Høyskolen Kristiania

Digital technology

TK1104-1 22H

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Hardware-Computer Organization

So far

- Generally
  - First Abstraction level, computer defintion
  - Digital vs analog, Harware, Software
- Computation in computer
  - Binary system
- Computer Arch.

  Gates, digtal circutes
- TYPES: Analog vs. Digital, Continuous vs. Discrete, Specialized vs. General, Electronic vs. Mechanical
  - https://www.youtube.com/watch?v=btgAUdbj85E&t=10s
  - https://www.youtube.com/watch?v=L_j8wlm2NKA

Today

- Instructions and programming based on CPU
  - Structure, Register, IPOS

- Construction of (IBM) PC systems.
  - Not the only ones, previous lecture.
  - Not looking at EVERYTHING.
  - Hopefully some of the most important

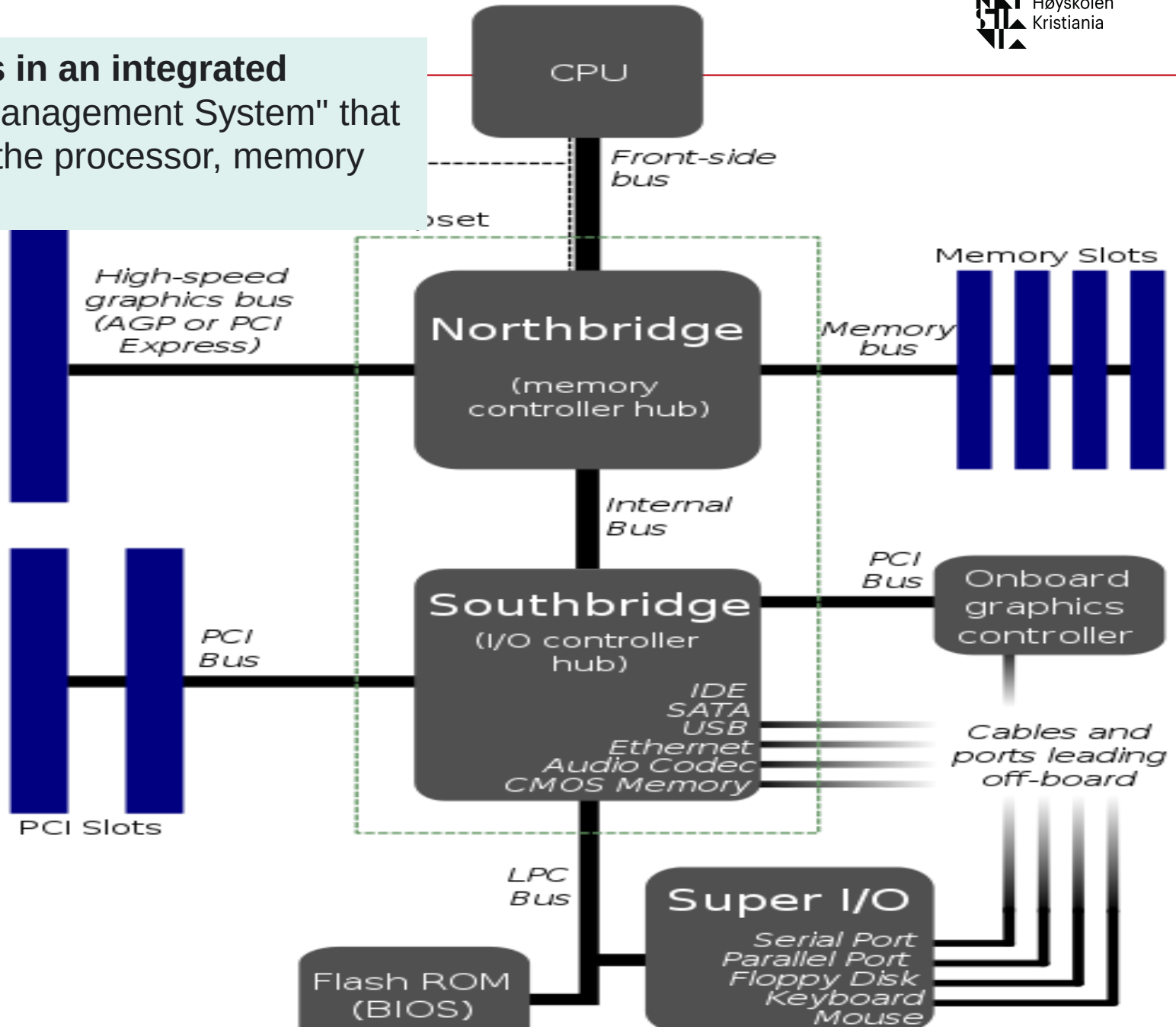
- Most important
  - Understand context
  - Not all components in detail,
    - but what type they are &
    - How they relate to the rest

The motherboard

Motherboard

a set of electronic components in an integrated circuit known as a "Data Flow Management System" that manages the data flow between the processor, memory and peripherals

- Conn
  - C
  - Chipset
  - Buses
  - Memory tracks and RAM
  - Expansion slots and extra cards
  - Gates and «plugs»



Modern Motherboard Ports & Chipsets

DIMM (dual in-line memory module) slots are the place on your **motherboard** where the **RAM** goes

1. CPU socket
2. Chipset
3. DIMM/RAM slots

X16 ideal for large and power hungry cards like a graphics card

6. M.2 connector

To connect hard drives to motherboards

8. Front panel connectors
9. USB 2. header

10. USB 3.1 Gen 1 header

The BIOS is the program that starts a computer up, and the CMOS is where the **BIOS stores the date, time, and system configuration details** it needs to start the computer. ... CMOS is a type of memory technology, but most people use the term to refer to the chip that stores variable data for startup.

13. CPU power connector
14. BIOS chips
15. CMOS battery

16. Fan headers
17. Front panel header
18. VRM heatsink

Voltage Regulator Thermal Module Pad

19. COM/Serial header
20. TPM header
21. RGB header

Different USBs

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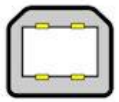
USB 1.0
12mbps

