Lecture 4

Communication Fundamentals in Computer Networks

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Topics

Basic Terms and Concepts

- Communication and Data Transfer
- Classification of Communication Systems

Computer Networks and Packet Switching

- Classic Point-to-Point Connections

Basic Terms and Concepts

Communication *(communicare = [Lat.] impart, share, make common)* is the exchange, provision, transmission and reception of information.

> *In the case of digital communication, this means digital data between two or more communication partners.*

The basic components of every form of communication are made up of

- the transmitted information itself,
- its sender and receiver,
- the communication medium over which the information is transferred.

Basic Terms and Concepts

The following conditions must be fulfilled so that communication can take place:

- The information must be presented in a suitable system of signs for communication *(e.g., sounds, text, binary coding, etc.)*
- It must be possible to transform these signs into physical signals *(e.g., sound waves, electrical impulses, radio waves, etc.)*
- The receiver needs to be able to read the signals received and through this interpretation to understand the meaning contained in the message.

Basic Terms and Concepts

Data transmission is defined as the exchange of units of information (data) between two or more physically separate computers that make up the information.

The interconnected computers form a computer network or, in short, a net.

The system of transmission lines is the transmission network or network.

The computers involved in the transfer must follow the fixed rules – called a communication protocol.

> *This means being able to send or receive the data so that the other computer can correctly interpret and process it.*

Basic Terms and Concepts

Every data transmission system is made up of (at least) two data stations (hosts), which are linked to each other via a transmission line.

Each data station connected by a computer to a transmission network needs to have two components:

- Data Circuit transmission Equipment (DCE) converts the data to be sent into electrical signals, or, as the case may be, the received electrical signals back into (usually binary coded) data.
- DCE communicates with the second computing unit, the Data Terminal Equipment (DTE).

