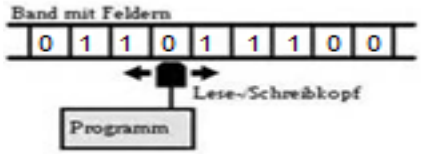
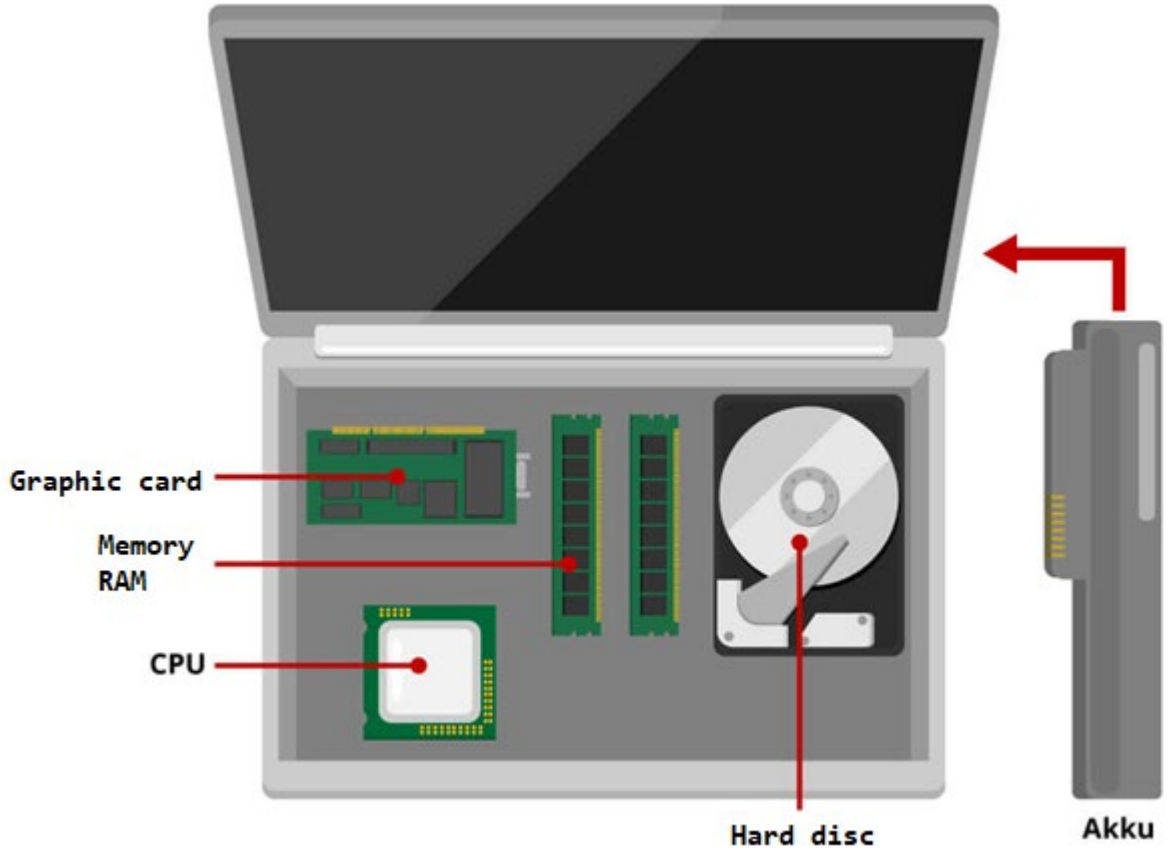
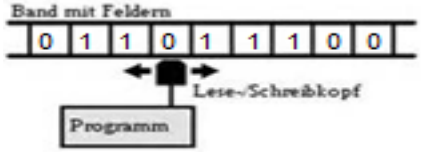


