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Concepts of a computer network

Basic problematics

The basic problematics of networks is the communication and the exchange of data between users. In this chapter, we will call "user" a person, a program or a terminal... The sender of the message imposes some constraints regarding the transmission of data. He expects in particular the following things:

- the data is received by a well-identified user,
- the data fully arrives without any error,
- the data arrives in the same order it has been sent.

Besides these constraints, we can find other problems in particular related to the means we have to transmit data. Indeed, data transmission is performed using the existing telecommunication infrastructures and these infrastructures have some defects: there is seldom a dedicated line between 2 given users, and these lines, because of physical limitations, cannot guarantee a perfect quality of transmission (lines alter signals).

Last important issue: we must translate the (logical) data a user want to send into a physical representation that can be really sent over the physical infrastructures. Clearly speaking, it is a matter of building "bridges" between two different elements of the chain of transmission. Data to be transmitted is very likely to be transformed to go through the different bridges, but at the end, it must be correctly rebuilt according to the sender requirements.

The data transformation

The transformation we have just mentioned is progressively performed in 3 steps:

1. **transformation performed by users**: both users must agree on the exchange procedures and must find a common meaning for the data they are exchanging. Some methods must be set up; in particular, they must permanently check that everything is going right.
2. **parallel-serial conversion**: it is a "reasoned" transformation. It is indeed cheaper to send serial data than parallel data. Users must then be able to convert.
3. **digital-analog transformation**: this transformation simply comes from the fact that digital signals cannot be transmitted over a physical medium without being defaced. Digital signals are therefore converted into analog signals that are more adapted to long distance transmissions.

Routing mode

Connection-oriented and connectionless modes

There are 2 modes (or services) of transmission: the **connection-oriented mode** and the **connectionless mode**. Let's have examples to highlight the differences: the telephone and the mail system.

The typical example of a connection-oriented mode is the telephone. To converse with someone else, one must take off the hook, dial a number and once the other guy has picked up the phone, one speaks. When the conversation is over, and only when it is over, one hangs up. In concrete terms, the connection-oriented mode is always characterized by the following set of processes: we must first establish a connection, then at the end we close the connection.

On the other hand, the mail system is typical of the connectionless mode. Every message holds the destination address and is transmitted independantly of the others. If everything works as it should, the first message arrives before the second one and so on. But actually, because each message is sent independantly and because of intermediate nodes, it is possible for the second message to arrive first. This case is absolutely impossible with the connection-oriented mode. We also call the connectionless mode as **datagram mode**, to refer to the old telegraph system that did not use acknowledgements.

Every service may be characterized by a **quality of service**. The quality of service is the ability to guarantee that a message can be completely delivered without any error (neither inversion nor content error). The connection-oriented mode is therefore characterized by a high quality of service, although the connectionless mode is characterized by a low quality of service. To guarantee a higher quality of service, we user in particular **acknowledgements**: regularly, the receiver report to the sender thanks to a new message it has correctly received the data. Usually, the sender waits for this acknowledgement before sending another packet. this is a very efficient system but unfortunately slow and uses unnecessary resources. That is why the sender may send several packets at a time without waiting for the corresponding acknowledgements, in order to improve network performances.

We would often tend to ask for the highest quality of service, but we must understand that a high quality implies high and unrelevant infrastructure costs. We must make a reasoned choice according to both transmission infrastructures and real needs. For instance, to transfer a file, it is better to use the connection-oriented mode. On the contrary, it is better to use the connectionless mode to send a mail, because we do not really care if the second mail arrives after a first one (it is still possible to order the mails afterwards) and the probability for a message to be lost is very low. Actually, an acknowledgement can be performed with the connectionless mode or the connection-oriented mode. We can then define 4 classes of quality of service.

Consequences for networks

Having two modes of transmission makes us distinguish 2 classes of networks, according to the kind of connection:

- **circuit switching networks**: they are typical of the connection-oriented mode. A dedicated communication path is established between the sender and receiver along the communication. All messages follow the same route.
- **packet or data switching networks**: they are typical of the datagram mode. There is no dedicated communication path, all paths can be used by several independant communications. Two messages can follow two different routes.

circuit switching   data switching

first message
second message
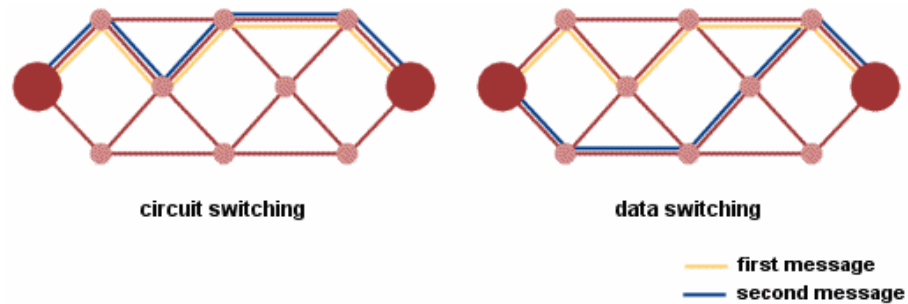
Functions of a network system

The functions of a network system are functions that permit:

- the direct or indirect physical **connection** between 2 users,
- **broadcast** by a user of a message transmited by the system to one or more other users,
- **reception** by a user of messages of which he is the adressee,
- **routing** of messages without error, loss, disorder or duplication and in time,
- **optimisation** of communication lines by sharing the physical medium,
- **flow control** and storage of messages in transit before they are used,
- the **choice** between different dialogue methods,
- **management** and control of uses of network functions.

The variety of communication needs leads to differences in functionalities required at the network system level. For instance, needs for a telematic application are very different from those for a transfering banking files. The differences of needs between applications concern transfer rates, fault tolerance and data integrity.

Thus, we divide the network software into a set of basic activities and sencondary activities. For a given network or a particular application, only a part of these activities wil be implemented.

Basic activities are:

- **reliability** (error correction, messages order preservation),
- **flow control**,
- **addressing** (to refer to users),
- **connection and disconnection**,
- **routing**.

Secondary activities are for instance:

- take the heterogeneity of the network into account,
- synchronization of the transmission,
- multiplexing-demultiplexing,
- error recovery,
- congestion control,
- failure management,
- ...

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classification   **network software**