Basic Terms and Concepts

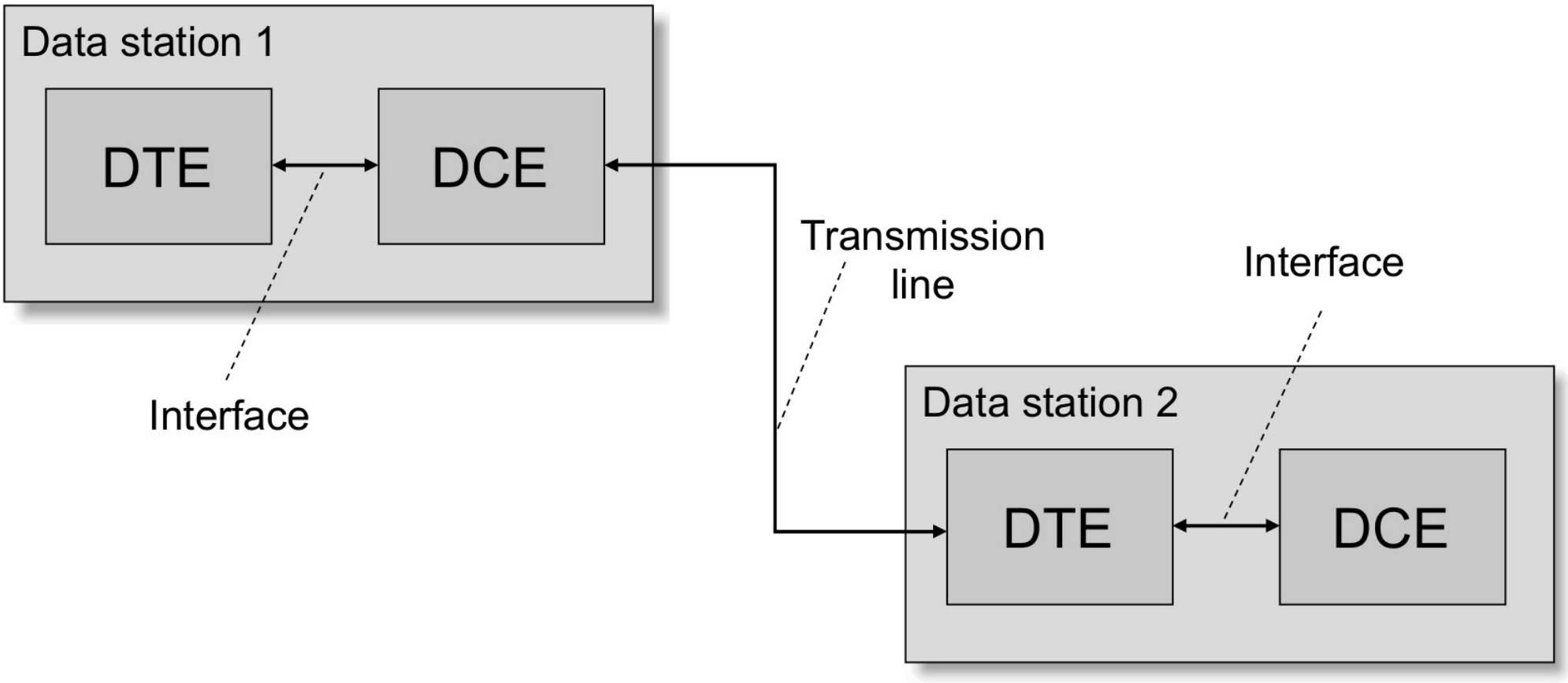


Fig. 3.1 Data transmission model based on DIN 44302.

Basic Terms and Concepts

The task of the data terminal equipment (DTE) *is to send and to receive data*. A DTE contains one or more of the following components:

- input processing unit,
- output processing unit,
- arithmetic logical unit (ALU),
- control unit and memory.

The data circuit transmission equipment (DCE) is responsible for the following tasks:

- transformation of the sent data into signals suitable for the transmission medium and then transformation of the received signals into understandable data for the DTE (signal conversion),
- establishing and dismantling data connections,
- generating and maintaining a constant sending and receiving clock between the involved DCEs and
- detection and correction of transmission errors.

Topology

Computers can be connected in a variety of arrangements in data transmission. These arrangements are known as topology, the distribution and connection form of the individual computing nodes.

The simplest and also oldest type of networking between two computers is the point-to-point connection. When multiple computers share a transmission network the computers are only indirectly connected to each other.

The end devices and computers connected to the network are generally referred to as hosts. Seen from a topological perspective, the connected computer systems in the network make up the network nodes.

Network Concepts

Various interconnected networks create a network group or an internet.

- Two computers that form the end points of communication taking place on the internet are called end systems
- All computers along the connection path between both of the end systems are referred to as intermediate systems.

If these intermediate systems are integrated into multiple communication links and connected directly to other intermediate systems in the internet, they must determine via what communication link the information is to be forwarded. This decision-making action is called routing and the intermediate systems that make this decision are known as exchanges, switching computers or routers.