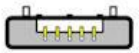
Type A



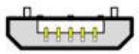
Type B

Mini-A

Mini-B



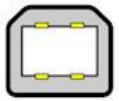
Micro-A



Micro-B

USB 2.0
480mbps

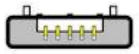
Type A



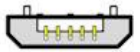
Type B

Mini-A

Mini-B



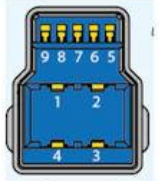
Micro-A



Micro-B

USB 3.1 Gen1
(Previously 3.0)
5gbps

Type A

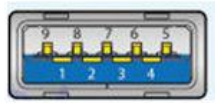


Type B

Mini-B

Micro-B

USB 3.1 Gen2
10gbps



Type A

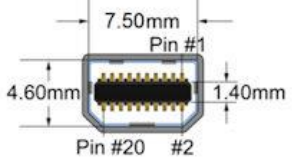
Type-C

USB 3.2
20gbps

Type-C

Thunderbolt 2
20gbps

Mini DisplayPort Connector



Thunderbolt 3
40gbps

Type-C

https://www.youtube.com/watch?v=dERa_bMDvcg

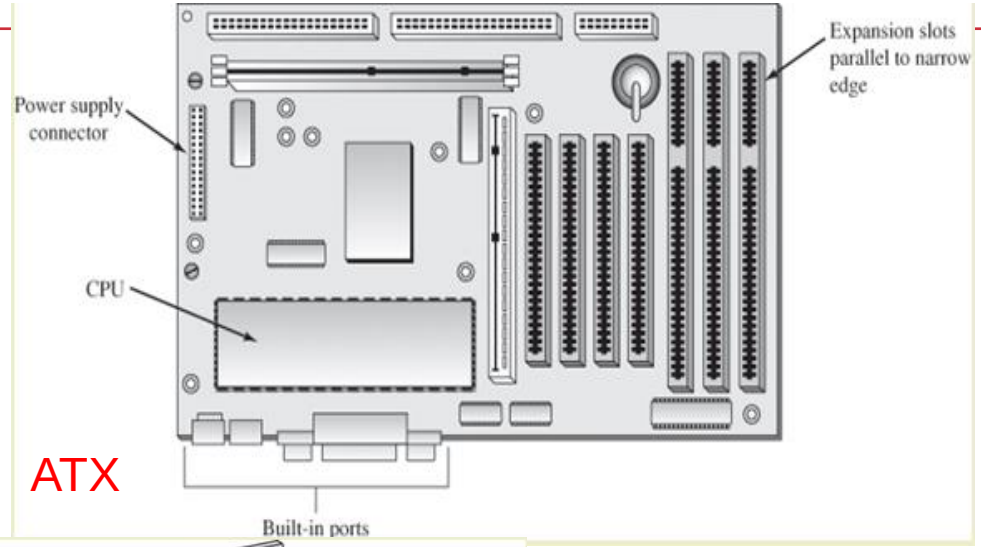
Rear Ports

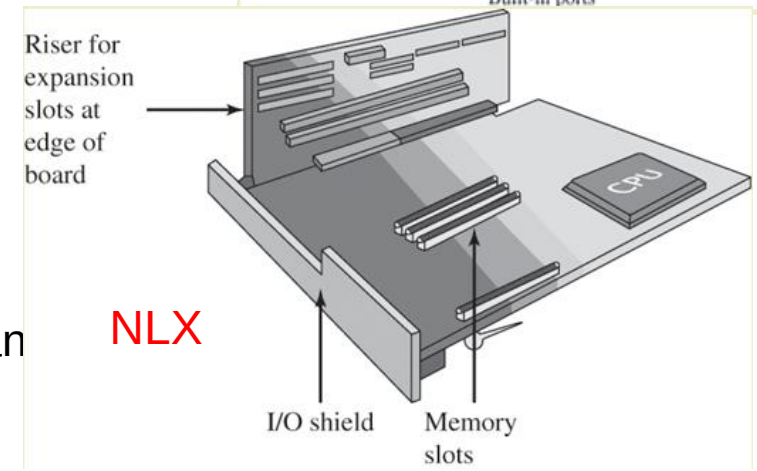
High-Definition Multimedia Interface (**HDMI**) is an audio/video interface for transmitting uncompressed video data and compressed or uncompressed digital audio data from an HDMI-compliant source device, such as a display controller, to a compatible computer monitor, video projector, digital television, or digital audio device.

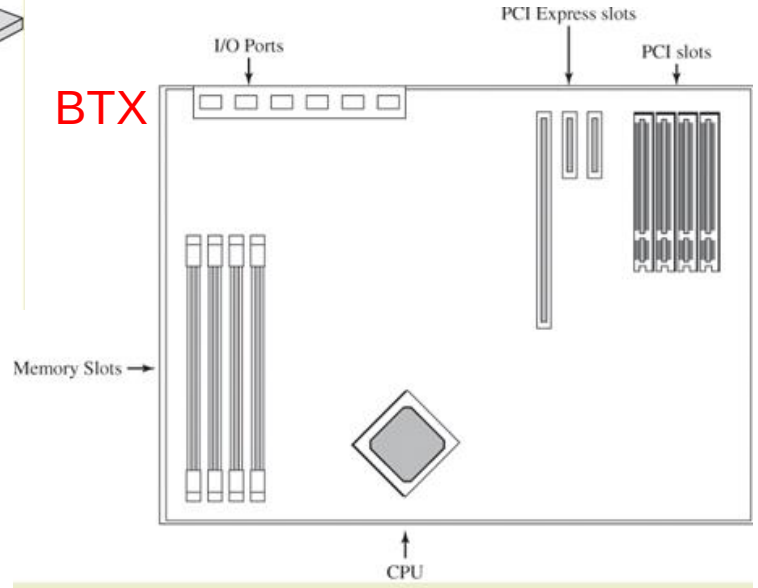
22. PS/2 Keyboard/Mouse port	23. USB 3.0/3.1 Gen1 ports
24. DisplayPort	25. HDMI port
26. USB Type-C	27. USB 3.1 Gen2
28. Ethernet port	29. Analogue/digital audio ports

Form factor

- The form factor defines the physical size, design and to some extent available functionality on the motherboard.
- ATX (12"x9.6")
  - Expansion grooves on the wide edge
  - Built-in IO ports on one side
  - CPU oriented so it can be cooled by the power supply fan
  - CPU and RAM perpendicular to expansion slots
  - Additional space for extra cooling
  - Micro ATX (9.6 "x9.6")
    - Smaller machines
- NLX
  - Standing expansion.
- BTX
  - Should provide better cooling options than ATX
  - Three different sizes:
    - Full (326 x 266 mm)
    - microBTX (264 x 266 mm)
    - picoBTX (203 x 266 mm)





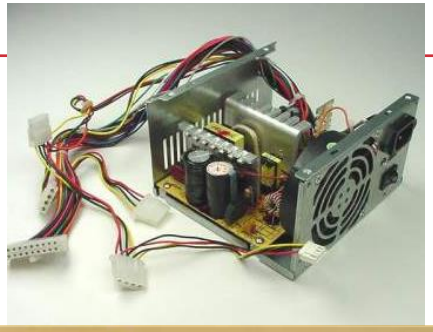


Integrated and Non-Integrated

- Many motherboards are integrated and come with CPU, video card including GPU, network card, bus controllers and everything ready built into the card itself.
  - Typically for e.g. cheap laptops etc..
- Non-integrated motherboards.
  - Fits additions as expansion cards
  - Disk controllers, video cards, network cards,…
- Increasingly unclear distinction nowadays…

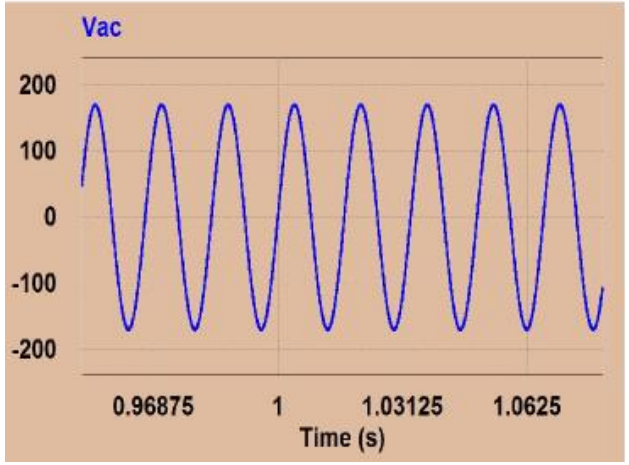
Power supply

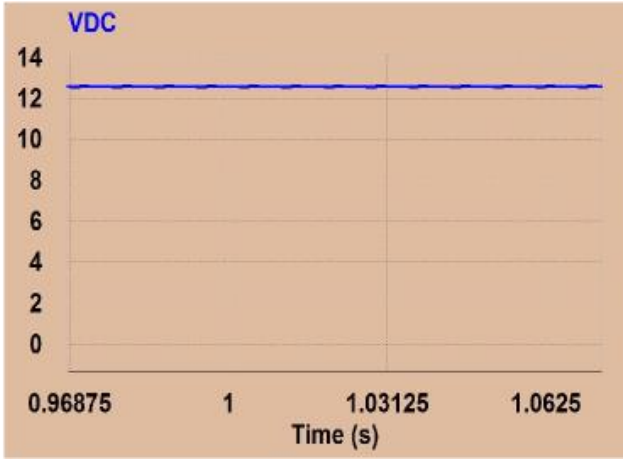
- Transforms 220 V, 50 Hz AC (AC) to the voltages DC (DC) components of the motherboard need
  - 3,3 V
  - +/-5 V
  - +/- 12V
- The type of power supply you can use depends on the other things, form factor on the motherboard