Hardware components of a computer

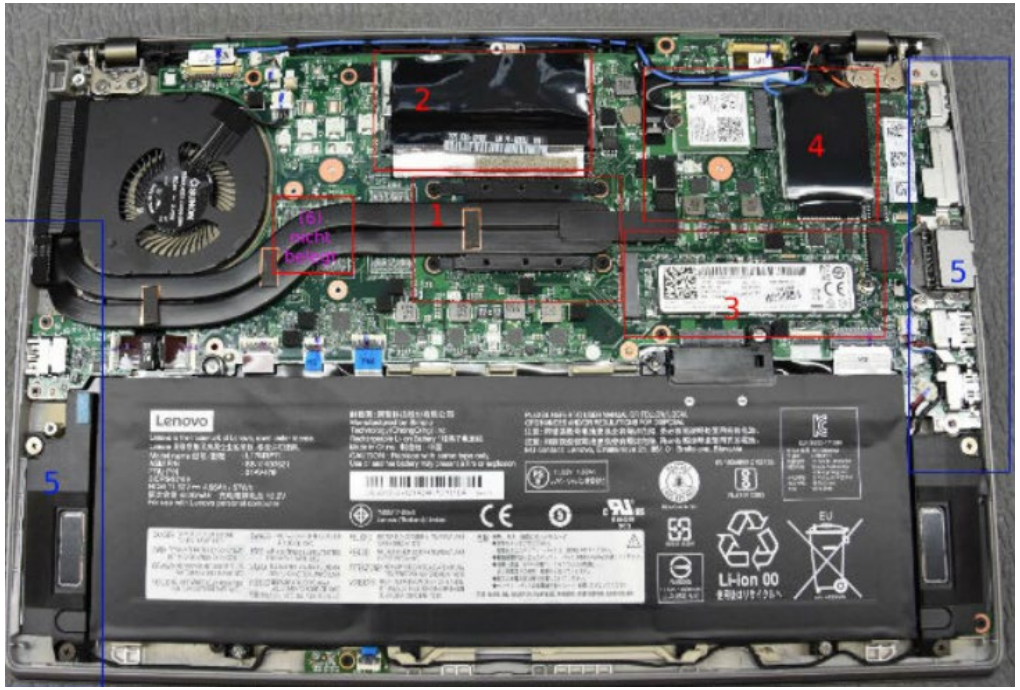


Internal structure of a computer



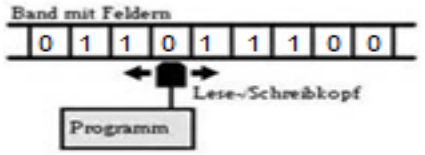
Central unit and peripherals

Laptop with central unit

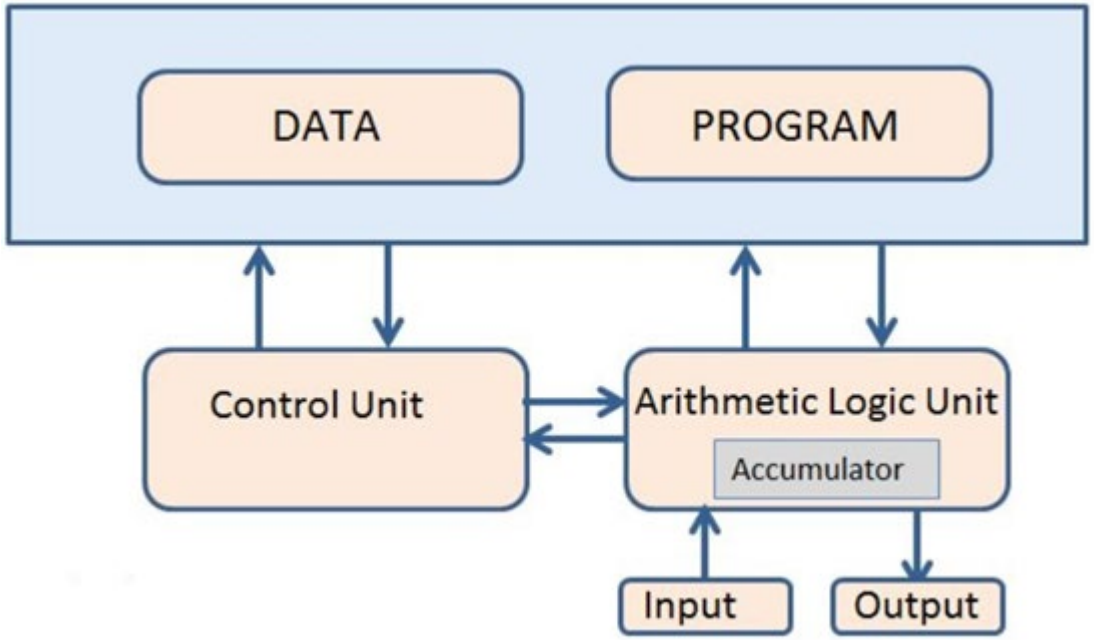


Periphery

Von Neumann Architecture

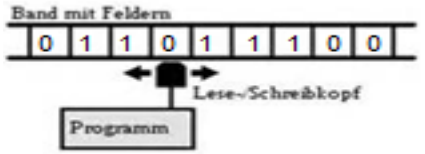


- The basic components of a von-Neumann computer. The memory contains both data and program code.



Von Neumann Architecture (VNA)

Von Neumann Architecture (VNA)



Structure

- The basic units are located on the motherboard (mainboard).

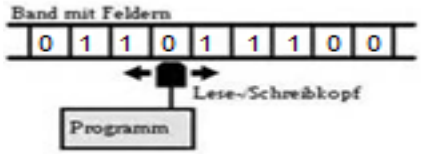
Operations

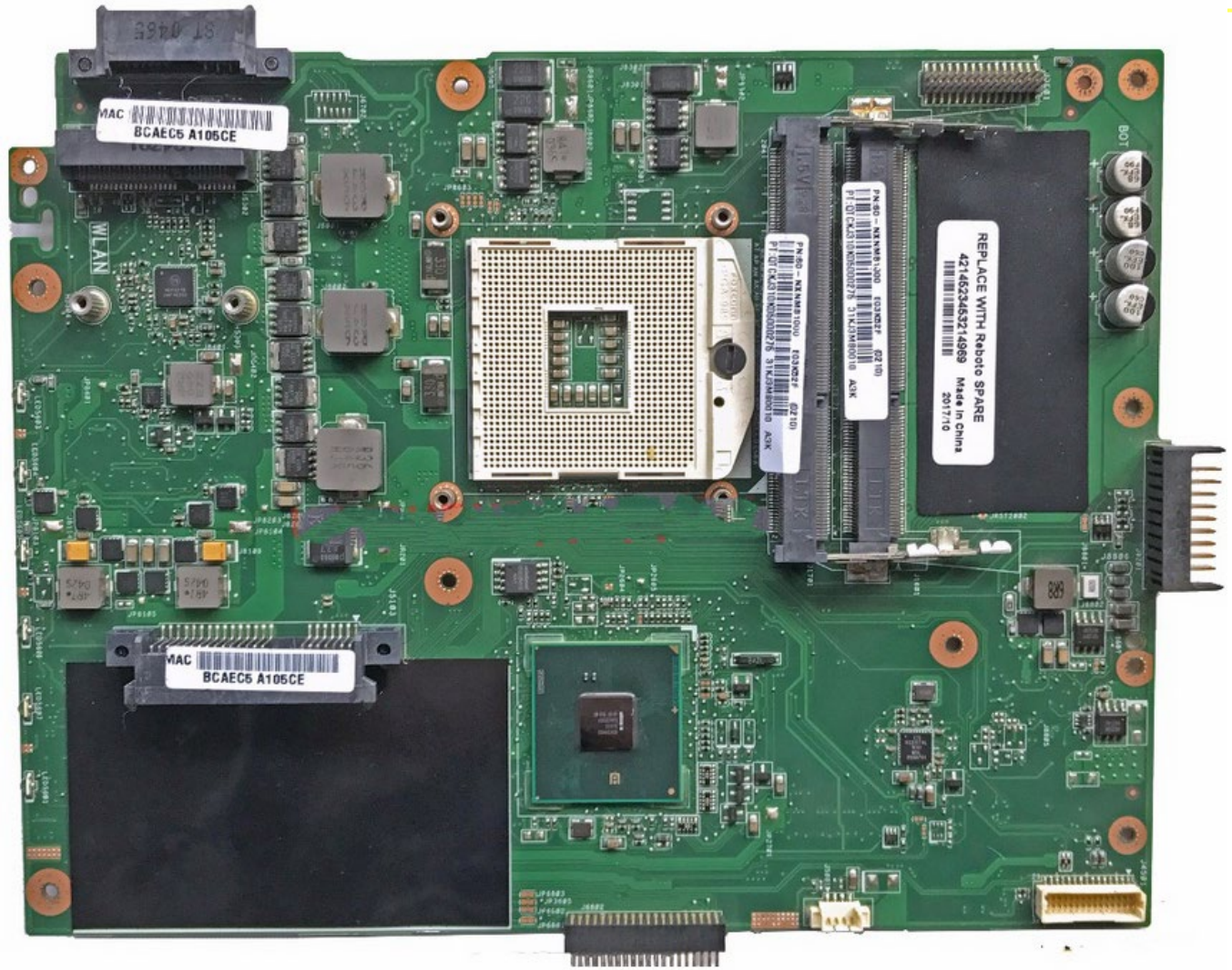
- The operations specified in form of machine instructions (assembly code) are applied to the content of the specified memory cell

```
SUB32   PROC          ; procedure begins here
        CMP   AX,97   ; compare AX to 97
        JL    DONE    ; if less, jump to DONE
        CMP   AX,122  ; compare AX to 122
        JG    DONE    ; if greater, jump to DONE
        SUB   AX,32   ; subtract 32 from AX
DONE:   RET           ; return to main program
SUB32   ENDP          ; procedure ends here
```

Example assembly code

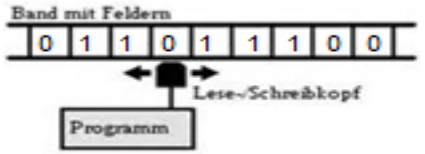
The central unit





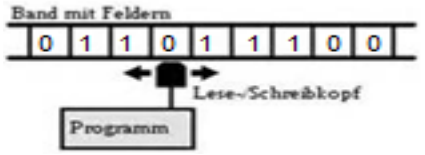
The motherboard or mainboard

The central unit



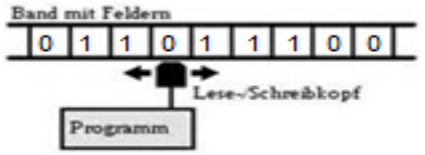
- The central unit consists mainly of the components of the motherboard (mainboard)
- The essential components on a motherboard are:
  - The micro processor (CPU, Central Processing Unit), which is responsible for running the programs as well as for controlling and managing the hardware. This is the heart of a computer.
  - RAM / Memory (RAM, Random Access Memory) contains the program that is currently running, as well as the necessary data.