Network Concepts

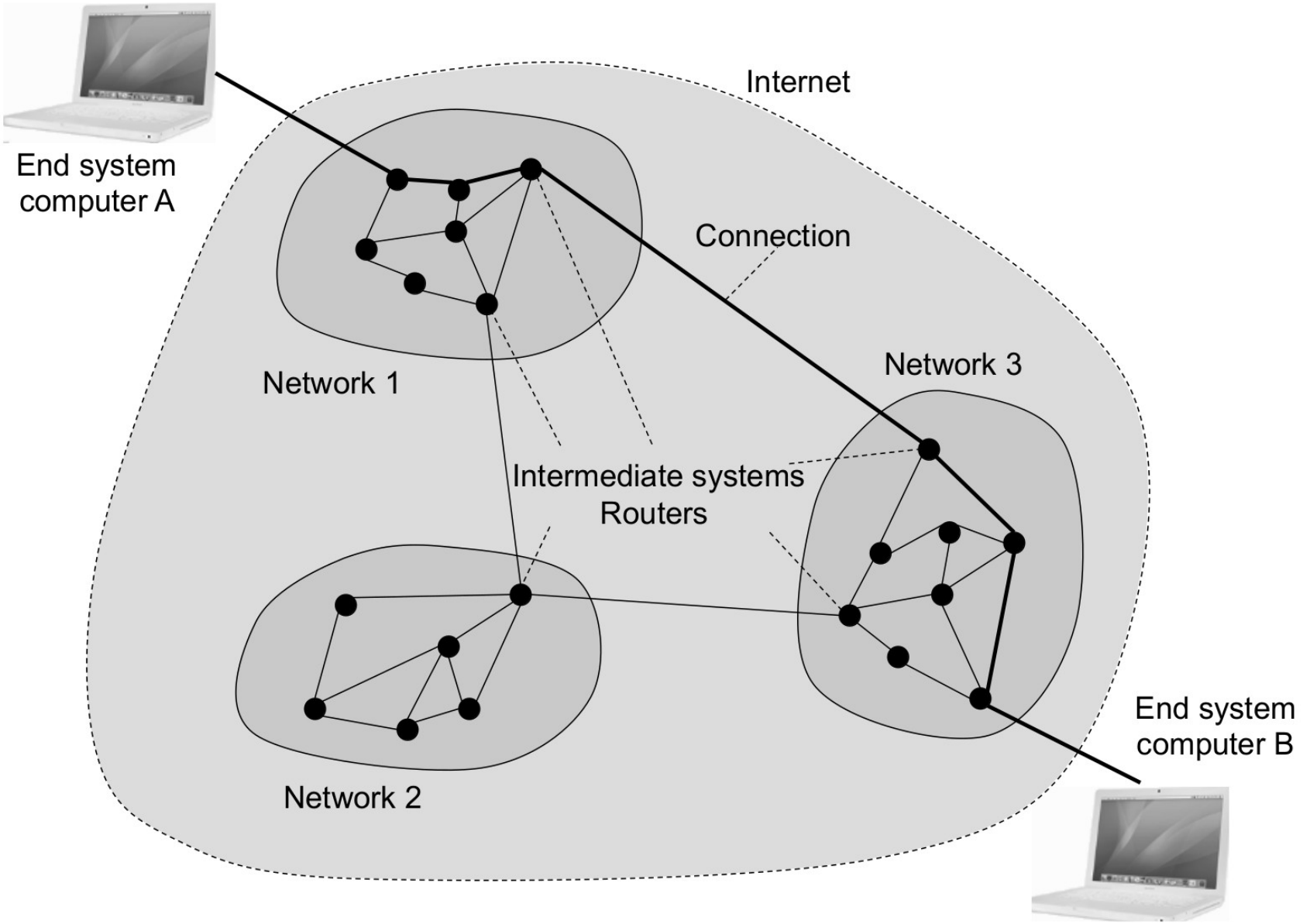


Fig. 3.2 Basic network concepts.

Modes of Transport

Depending on whether information is sent to one, several or to all network end systems, a distinction is made between unicast, multicast or broadcast

Transport modes

The mode of transport indicates how many of the devices connected to the network, or network group, receive information from the sender. The main groups are:

- **Unicast**:
  A sender transmits information to a single receiver (point-to-point transmission). Examples for a unicast transmission are a telephone conversation or a private email.
- **Multicast**:
  A sender transmits information to a group of receivers (point-to-group transmission). Examples for a multicast transmission are a multi-party conference call or an email message sent via a mailing list.
- **Broadcast**:
  A transmitter sends a message to all receivers in a network (point-to-all transmission) An example of broadcast transmission is classic mass media such as newspaper, radio and television.

Fig. 3.3 Modes of transport in communication networks.