AC Voltage In

DC Voltage Out





CPU

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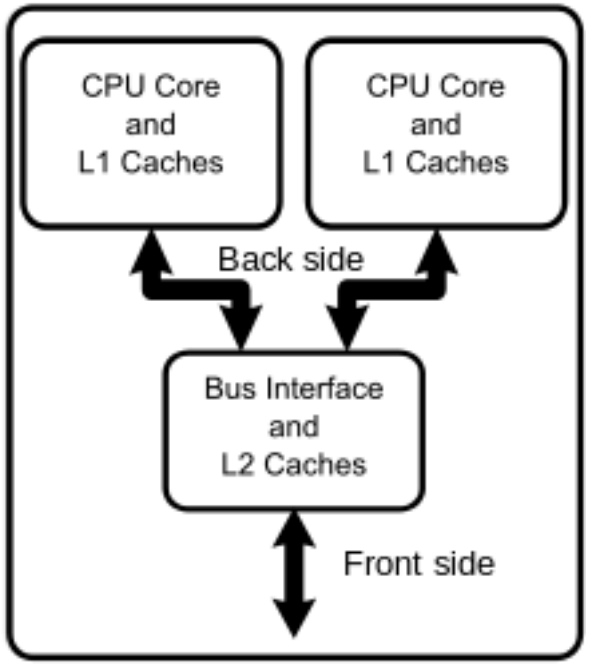
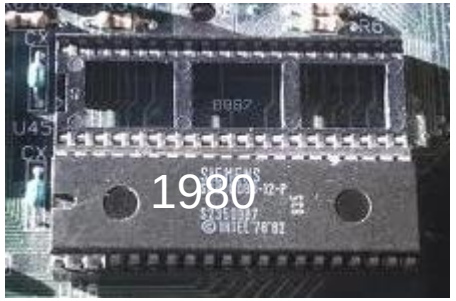
CPU Socket

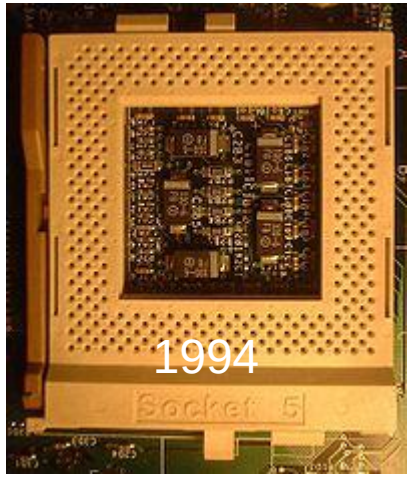
- The CPU is connected to the motherboard through a socket (or in an expansion slot)
- Different types with different number of slots for CPU pins

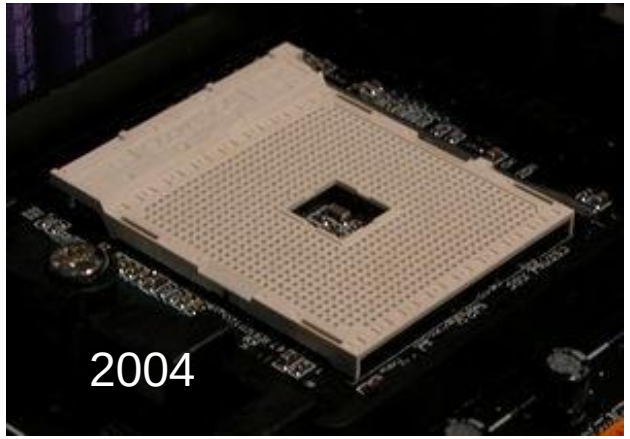
- Speed on Front Side Bus (FSB)

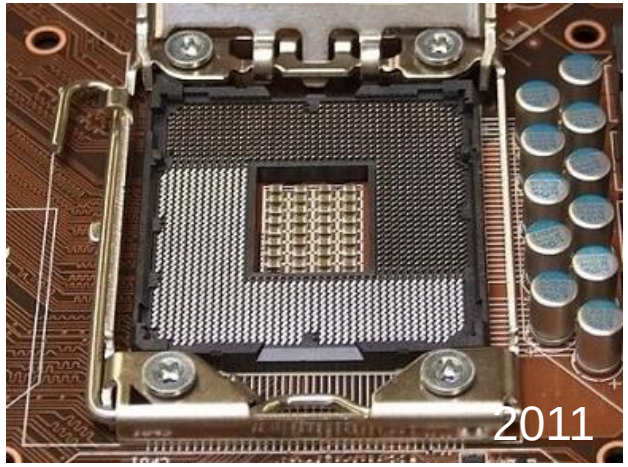
Depends on the motherboard









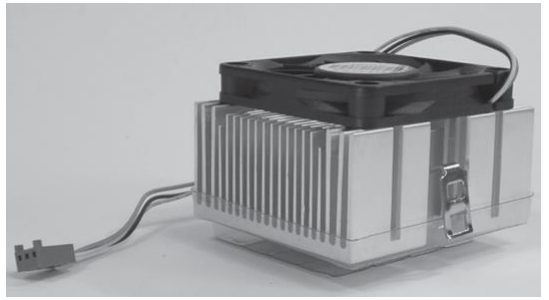


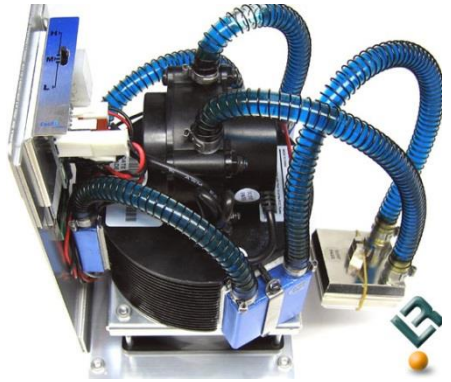
CPU cooling

- CPU
  - Power (W = J / s) is energy per unit time, **1 Watts = 1 Joules per second**
  - manifests itself as heat generation
  - E = UI, U = RI (Ohm's law), $E = RI^2$

    Ohm's law can be expressed as *I = U / R where*
    I = current (ampere, A), U = electrical potential (volts, V),R = resistance (ohms, Ω)

    Electrical Power = energy
    $E=UI=RI^2$
  - => The heat rises with the square of the current
- Air cooling
  - Uses fan
- Liquid cooling
  - Pumps away the heat with liquid
  - Typical water (or liquid nitrogen)





Troubleshooting: CPU

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- Typical problems are cooling or electricity
- Symptoms
  - PC does not boot or load OS
  - PC crashes with some applications
  - Sudden POST errors for a lot of different equipment

error message displayed on the monitor during the power-on self test if the BIOS encounters some kind of problem while starting the PC.

  - Heat problems (typical)
  - PC boots, but stops / freezes / reboots after a few minutes
  - Mt

itigation: better cooling

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RAM

Bit, Byte and Word

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- BIT
  - **B**inary Dig**IT**
  - On/off
  - 1 or 0
- BYTE
  - 8 BIT
  - Can store e.g. an alphanumeric character
  - Smallest addressable device in RAM.
- **WORD**
  - In computer architecture, this has several meanings
  - The size of a register
  - The number of BIT the CPU can process as a unit
  - Addressing unit

Types of Memory Problems

- Configuration
  - More memory than PC or OS support
  - BIOS CMOS error
- Hardware
  - Defective pieces or modules
  - Incompatible modules.
- Installation
  - the module is not inserted correctly into the slot
  - Tracks ("socket" defective, or should be cleaned)

Memory troubleshooting

- Other components can cause problems that look like memory problems!
- Memory problems typically show up:
  - First booting
  - Immediately after installing
  - new RAM module
  - new software or new OS
  - After new hardware has been added, or old removed
  - Completely without any obvious cause
  - Corrosion ("rust")
  - Heat damage

Common RAM issues

- PC does not boot, POST beep code
  - Memory inserted, or configured, incorrectly
- PC boot to blank screen
  - Memory module detached
  - Memory module of the wrong type
- POST memory count error
  - Incorrect RAM module type
- "Memory Error" message
  - Compatibility issues with old and newly installed RAM
  - RAM module about to break

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Peripheral buses & equipment

I/O devices

- Almost endless selection of I / O
- Common concepts
  - Gate
  - Bus (daisy chain or shared direct access)
  - Controller (host adapter)
- I/O instructions control devices
- The collaboration with the OS usually takes place through a driver that translates the OS instructions into Controller instructions

A **host adapter**, **HBA** (**host bus adapter**), or **host controller**
allowing communication with devices

some host adapter can be added to a computer, like a PCI card, others are integrated into the computer motherboard (e.g., hard drive host adapter). Integrated host adapter are commonly referred to as IDE ports or SATA ports on a motherboard.