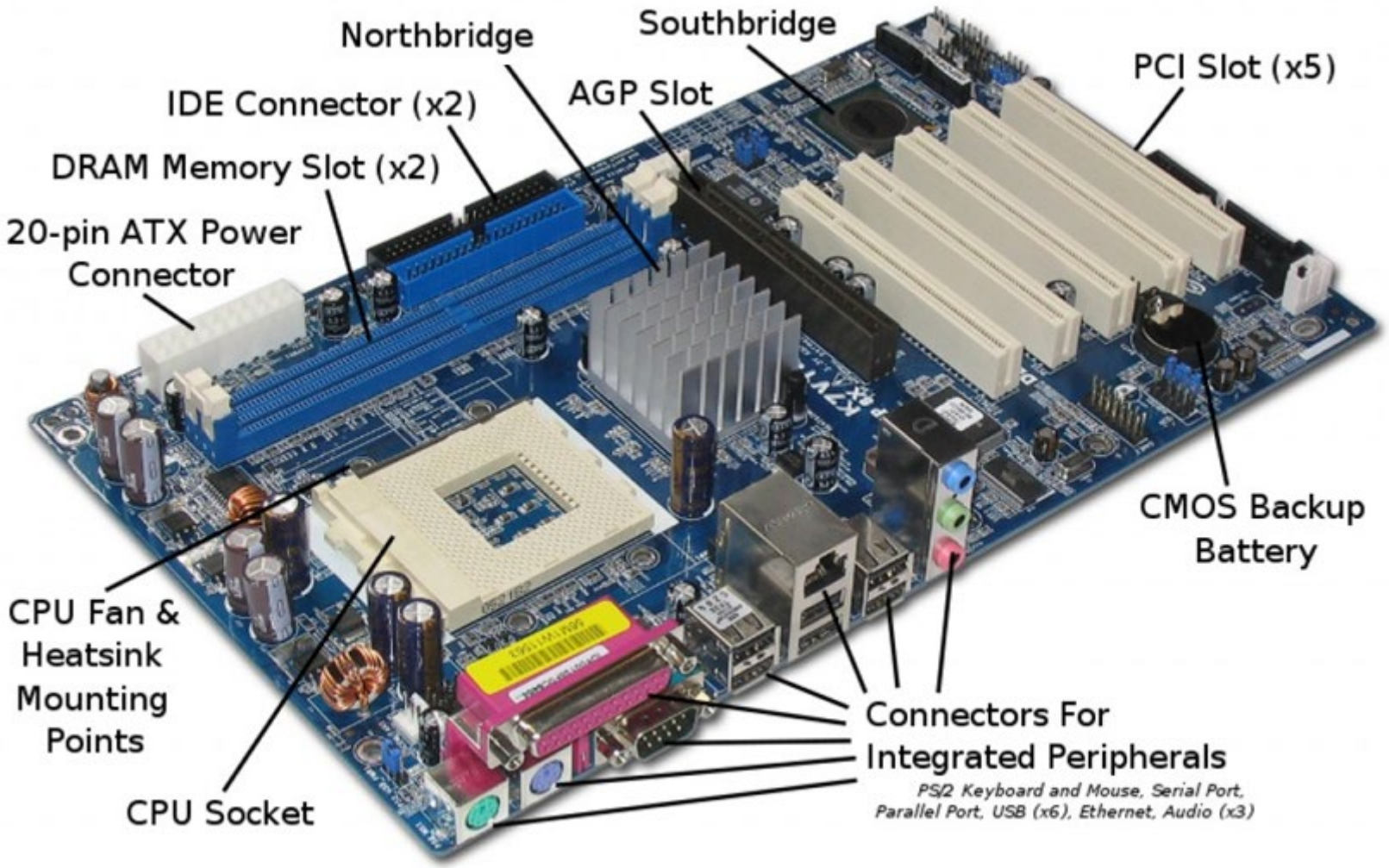
The central unit



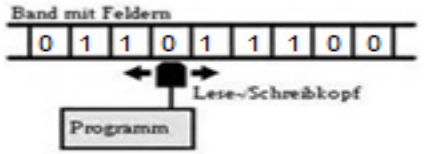
- The ROM usually contains a program (BIOS) that checks the most important hardware components when turned on and then boots the operating system of the hard disk.
- Buses and interfaces are used for the communication
  - between the individual components of the motherboard
  - Between the motherboard and peripherals, such as graphics cards, network cards, hard drives, printers, etc..
- The PCH (Platform Controller Hub) contains the clock and builds the interface between the CPU and the peripheral I/O (e.g., the USB slots or graphics card or network card).

The most important parts of the central unit

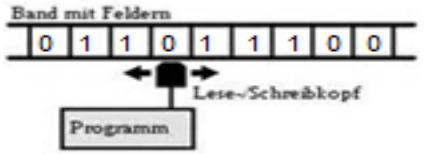




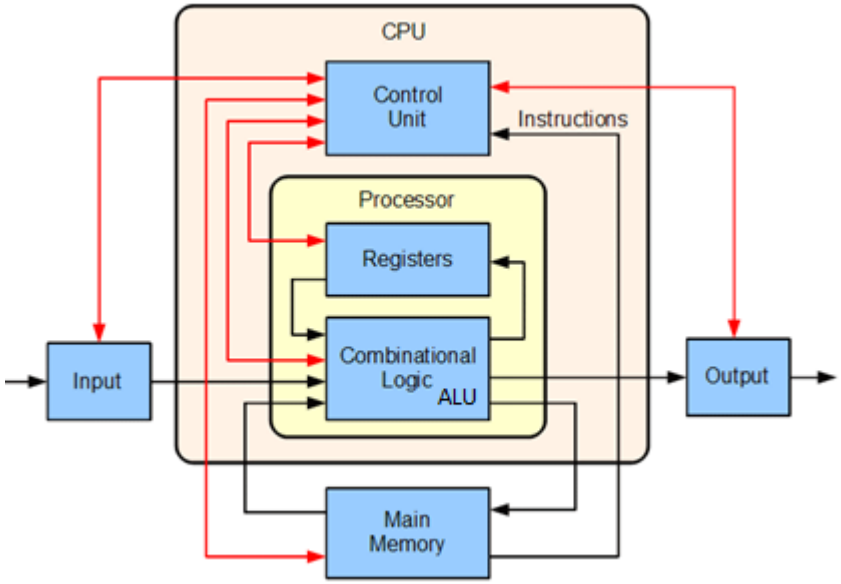
The processor (CPU)