Modes of Operation

The mode of operation in message transmission indicates in which direction information is to be exchanged between two end systems.

In simplex operation information is sent unidirectionally, i.e., in one direction, while in duplex operation a bi-directional information exchange is possible with two end systems exchanging in both directions.

There are two variations of duplex operation:

- half-duplex, in which information can be exchanged between the two end systems in both directions only sequentially, i.e., alternatively exchanged in succession.
- full duplex, in which exchange is possible in both directions at the same time.

Modes of Operation

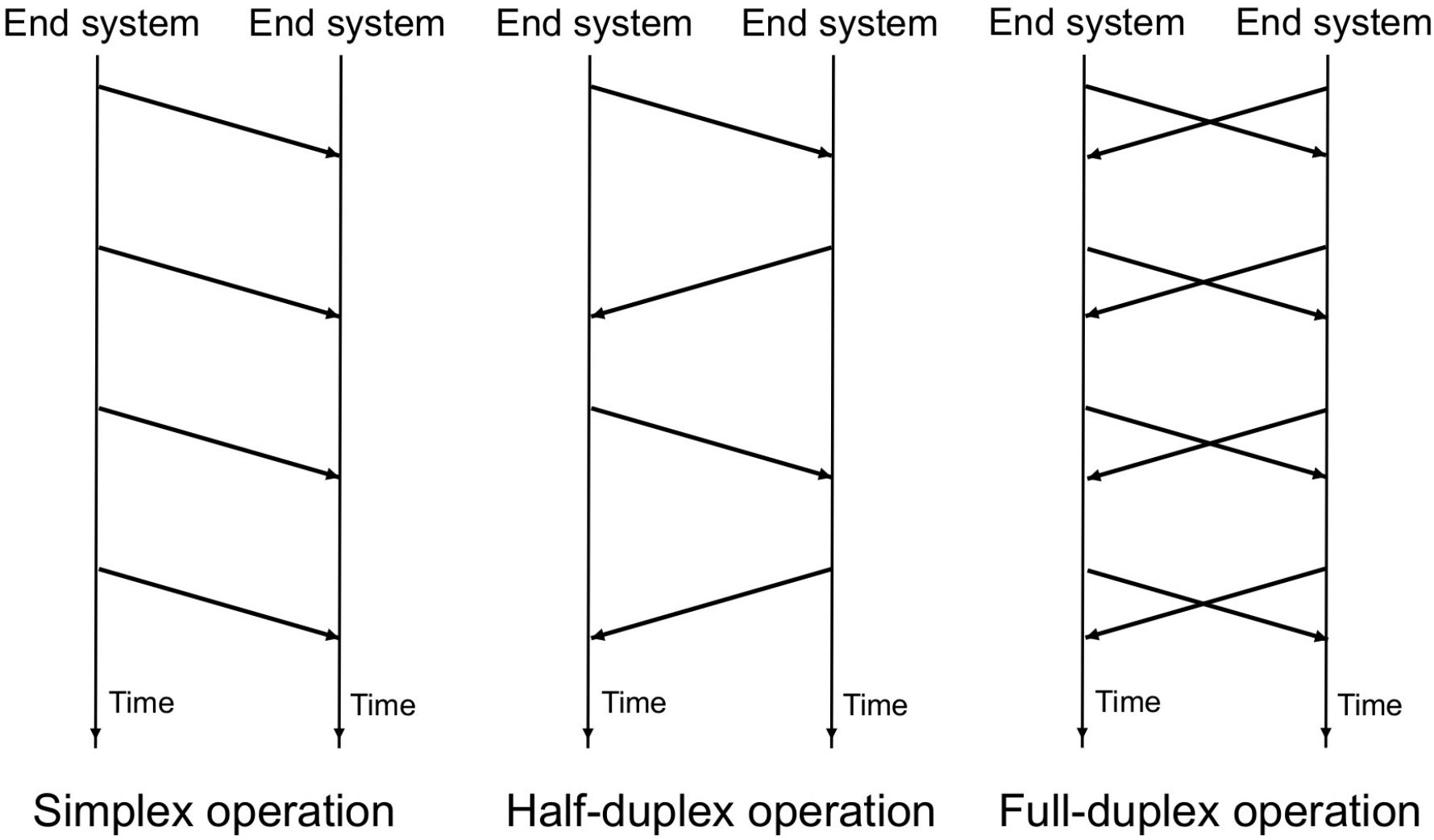


Fig. 3.4 Types of operational modes in computer network communication.