VIA VT6308S Host Controller

ComputerHope.com

Addressing devices: Direct, *Memory-mapped*

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- **Memory-mapped I/O** (**MMIO**) and **port-mapped I/O** (**PMIO**) are two complementary methods of performing input/output (I/O) between the central processing unit (CPU) and peripheral devices

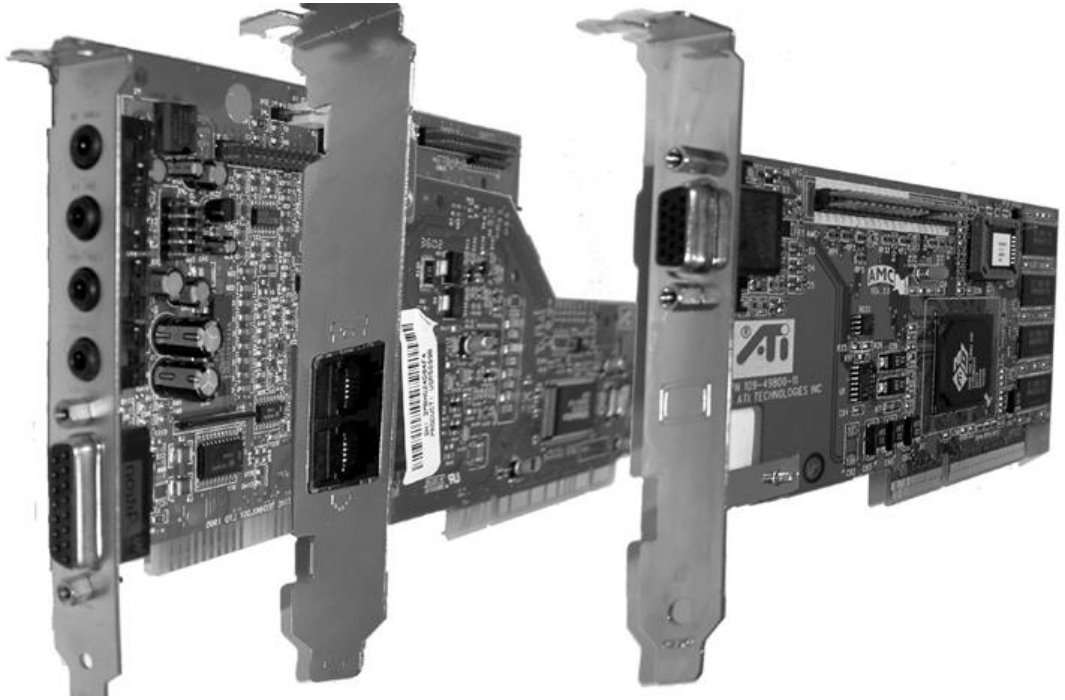
- Memory-mapped I/O uses the same address space to address both memory and I/O devices.
- The CPU instructions used to access the memory can also be used for accessing devices.

- Port-mapped I/O often uses a special class of CPU instructions designed specifically for performing I/O, such as the in and out instructions found on microprocessors based on the x86 and x86-64 architectures

Resource conflicts can arise when two different subjects try to use the same Object (resource)

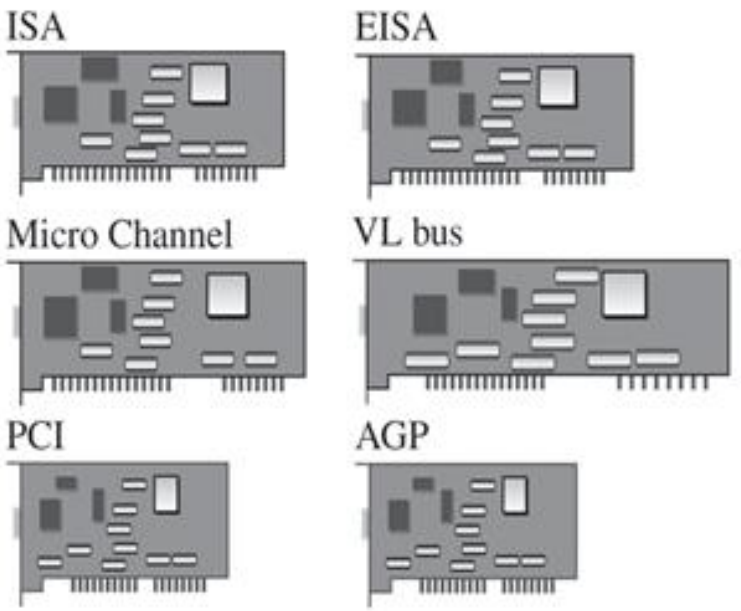
Expansion buses

- Let us add new functionality in the form of cards and peripherals
- Connected to slots on the motherboard where we mount the expansion card
- Different technologies
- PCI, AGP, ISA, PCIe
- Perform communication between the card controller and the chipset



Expansion card

Old expansion cards and slots



PCI

- 32 and 64 bit data
- Bit rate up to 66 MHz, 533 MB / s (64 bit)
- CPU independent
- Backcompatible with ISA, EISA
- Plug and Play (PnP) support

Accelerated Graphics Port (AGP)

- Made to support 3D graphics
- Connected directly to Northbridge
- 32 bit, 66 MHz
- Bit rate from 266 MBps to 2133 MBps depending on version
- Versions 2X, 4X, 8X transmitted data 2x, 4x and 8x per clock cycle

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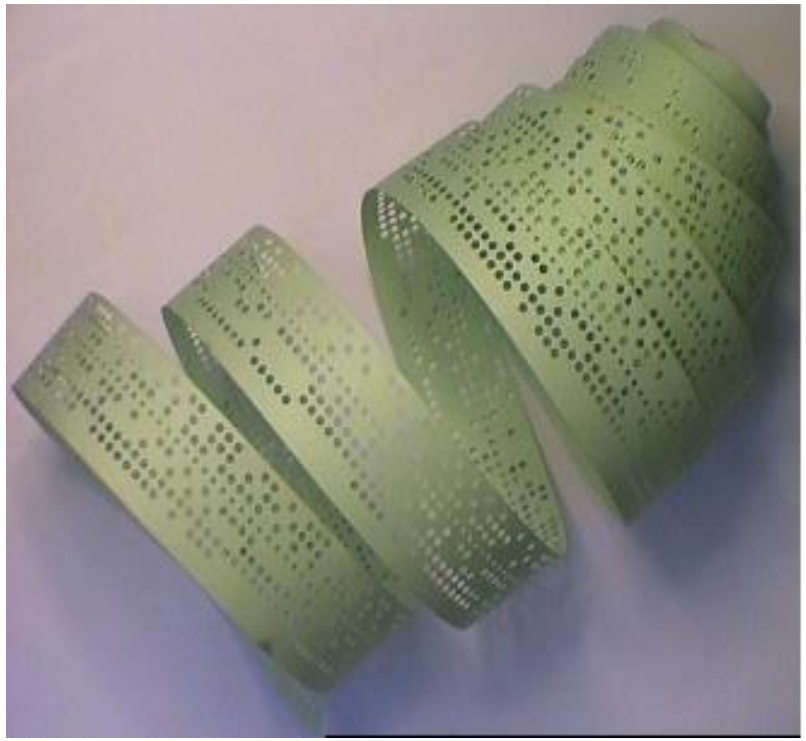
Data Storage (Hard disk)

Data Storage

- Used for permanent storage of large amounts of data
  - Punched card
  - Punch tape
  - Diskette, Flash Mem
  - Zip, Jazz
  - Disk
  - CD, DVD
  - Magnetic tape (reel tape, cassette)
  - Transfer to the processor via a controller
  - Use different **HBA:** IDE / EIDE, SATA, **Small Computer System Interface** (**SCSI)**,…

Paper as a storage medium



Files, Organization of data

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- Data is basically a collection of 0s and 1s which in their context represent a document, image, music etc.
- This collection is called a file
- A file has a name that makes it easy to identify
- In an identification field that is added to the file, in addition to the name, there is also information such as the size of the file, when it was created, the owner of the file, ...