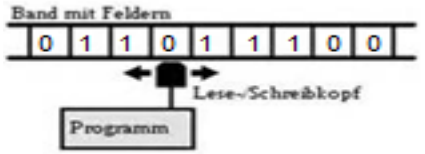
How a processor works



- The command counter points to the next machine command.
- The command is transferred from memory to the command register via the data bus. The command is analyzed and then executed.
- Depending on the command, reading data from memory, controlling peripheral interfaces, calculation in the ALU, or performing a jump is executed simultaneously.

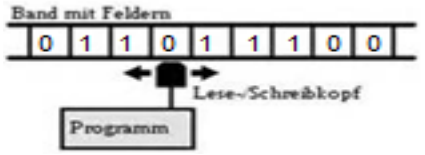


The memory (RAM)



- RAM is used to store (volatile) data.
- In case of a power interruption, the RAM contents are lost.
- RAM is used to store the program code and data, as the number of registers in the CPU is small (caching).

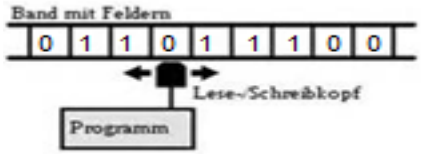
BIOS / UEFI

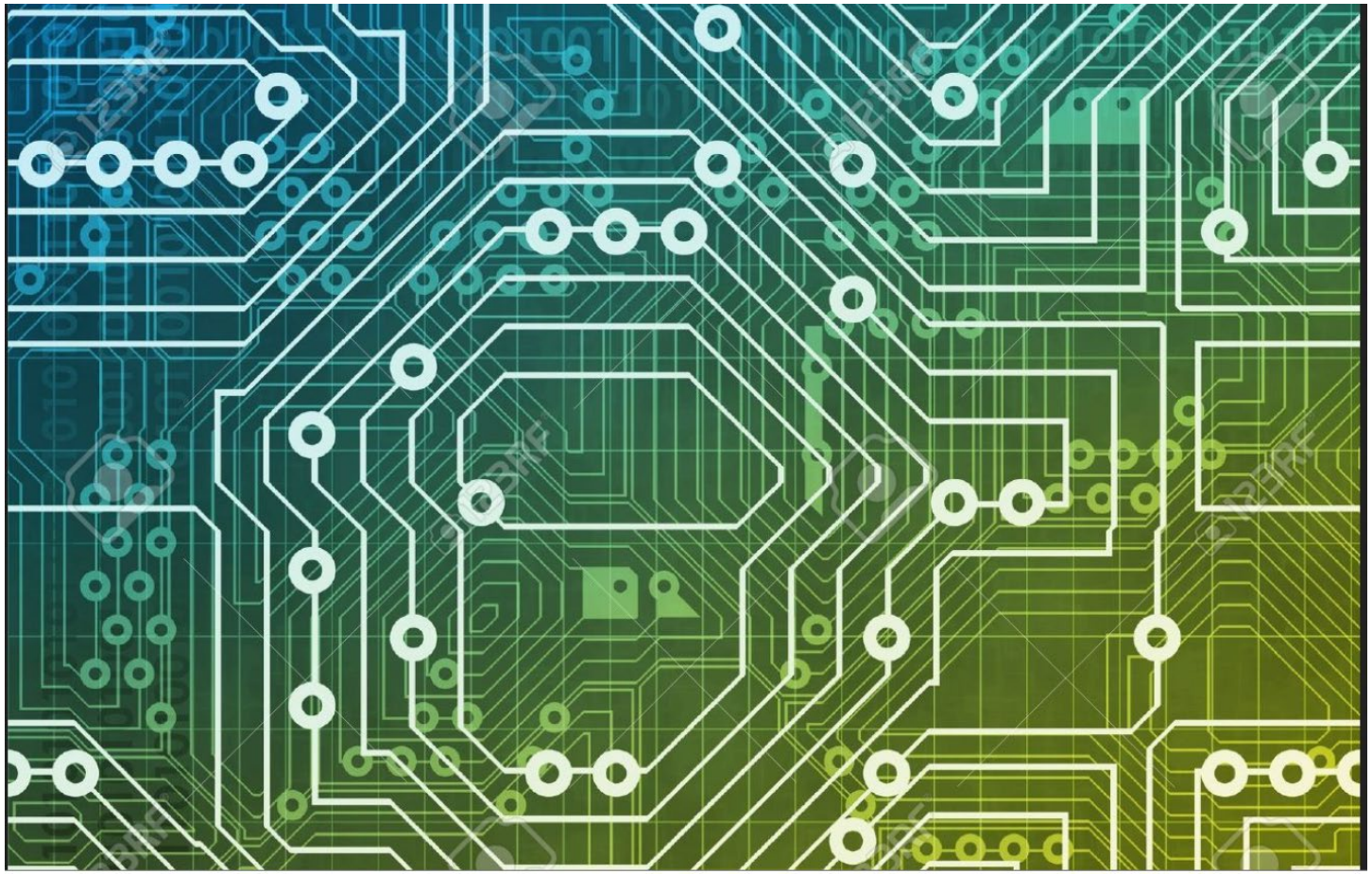


BIOS (Basic Input-Output System) / UEFI (Unified Extensible Firmware Interface)

- … is a chip that is located on the motherboard and contains the firmware.
- Firmware is the basic control logic to start the computer.
  - When the computer is booted, the initialization program from the BIOS or UEFI is run.
  - The BIOS / UEFI performs certain tests, displays the control messages, loads the operating system from the hard drive and starts it.