Classification of Communication Systems

The following characteristics are essential regarding the practical implementation of computer networks:

- spatial extent of the network,
- type of computer networking *(direct or indirect networking)*,
- particular application characteristics for which the network is designed,
- degree of homogeneity of the components involved,
- targeted user groups *(public or non-public access)*,
- transmission capacity (bandwidth) of the network *(narrowband vs. broadband)*,
- technical transmission concept of the network *(broadcast network or point-to-point connection)*
- network operator type *(private or public)*.

Classification of Communication Systems

Table 3.1 A classification of computer networks based on their spatial extent

Distance	Location	Example
0.1 m	Circuit board	Multiprocessor system
1 m	System	Multiprocessor cluster
10 m	Room	Personal Area Network
100 m	Building	Local Area Network
1 km	Campus	
10 km	City	Metropolitan Area Network
100 km	Country	Wide Area Network
1,000 km	Continent	
10,000 km	Planet	Internet

Classification of Communication Systems

Personal Area Networks (PAN)

A personal area network is usually set up between small devices such as PDAs (Personal Digital Assistants) or mobile telephones, whose peripherals can be set up or dismantled ad hoc.

Local Area Networks (LAN)

The local area network range extends from individual rooms, to entire floors and multiple building complexes, whereby it is rare that more than one individual piece of property is networked via a LAN technology.

Classification of Communication Systems

Metropolitan Area Networks (MAN)

A metropolitan area network (MAN) is a broadband, communication network usually based on fiberglass technology. Its primary implementation is to link the most important office centers of one large city with another.

Wide Area Networks (WAN)

Remote networks and wide area networks extend over a large geographic area (e.g., country or continent) and serve the extended networking of end systems and individual LANs.

Classification of Communication Systems

A further criterion for the classification of computer networks is the type of computer networking within the communication system.

- If the computers, or more precisely data terminal equipment (DTEs), are directly connected to each other without independent routing computers being switched to organize the forwarding of data, one refers to a direct interconnection.
- If, in contrast, switching computers are involved in the forwarding of data one refers to an indirect connection.

Classification of Communication Systems

Computer networks and distributed systems

Distributed systems and computer networks have many **common characteristics** (see points 1-3), however they **differ** considerably in the software used and the transparency of the services provided (points 4-5):

- Similarities:

  1. An association of a multiple number of physically and logically different components whose tasks can be assigned dynamically.
  2. Individual components are spatially distributed.
  3. Individual components work autonomously but cooperatively.

- Differences:

  4. The services provided by the system components appear transparent in distributed systems and cannot be assigned by the user to a specific individual component.
  5. The computer network is controlled by a network operating system that coordinates the necessary processing steps of a user order.

Fig. 3.5 Computer networks and distributed systems.

Classification of Communication Systems

A distributed system appears as a homogeneous system to users, purposely concealing where and how the processing load is carried out.

The user has the impression of working in one single system and not on a composite made up of individual processing units. Direct allocation of resources and access to the system periphery are not visible for the user.

On the other hand, in a computer network the allocation of resources is dependent on the coordination of the user and not on the parent operating system.