Disk


Cover Mounting Holes
(Cover not shown)
Base Casting
Spindle
Slider (and Head)
Actuator Arm
Actuator Axis
Actuator
Case
Mounting
Holes
Platters
Ribbon Cable
(attaches heads
to Logic Board)
SCSI Interface
Connector
Jumper Pins
Jumper
Power
Connector
Tape Seal

Disks

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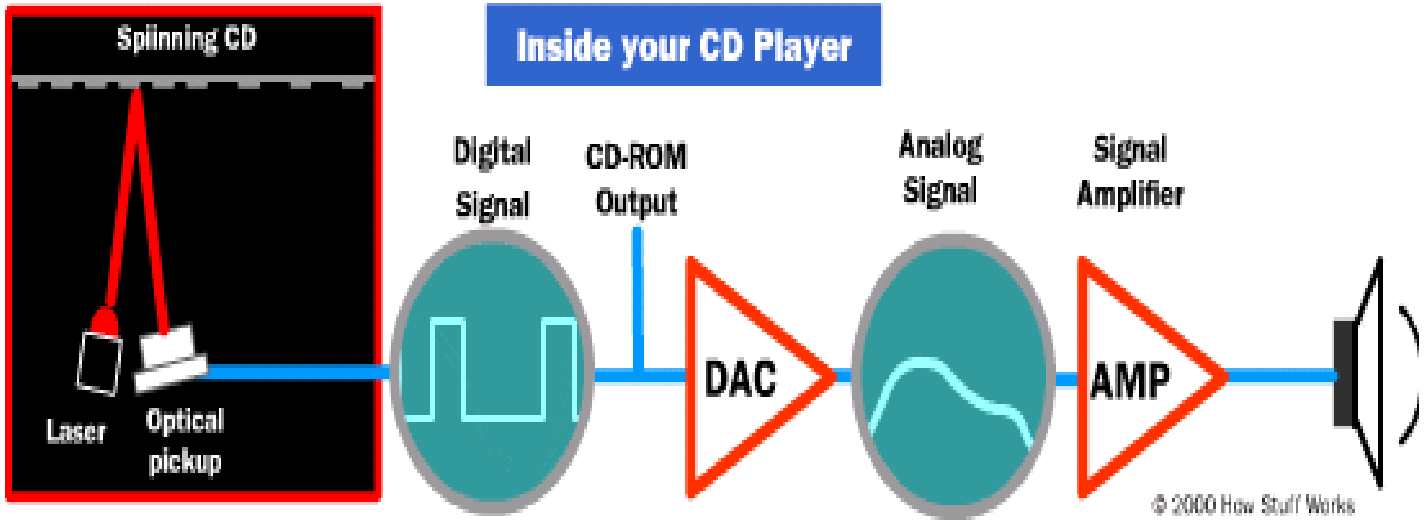
- Disks ...
  - Provides lasting storage
  - is cheaper per byte than RAM (currently)
  - ☺has greater capacity.
  - ☹are many orders of magnitude slower.
- Important parameters are
  - storage space
  - I/O bandwidth

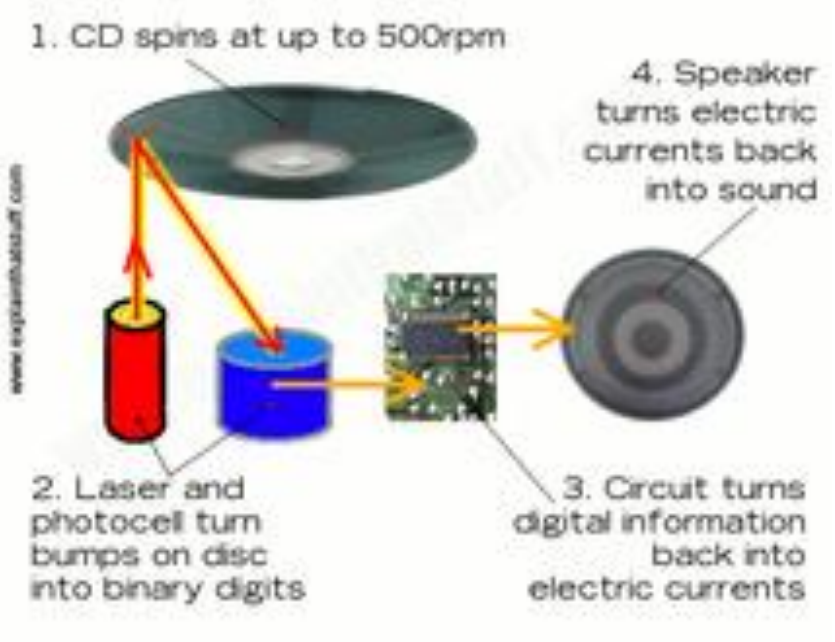
the **speed with which the data transfer takes place between the hard disk drive and RAM**

- Because...
  - ... there is a colossal speed difference (ms vs ns ~ 106) with RAM.
  - ... disk I/O is very often the most important performance bottleneck.

CD/DVD/Blue-Ray (1)

A CD can store 700 MB, DVD 4 GB on each side, Blue-Ray 25GB per layer (up to 8 layers in RW)