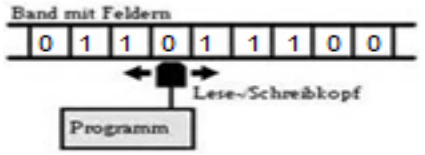
Busses and Interfaces





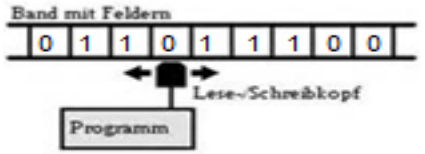
Circuits Background

Buses and interfaces

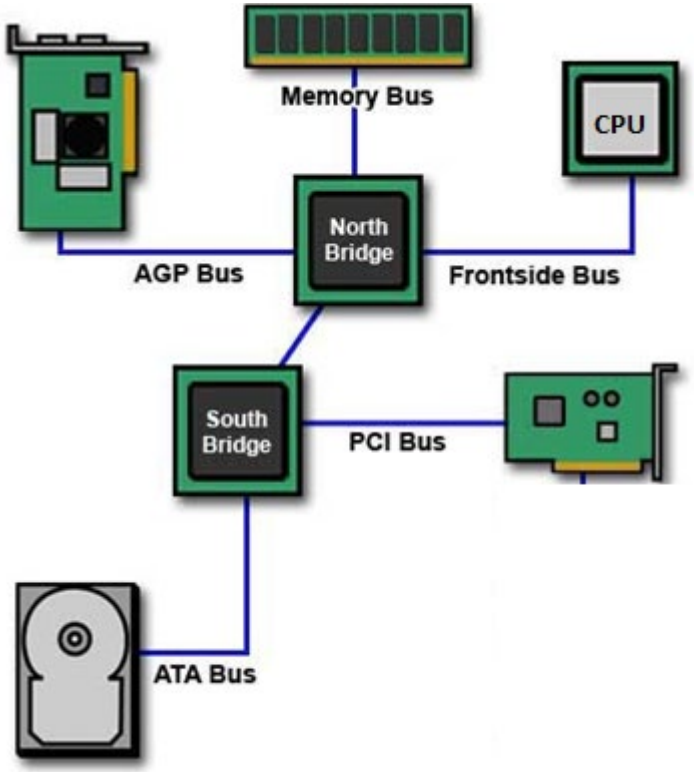


- Buses and interfaces are required for the communication between the individual components of the motherboard and for connecting all types of peripherals, such as the graphic cards, hard drives, printers, network, etc.
- The internal bus system is responsible for the transport of data between the units on the motherboard, the processor, memory and input/output units.

Buses and interfaces

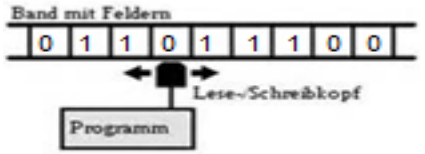


- A bus is a circuit that connects the different parts of the motherboard.
- The more data a bus can handle at one time, the faster it allows information to travel.
- The speed of the bus, measured in megahertz (MHz), refers to how much data can move across the bus simultaneously.

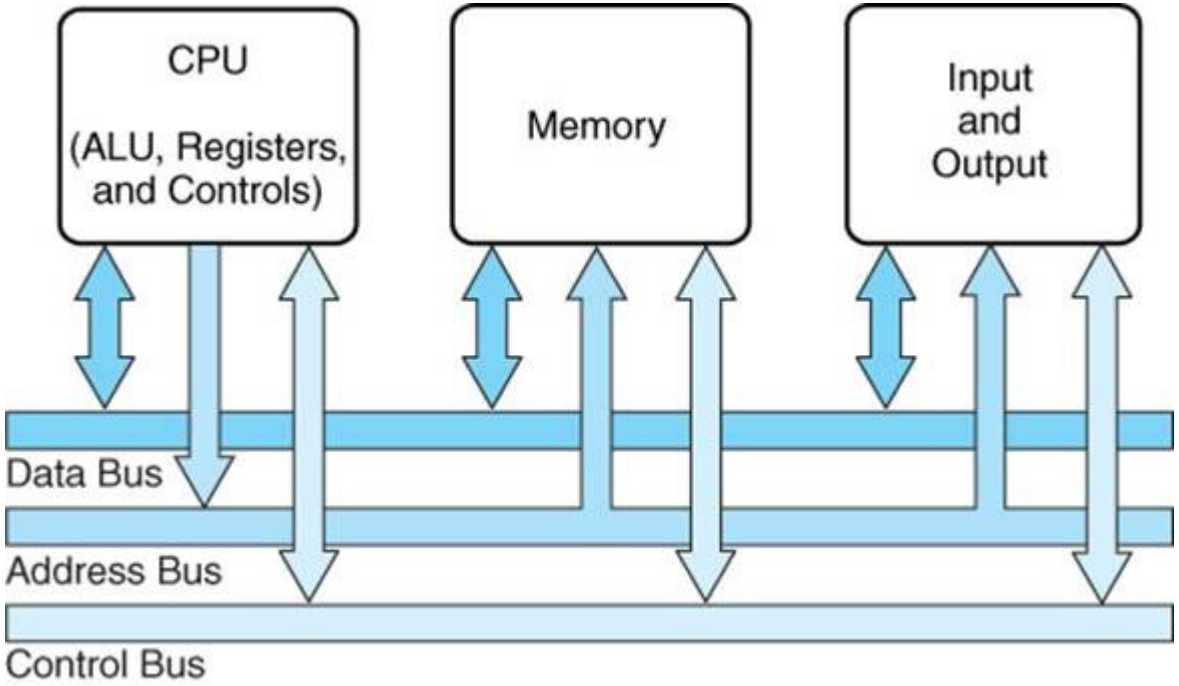


AGP: Accelerated Graphis Port
PCI: Peripheral Component Interconnect (Ethernet, USB, …)
ATA / IDE: Storage adapter interface (HD, DVD, ...)