Classification of Communication Systems

Computer networks can be subdivided according to their application characteristics:

- Function sharing
- Load sharing
- Message sharing
- Safety network

Computer networks can be subdivided according to type of interconnected computers:

- Homogeneous network *(if all computers are of the same type)*
- Heterogeneous network *(otherwise)*

Classification of Communication Systems

A further difference between networks can be identified that is based on connection type:

- Dial-up connection
- Leased line

Networks can be available for different kinds of user groups:

- Public access *(computer networks can be accessed by everyone)*
- Nonpublic *(only available to a limited user circle, such as the network of of banks, the police or military)*

Classification of Communication Systems

Private networks are distinguished from public networks.

Among private networks are all of those whose network infrastructure, i.e., cabling, network hardware and software belongs to a company or a private owner. The vast majority of local networks (LANs) located on private property and connected to the computers of the owner are private networks.

A public network is a network that can be compared to the traditional telephone network. Anyone who wants to connect a computer to a public network pays a network operator for permission to use the network.

A network that functions as a private network but is based on the infrastructure of the Internet is known as a virtual private network (VPN).

Topics

Computer Networks and Packet Switching

- Classic Point-to-Point Connections

Computer Networks and Packet Switching

A message that is to be sent is disassembled into individual data packets of fixed, predetermined length at the sender.

Independent of each other, these packets are sent separately through the labyrinth of the Internet. So that the packets are also able to find their way through different types of networks to the receiver there must be exchanges on the Internet. These are the so-called packet switches or routers.

The packets do indeed arrive where they should and can be reassembled into a meaningful message again. For this every single packet must receive additional information for the journey.

With the help of this additional information it is also possible to recognize transmission errors if they occur and even to be able to correct them.

Classic Point-to-Point Connections

Each one of the two communicating end systems has its own separate connection (cable, line, radio link), which means both terminals are permanently connected and can use the communication medium solely for their data exchange.

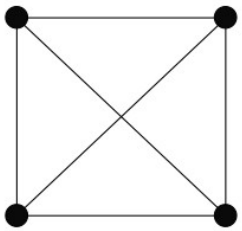
It is also an advantage that only the two communication partners need to agree on a common communication protocol. Implementation of the communication software is thus simplified considerably *(no consideration need be given to potentially different data formats, data sizes or error detection mechanisms)*.

Classic Point-to-Point Connections

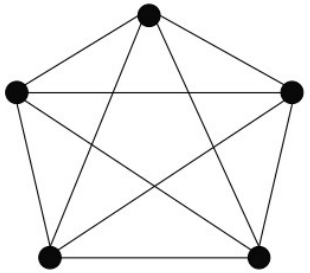
Point-to-Point Connections

Number of computers	Number of connections
4	6
5	10
6	15
7	21
10	45
100	4,950
1,000	499,500

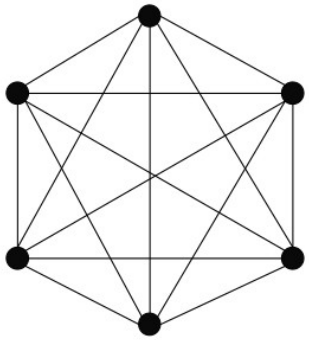
n=4



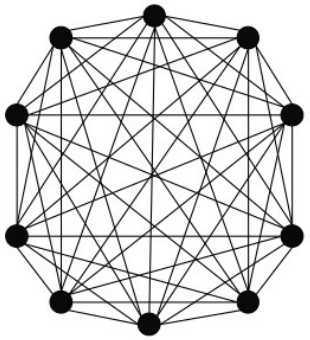
n=5



n=6



n=10



If n hosts are linked together using point-to-point connections, the following number of connections are needed:

$$\sum_{i=1}^{n-1} i = \frac{n^2 - n}{2}$$

Fig. 3.6 Point-to-point connections.

Classic Point-to-Point Connections

If more than two computers are linked to each other a point-to-point connection is a different matter. While theoretically simple to implement via an individual direct connection for all potential computer pairs, the required cabling effort quickly reaches its limits in practical application.

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