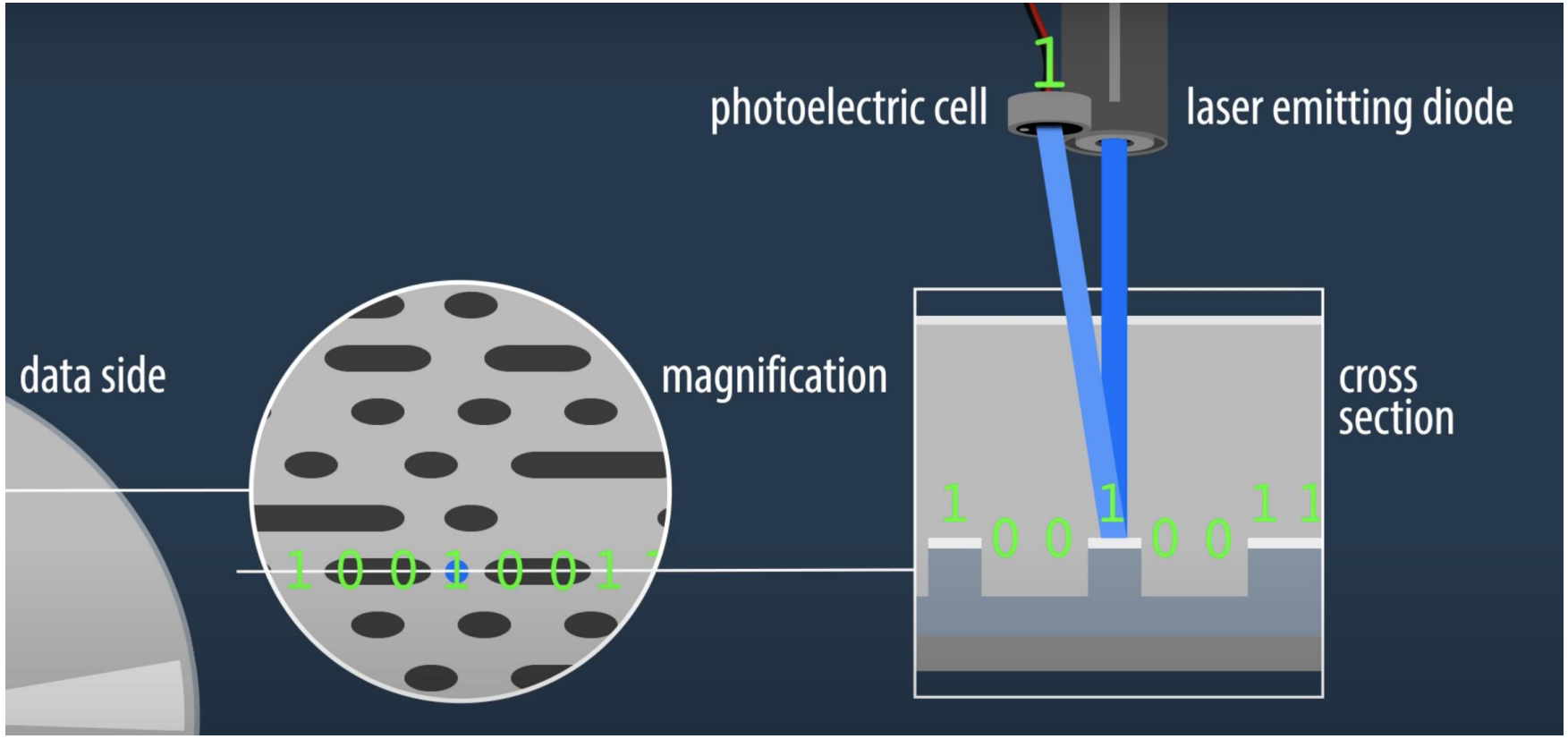


https://www.youtube.com/watch?v=H-jxTzFrnpg

CD/DVD/Blue-Ray (2)

https://www.youtube.com/watch?v=H-jxTzFrnpg

https://www.youtube.com/watch?v=2lzKy8d9BKE



Backup

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- All types of storage media can break
- Important data should therefore be stored in more than one place
- It's too late to think about backing up **after** a crash
- Home burning has become more popular lately!
- Remember the legal / ethical side of data copying !!

RAID (Some types)

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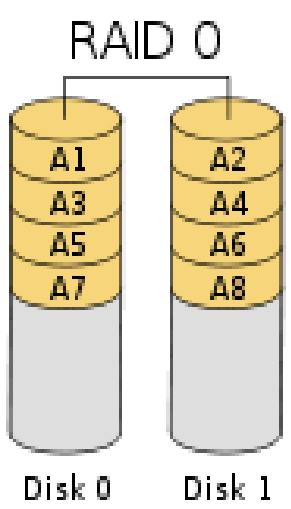
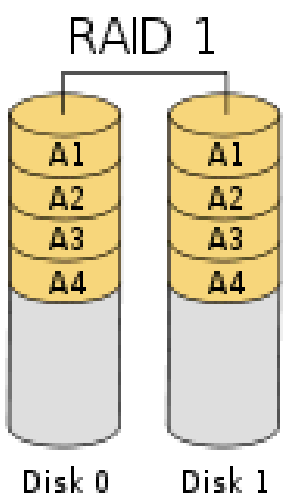
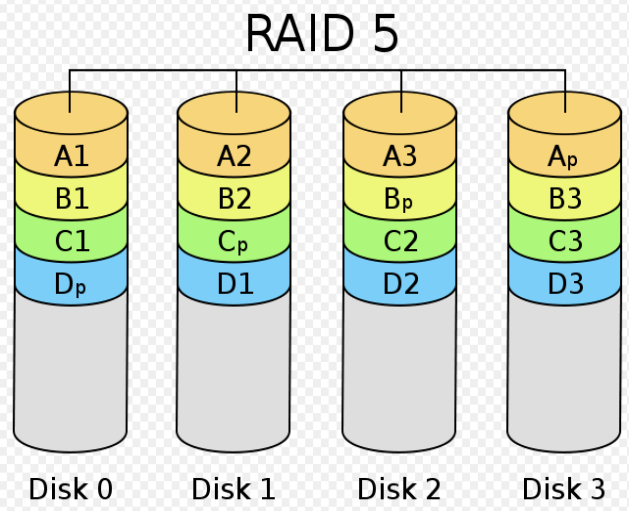
Designation	Technique		
RAID 0	Striping	Faster access	
RAID 1	Mirroring	Faster access, more reliability	
RAID 5	Striping and distributed parity blocks	Faster access and more reliability	

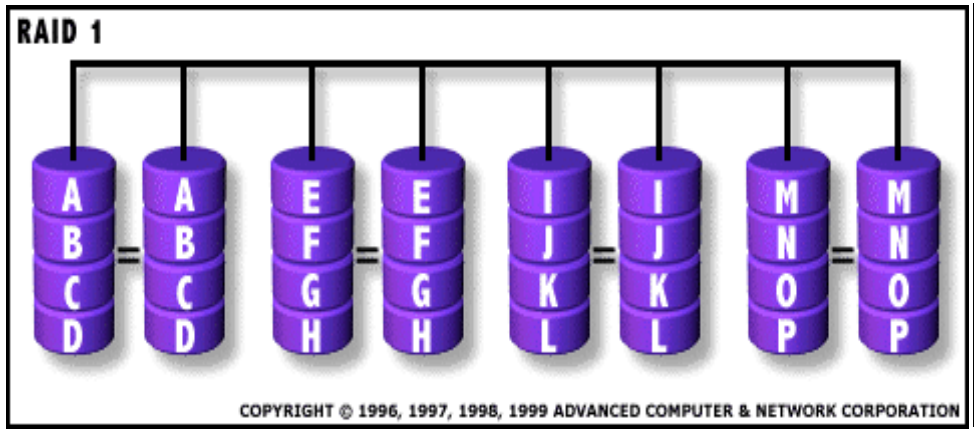


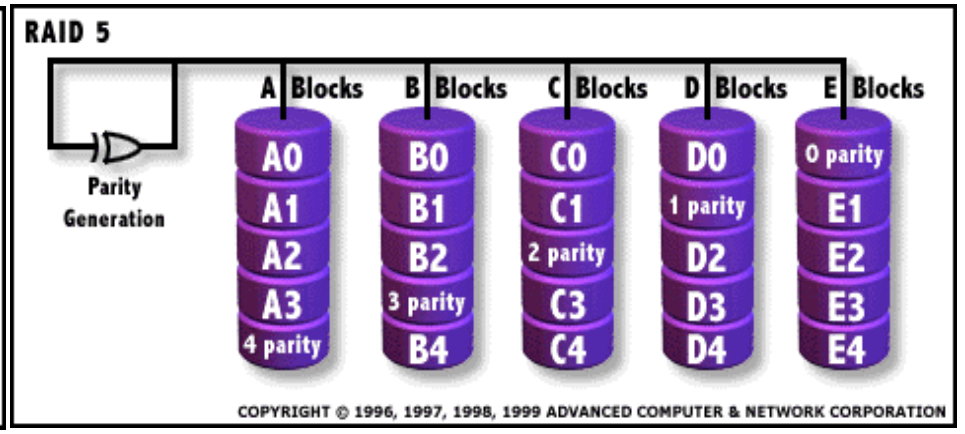




Protection against errors and crashes (RAID)

- Large disk banks can leave each disk on its own two feet, RAID0
  - or generate continuous copy of all disks, RAID1
  - or use other securing techniques (e.g. striping)
- RAID5 creates a checksum (XOR) for two disks and stores this on a third disk. This is good enough if a disk crashes.





Typical Hard Disk Problems

- common causes
  - Fault in controller / adapter
  - Incorrect pairing of adapter and disk
  - Errors on the disks themselves
  - CMOS config error
  - Resource conflict
  - Corrupt or missing Boot partition
  - Virus in boot partition
  - Defective (mechanical defects)

A boot partition is **a volume of the memory that contains the system files used to start the operating system**.