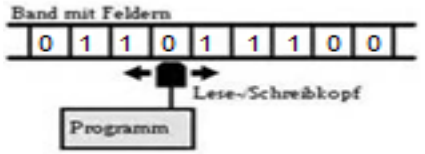
Schematic bus system

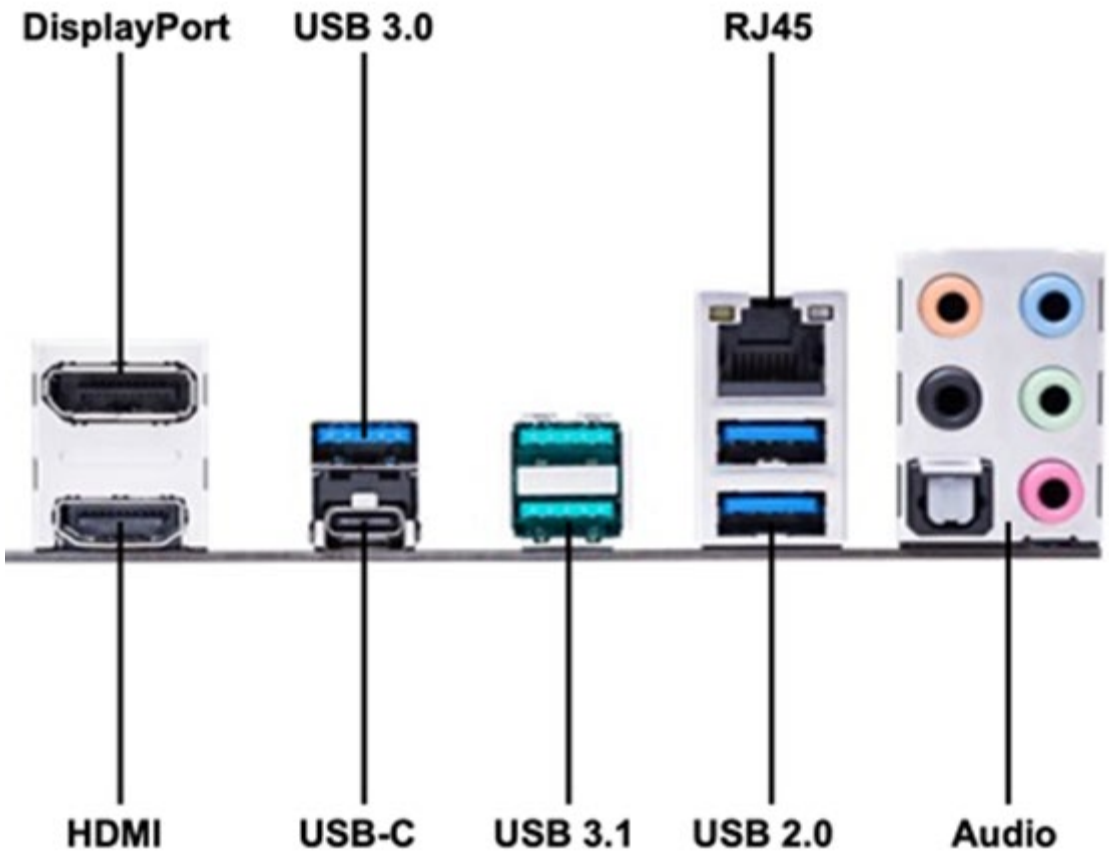


- Von Neumann Architecture

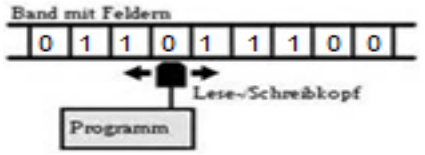


External Interfaces



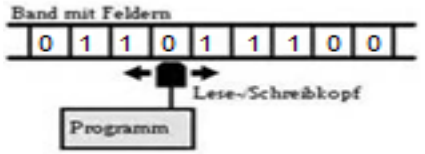


External Interfaces: USB



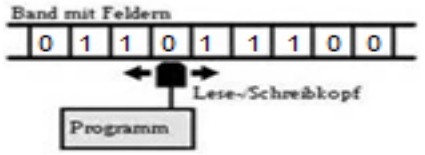
Universal Serial Bus (USB) is an industry standard for connecting peripheral devices to the computer. The advantage is the easy installation and handling (hot plugging, plug-and-play, a reboot is not necessary).

External Interfaces: Wireless



- Wireless interfaces
- Infrared connections: visual contact required (see remote control).
- Wireless connections (Bluetooth): Wireless connections with microwaves, only in the vicinity
- For higher data transfer rates: Wireless Networks (WLANs - Wireless LANs).

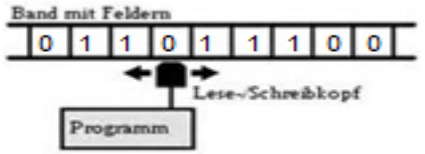
Serial and parallel data transmission



- In serial data transfer, the individual bits are transmitted one after the other
- In parallel transmission, the bits are simultaneously transmitted on several adjacent lines (e.g. 8, 16, 32 or 64 bits).
- Serial data transmission requires less power and can be used for longer distances.

- Serial data transmission is therefore used more frequently than the parallel.

Mass storage



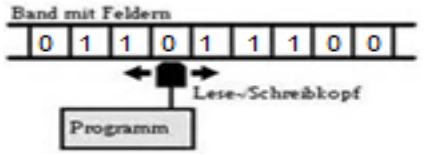
Mass storage uses various methods.

- Magnetic data carriers:
  - The bits are saved by magnetic areas with opposite polarity.

    -> e.g. hard drives or backup tapes.
- Optical media:
  - The data is stored on a reflective metal surface, which is scanned by a laser beam.
  - The bits are represented by drilled holes (pits)

    -> CD/DVD.

Mass storage: SSD



Hard disks are increasingly replaced by much faster but more expensive solid-state disks (SSD).

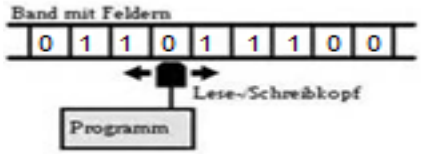
- SSD uses flash memory
- SSD has no mechanical components

  →no noise, less power needed, insensitive to rotations or shocks

The data is continuously moved internally in order to achieve a uniform “aging” → longer lifetime.

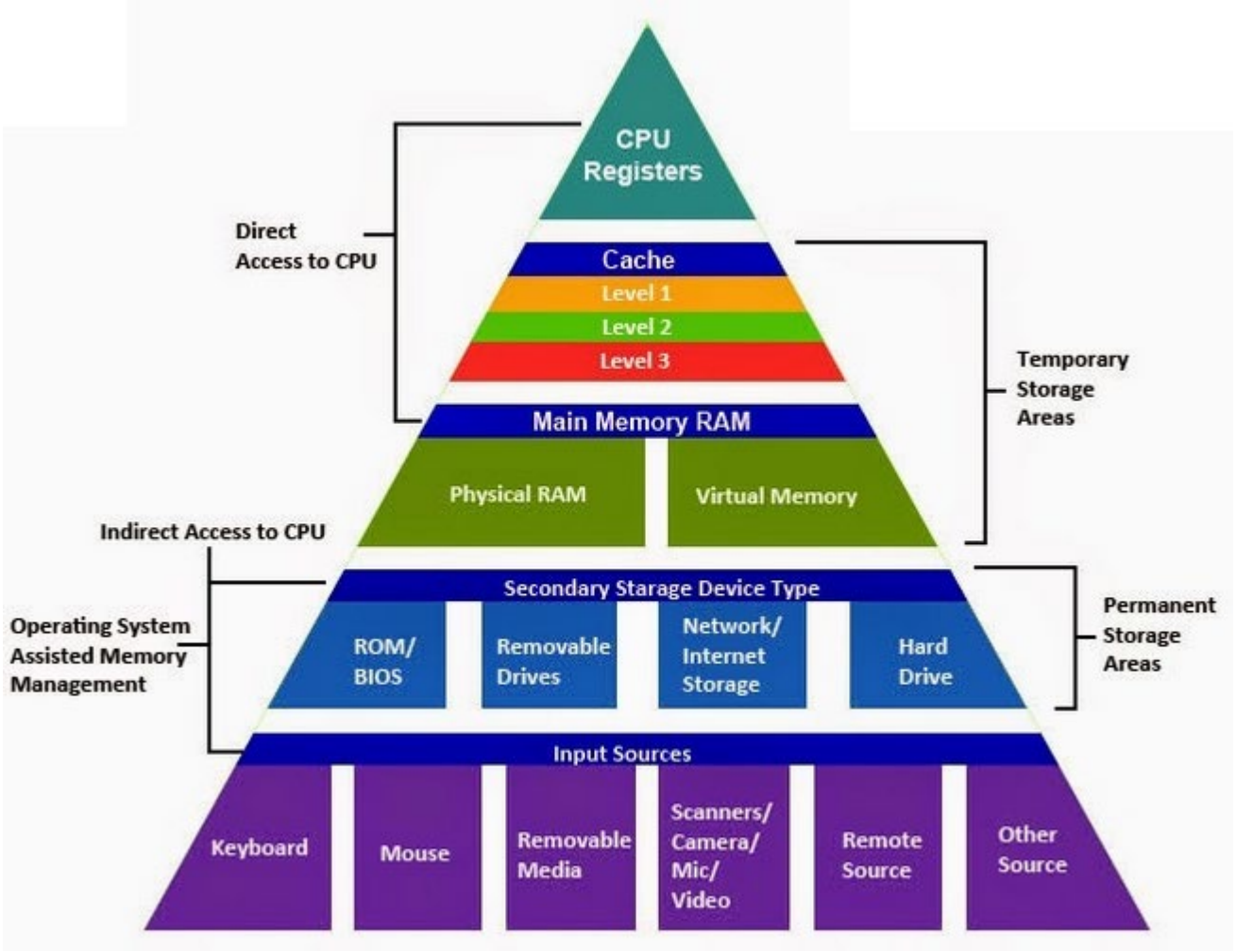
USB sticks are also flash memory chips.

