Lecture 6

Communication Fundamentals in Computer Networks

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Topics

- Connectionless and Connection-Oriented Network Services
- Service Paradigms of Computer Networks
- Error Detection and Error Correction

Connectionless and Connection-Oriented Services

Connectionless services in packet-switched networks

- The previously discussed variations of packet-switched networks are considered connectionless network services *(also called datagram networks)*.
- A data packet provided with additional information necessary for its correct transport through the network to the receiver is also known as a datagram.

Connection-oriented services in packet-switched networks

- In connection-oriented networks while messages are disassembled into separate data packets prior to transmission, a so-called virtual connection *(Virtual Circuit, VC)* is set up at the same time.
- All packets are then transported between the two communication partners through the network via this virtual connection.

Service Paradigms

Connectionless Service

- Before a computer can send a message to another computer it must convert it into a predefined data packet format and include a receiver's and sender's address.
- This can best be compared to a written message put in an envelope on which the receiver's address is written.
- Just as a letter is brought to a mail collection point, the computer passes the completed data packet to the network for delivery.
- From there it is sent to the receiver.
- To keep administrative costs as low as possible, the connectionless service does not provide any guarantee that the packet actually arrives at the receiver or in what time frame.

Service Paradigms

No connection is made between the sender and the receiver

the individual data packets are transported independent of each other and without delay through the network.

If the communication behavior is characterized by frequently changing addressees and short message lengths, connectionless service offers important advantages over connection-oriented service.

Service Paradigms

Connection-oriented Service

- The operation of a connection-oriented service can be compared with a standard, analog telephone network.
- Before the message exchange operation between two computers begins, a connection first has to be switched between them. This is similar to dialing a telephone number and triggering a connection to the dialed subscriber.
- As soon as the partner has recognized the communication wish and accepted it, a switched connection exists between them – much like picking up a ringing phone with the partner at the other end answering.
- The switched connection may then be used in a virtually exclusive manner for the communication to follow.
- When the communication comes to an end, the switched connection is terminated.

Service Paradigms

A connection-oriented service always proceeds through three phases:

1. Connection establishment,
2. Data transmission and
3. Disconnection.

Connection-oriented services via packet-switched networks rely on the connectionless services available.

- With connection-oriented services the user is provided an interface that allows exclusive use of the virtual connection.
- This interface shields the user from all processes running on a hierarchically lower layer of communication *(such as structuring, addressing and transporting of individual data packets)*. Thus the user is offered comfortable communication access.

Error Detection and Error Correction

- To ensure reliable data transmission, mechanisms must be put in place to perform automatic detection and correction when transmission errors occur.
- The individual data packets are thus supplied with additional information to recognize errors.
  - *If errors occur they allow – at least up to a certain point – the reconstruction of the correct contents of a data packet.*
- It is referred to as redundancy.

Error Detection and Error Correction

For example,

- The sender calculates a checksum for the data packet to be sent and appends it to the packet.
- Once the packet has arrived at the receiver, the same procedure for checksum calculation is performed by the receiver.
- This calculated value is compared with the checksum value of the sent data packet.
  - *If both values match, the probability is high that the packet has been correctly transmitted.*
  - *But if the values don't match it is an indication that the content has undergone changes during transmission.*
    - *The receiver has the possibility to request the data packet again from the sender. In this case, the whole message does not need to be retransmitted but only the defective data packet.*

Error Detection and Error Correction

- When errors do occur in wireless communication it happens in a cumulative manner called as bursts.
- If it were the case that errors only occurred in isolated individual bits, this would mean a constant error rate of, for example, 0.01% per bit for a package size of 10,000 bits. In this scenario nearly every single packet would be faulty and need to be retransmitted.
- But if errors occur in bursts of 100 on the average, then only one or two packets out of 100 are affected.

Error Detection and Error Correction

A measure for transmission errors is called Bit Error Rate (BER).

It is calculated from the ratio between the incorrectly transmitted bits and the total number of bits transmitted measured over a longer period of time.

Table 3.3 Bit error probability.

Transmission medium	Bit error probability (Magnitude)
Radio	$10^{-1} - 10^{-3}$
Telephone line	10^{-5}
Digital data network	$10^{-6} - 10^{-7}$
LAN (coaxial cable)	10^{-9}
Fiberglass cable	10^{-12}

Error Detection and Error Correction

To be able to handle errors in the most efficient way, two fundamental coding methods have been developed:

- error-detection codes, and a related retransmission in the case of recognized errors
  - *A significantly higher effort is required for error correction. This procedure is necessary when the effort required for retransmission of a sent message is excessive.*

- automatic error correction, via error correcting codes.
  - *Using error-correcting codes it is possible – when not too many errors occur at the same time – to draw conclusions based on the original output message.*