Typical error messages (accordingly)

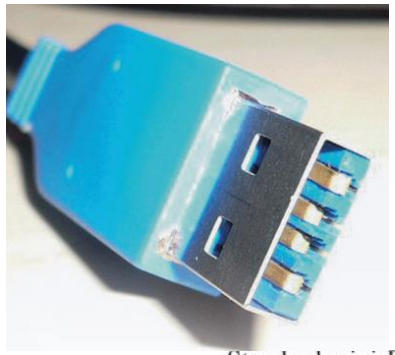
- Hard disk configuration error
  - Incorrect CMOS config parameters
  - Loose data cable
- Hard disk 0 failure
  - Incorrect CMOS config
  - Poor connection to power supply.
- Hard disk controller failure
  - Poor cable connection
  - Poor connection to power supply

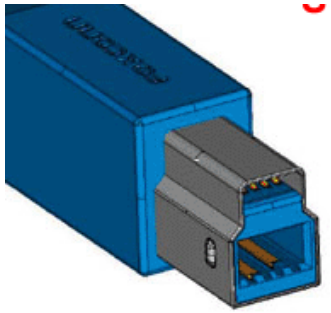
Høyskolen Kristiania

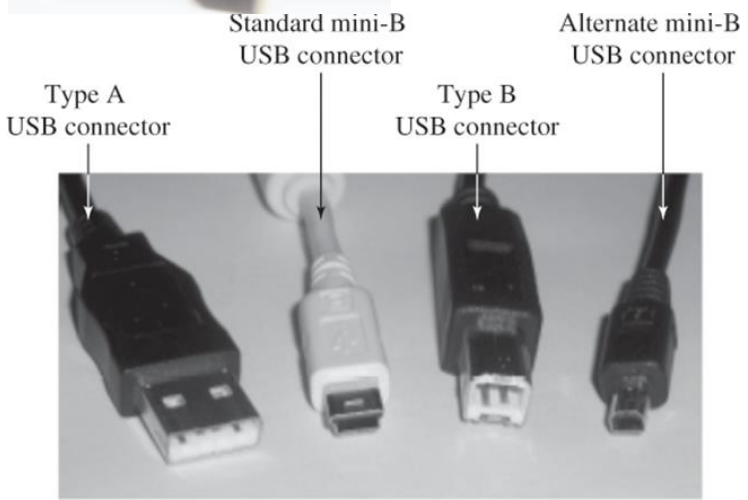
USB and Flash memory

USB – Universal Serial Bus

- Supports up to 127 different connected devices
  - Expands with **hub**
- High speed data transfer.
  - USB 1.1: 12 Mbps (max)
  - USB 2.0: 480 Mbps (max)
  - USB 3.0: 5 Gbps (max)
- Variable bitrate
  - Low speed channel for slow equipment
- Four main types of data transfer.
  - Bulk, interrupt, isochronous, control.
- PnP and hotpluggbar.
- Can be used for charging







Flash Memory

- Two types: "NOR" and "NAND"
- NOR (parallel-connected)
  - Random Access reading / writing
  - Best for programs
  - Widely used in mobile phones.
- NAND (serial-connected)
  - Read in blocks (as HD)
  - Cheaper, more transistors on smaller area
  - Faster to read from than to write to
  - Best for data.
- You can (on both types) only delete blocks!
- Holds to about 100,000 write / delete
- 512MB -> 256 GB (2009) -> 1 TB

NOR vs. NAND Flash Memory
https://www.youtube.com/watch?v=jAQiMWmSlIo

Høyskolen Kristiania

Peripherals

Keyboard

- Typically, 104-key IBM PC is standard (qwerty)

Mouse (optical)

- LED or LED laser emits a beam of light
- Low resolution «camera» (20x20 px ->) takes «pictures» about every 1/10 second (often more often)
- Chip measures / calculates the difference between images and calculates position change

Screen

- Two main types
- Cathode ray tubes (CRT – ***C***athode ***R***ay ***T***ube)
  - Was usually long, almost gone …

https://www.youtube.com/watch?v=K-kxIP3FhCk

- Flat-panel
  - LCD – ***L***iquid ***C***rystal ***D***isplay
  - Plasma display, FED, LED, polymer display, OLED

https://www.youtube.com/watch?v=qOsibeDX8jM

What should we know?

What should we be able to do now?

Høyskolen Kristiania

- What motherboards and chipsets are
- CPU (vs GPU) and why cooling is necessary
- RAM: types and roles
- Hard disk, addressing, partitioning, parity and RAID
- Peripheral equipment, expansion and peripheral buses
- The principle behind LCD monitors

Next lecture

Høyskolen Kristiania

- Operating system
  - What is it really for?
  - How does it relate to everything we've been through so far
  - What is the difference between the different (Windows, Linux, OSX)
  - How to work in a shell

Høyskolen Kristiania

For optional self-study

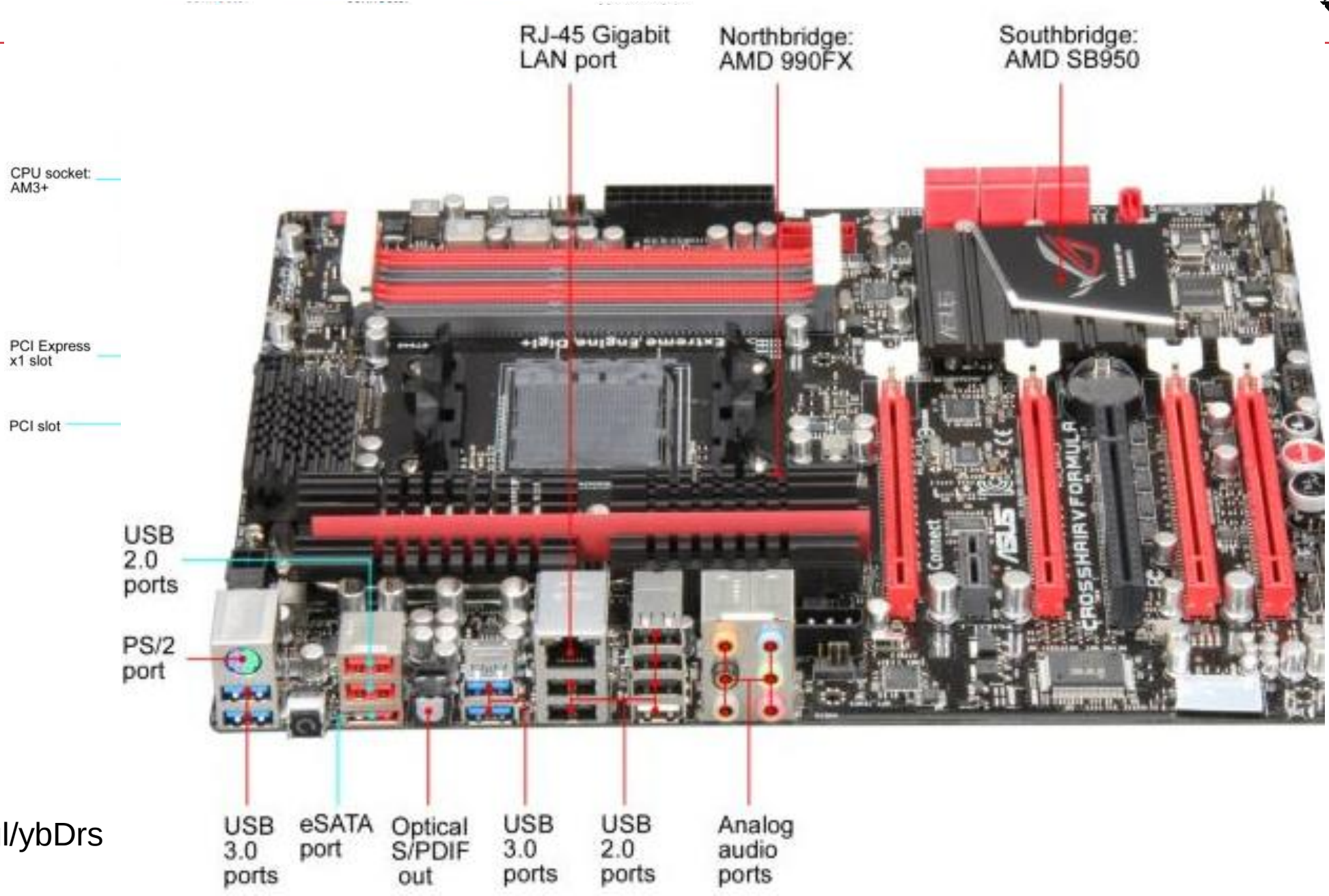
For those who want to learn some topics more in depth to better understand, here are some extra topics related to today's teaching, it must be expected some personal work to understand these topics.