Mass storage



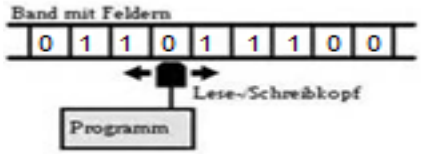
Memory hierarchy

Access speed

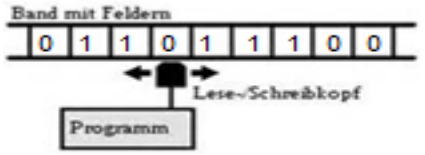


Costs per MB

Distributed Systems



Distributed System



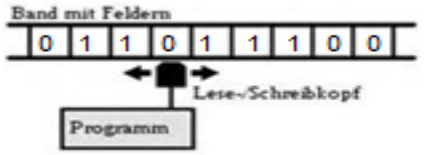
In distributed systems, components are realized on different platforms and several components can cooperate with one another over a communication network.

- Hardware and software resources are shared.
- It is possible to use hardware and software of different vendors.
- Higher performance by concurrent processing.
- Throughput is easily increased by adding new resources.
- Fault tolerance through compensation.

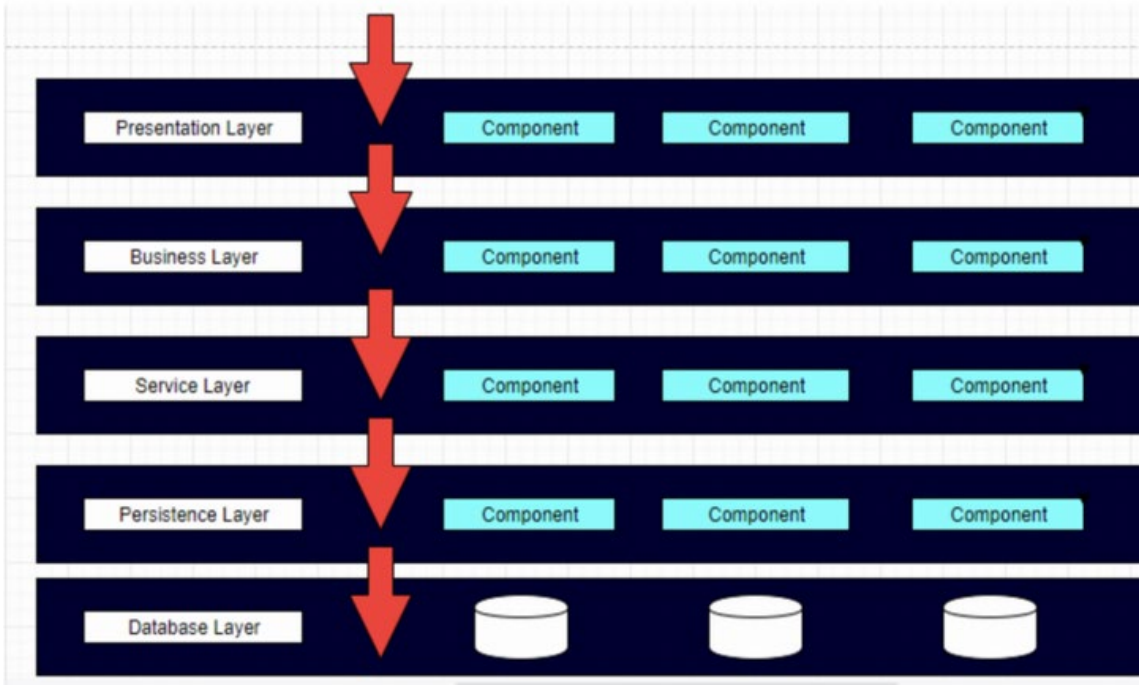
→ But:

Enhanced complexity during maintenance and use!

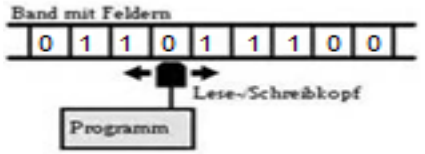
Layered Architecture (Multitier)



- In a layered architecture the components are organized in horizontal layers.
- All components are interconnected but do not depend on each other.
- All request go from top to bottom



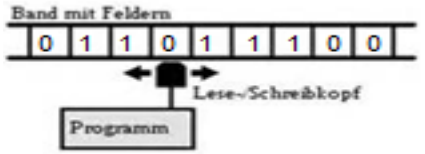
Characteristics of a Layered Architecture

