are the results of "The Fastest Mailing" game:

1. The first bag took 8.1 minutes.
2. The second bag took 6 minutes.
3. The third bag took 9.3 minutes.
4. Six books were delivered in 7.8 minutes, which means that the rate of data transfer is one book every 1.3 minutes.

The data transfer was affected by distance, congestion of the roads, the physical nature of the students in terms of size and speed, and the size of the data transferred.

Now, my dear students, and after solving the third question, discuss the following questions with your teacher's assistance:

- What if we changed the roles of the students? Will the mailing speed increase or decrease?
- What if the folder which contains the six books was carried in one bag?
- What if the books were of different weights?
- What if the books have not been labeled?
- What if the books are to be delivered after normal working hours?

- What if another type of bag is used in delivery (one with wheels, for instance).
- What if the number of roads is less than the number of bags?

Thank you for your correct conclusions.

We can thus conclude that the factors affecting data transfer within networks are:

- delivery paths (Which means the number of passages and gates for the network)
- how crowded the network is (i.e., the number of current users)
- the means of transmission (the type of wires used, the cables, the devices and protocols used)
- data size (whether text, picture, video or audio files)

Now, we know that data packets are data we send as parts.

If we want to send the six books electronically via the net, each part of the school network will correspond to a part of the computer net, as follows:

1. The school passages will be replaced by the net paths and gates.
2. The students carrying the books will be replaced by the transfer means.
3. The bags will be replaced by the data packets.
4. The students who distribute the books, and the one who receives the books and orders the folder will be replaced by the protocol applied in the net.

Of course, we need to know the folder size (i.e., the six books in bits), in addition to the mailing speed via the net.

What is the time needed for sending a folder that contains 876288 characters via a net with a speed of 100000 bit/second?

Note that the maximum length/size for the packet is 1024 bytes, which is equivalent to 8192 bits.

Let's overcome the final challenge. Remember what has been explained in the third section.

Let's review the steps of the solution:

1. The first step is to calculate the folder size in bits, which is 876288 characters x 8 = 7010304 bits.
2. The second step is to calculate the number of the sent packets, which is 7010304 ÷ 7168 = 978 packets.
3. The third step is to calculate the packet size: 768 bits for the head + 7168 bits for the data + 256 bits for the tail = 8192 bits.
4. As a result, the total size for the data is 8192 x 978 = 8011776 bits.
5. Finally, the time required for sending the data is 8011776 ÷ 100000 = 80.11776 = 80 seconds = 1.3 minutes.

Teacher's Guide

Students' Previous Knowledge Requirements:

- The concept of digital data.
- Measurement units of data (bits, byte, kilo, …)
- The concepts of network and protocols.
- Using the Internet or local nets.
- Mathematical problem-solving skills.

Teacher's Instructions:

The first session:

The students work in groups to help the mailman with their suggestions and solutions.

The second session:

Review the network concept, and ask the students–from their prior experience– to write down how data of any type is transferred through the network.

The third session:

Write down the measurement units of data that were mentioned in the lesson, and calculate the total number of bits in the sentence.

8 bits = 1 byte

1 byte = 1character

Calculating the data transfer time is done through connecting to prior experience.

The fourth session:

Correct the answers after explaining the concept of data packets.

The fifth session:

1. Student's expectations will be written down after calculating the distance, the speed of the students, road congestion, and the book size.

(It is recommended that the teacher prepare all the requirements and

calculate the number of passages in advance to save time.)

2. The answers should be compared to what actually happened.
3. Conclusions are to be recorded.

The sixth session:

The teacher discusses the following situations:

1. What if we changed the roles among the students? Will the mailing

speed increase or decrease?

The big-size student will be stuck and might not deliver the data.

2. What if the folder containing the six books was carried in one bag?

The size will increase and consequently it will slow the student down.

3. What if the books were of different weights?

The student responsible for distribution should distribute them equally if possible or close in size.

4. What if the books had not been labeled?

Some of them might be lost, or sent to wrong address, or longer time is needed to put in order and collect.

5. What if the books are to be delivered after normal working hours?

The speed will increase.

6. What if another type of bags is used in delivery—ones with wheels, for instance.

The speed will increase.

7. What if the number of roads is less than the number of bags?

The speed will decrease.

The seventh session:

The problem will be solved based on what has been explained earlier and compared to the model answer.

Conclusions are consolidated in solving the problem of "The Mailman and the Five Packages" as follows:

1. Each package will be labeled with the addresses of the sender and the recipient.
2. Strong and fast assistants are chosen.
3. Each of the three packages is carried by different students taking different routes in the shortest time.
4. The packages can be delivered between 2:00 pm and 3:00 pm.

Thank you