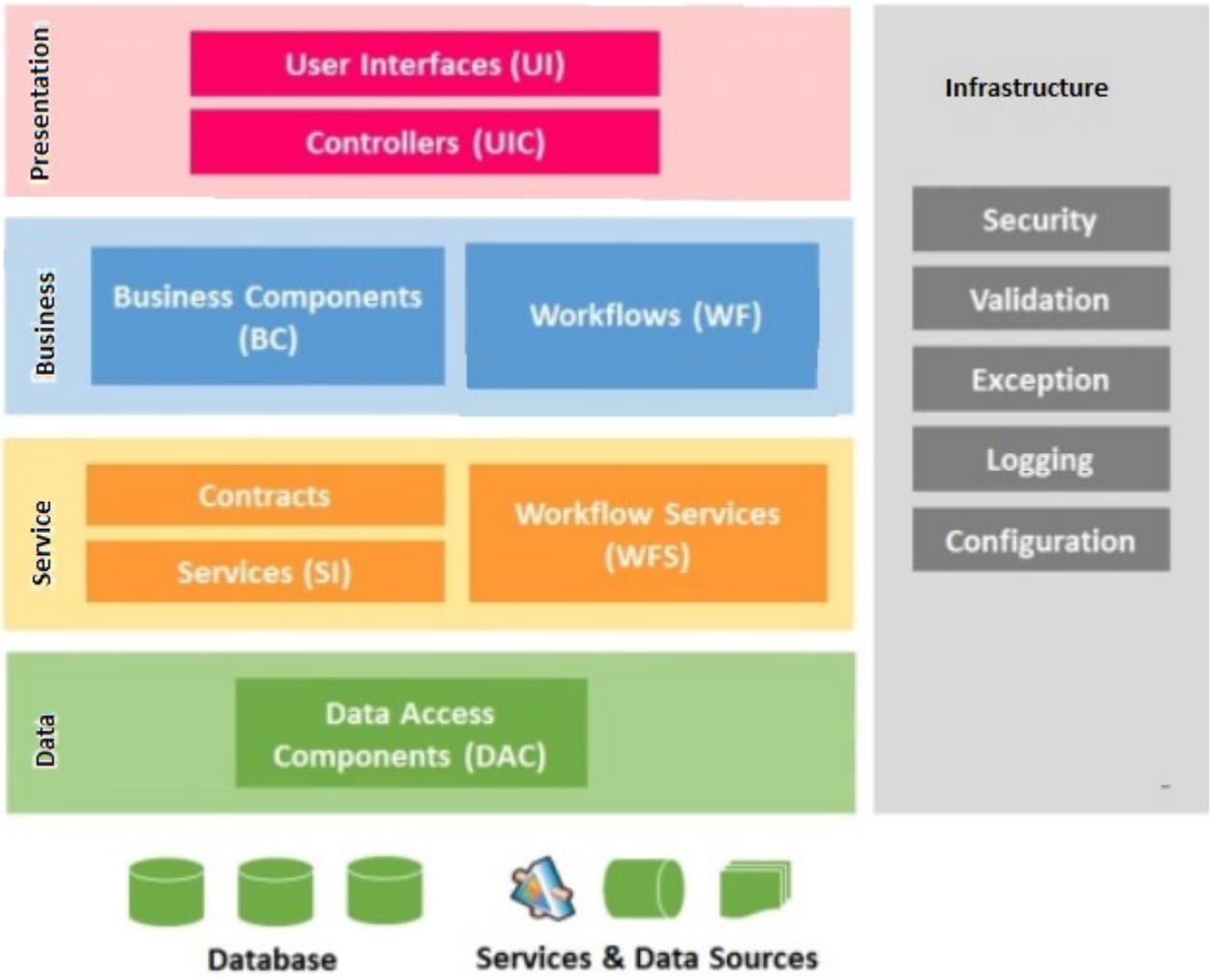


- Similar types of components are collected in one layer helps gather similar programming code together in one location.
- The layers are independent from one another.
- Clear definitions of responsibilities and interfaces help that changes in one layer have no impact to any other layers.
- Every layer can be tested separately.

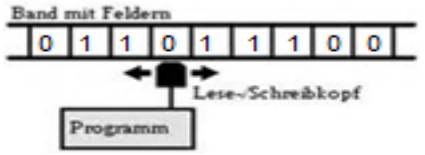
→ Has become the usual architecture for most (complex) software systems.

Layered Architecture Example

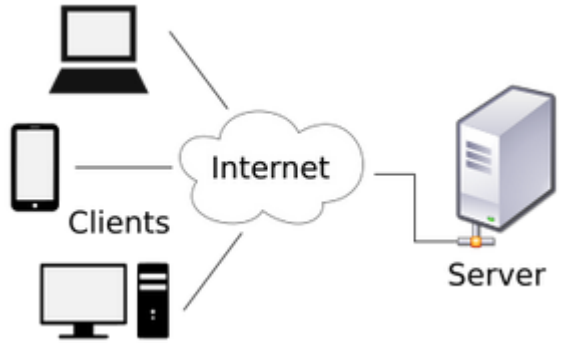




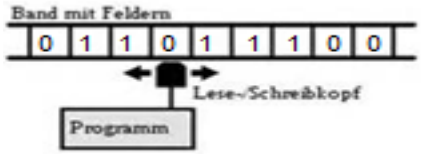
Client Server Architecture



- The term client server describes the relationship between two applications.
- The client requests a service from the server. The server fulfills the request.
- The client server paradigm can also be used by programs within a single computer
- On a network, the client-server model is a proven way to connect distributed applications or systems.

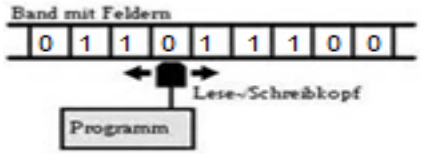


Characteristics of the Client Server model



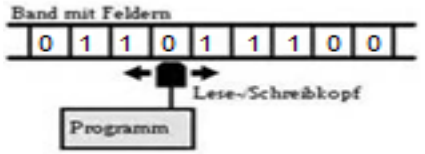
- The tasks are distributed between client and server.
- One server provides different services for many clients.
- Clients request for a service from a server.
- The communication and exchange of information works via predefined protocols (e.g. TCP/IP)
- Server and client functions or tasks are not tied to a physical hardware.
- Physical computers can perform as both client or server.
- The origin of the interaction is always at the client.

Client-Server Application Examples



Application	Client	Server
WWW, Browsing in the Internet	Firefox, Chrom, Internet Explorer, …	Web-Server (Apache, Microsoft, …)
E-Mail (read/write)	Thunderbird, Outlook, …	MS-Exchange, Zimbra, Eudora, …
File (read/write)	Operating System	File-Server, local or remote
Print a document	Operation System, Device driver	Print Server
Find a service and forward a request	Operating System	Proxy Server

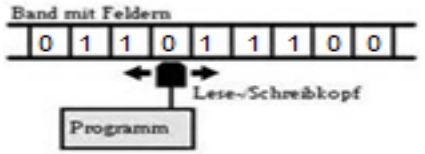
Peer to Peer (P2P)



A P2P network is computer network

- in which all computers in the network work together as peers.
- each computer or server can offer functions and services to the others
- each computer can use functions, resources, services and files offered by other computers.
- The data is distributed over many computers.

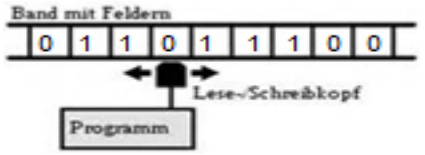
Peer to Peer (P2P)



- P2P is decentralized concept, with no central server.
- Each computer can be connected to several other computers.
- Each node provides data or resources.
- Unstructured P2P networks organize themselves.
- Since only the target system has information about the stored data, searches are made via flooding.

- In structured peer-to-peer networks, the routes to specific data on individual devices is stored (on specific nodes).

P2P Application Examples



Application	Client
	Distributed Database
Blockchain	Distributed Accounts (Internet of Values)
Skype	Internet telephony
BitTorrent	Distributed Filesharing (e.g. videos, …)
Napster	Streaming and download service