There will be no questions on the exam from these, and this is therefore not considered to be part of the syllabus.

SSD: Solid State Drive

- (Most often) the same storage technology as Memory Stick (NAND)
- 50-100 times faster (shorter access time) than HardDisk
  - No mechanics, arms that have to be moved, etc.
- Limited life, just like Flash Memory.
- 10-20 times as expensive per GB.
- Available up to 4TB (?).

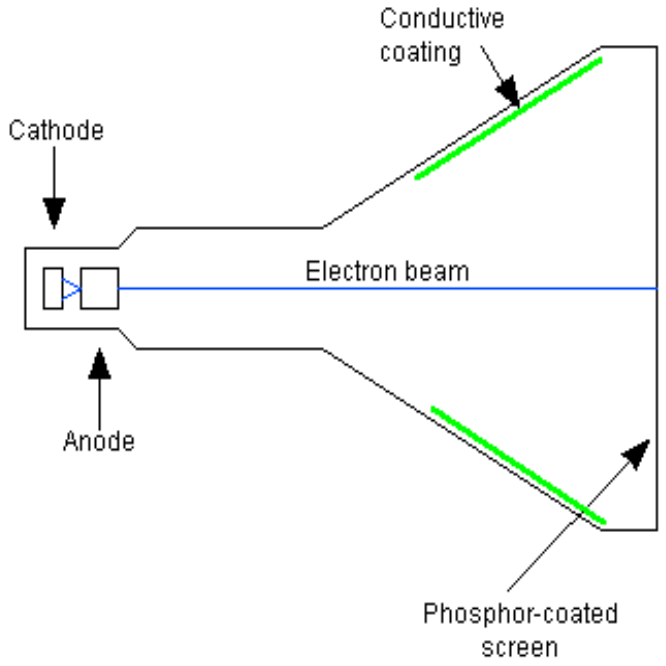
Motherboard about 2011



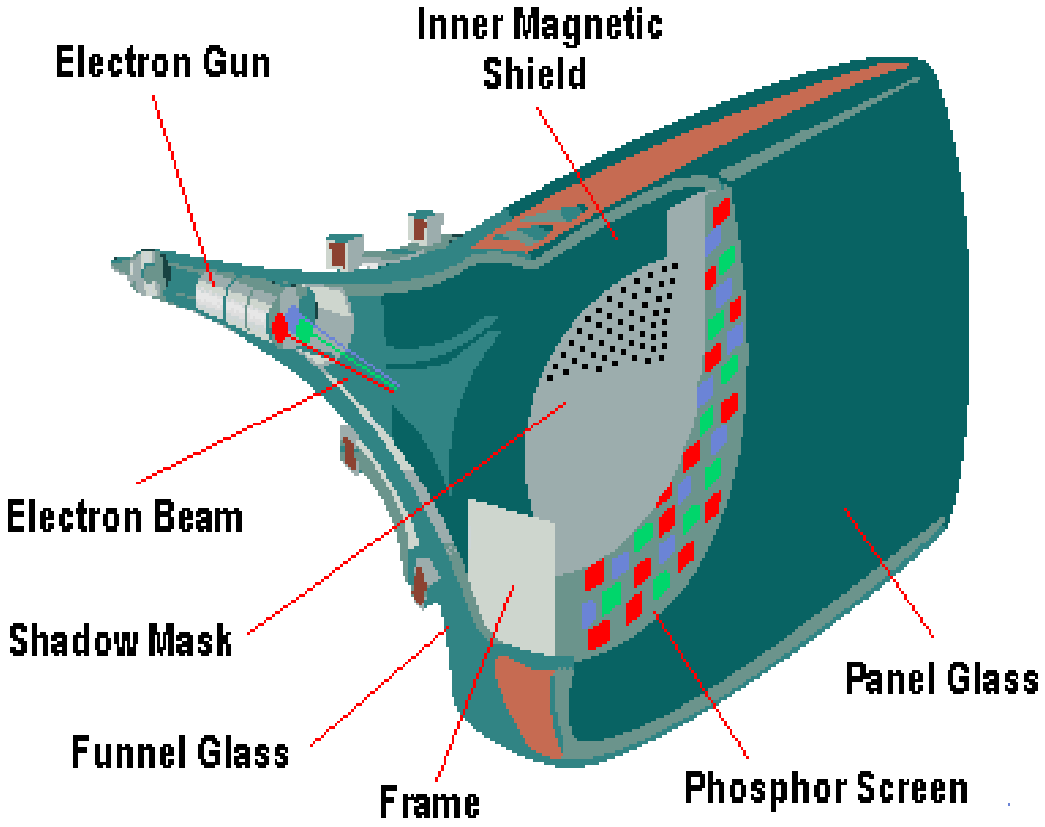
ilde: http://goo.gl/ybDrs

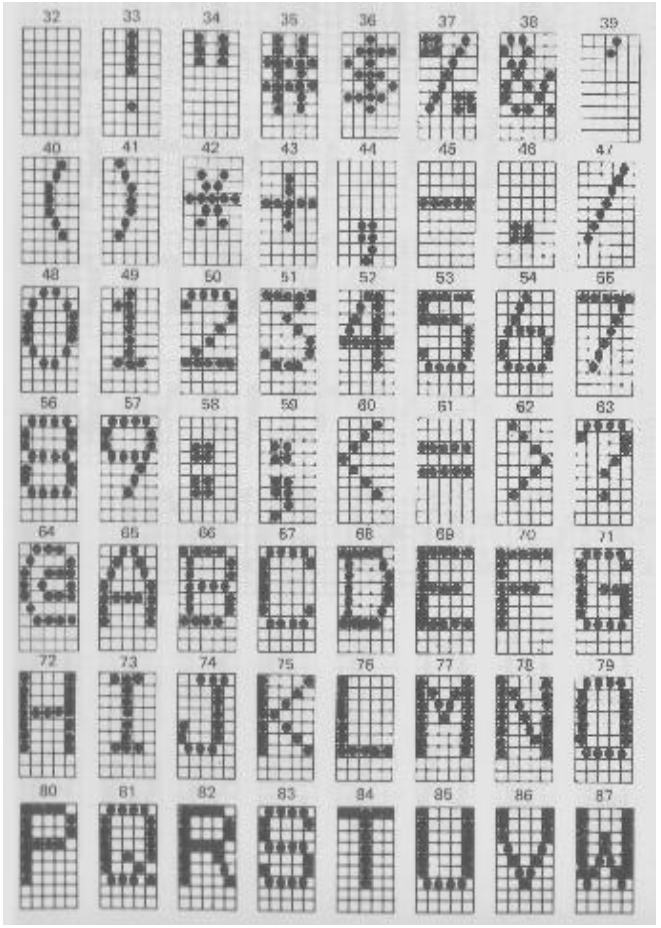
Screen

- An image element (pixel) consists of 3 colors (red, green and blue)
- All items on the screen were updated several times per second.
- The size of the screen is stated as the length of the diagonal.
- Controlled by graphics card with memory.



Screen

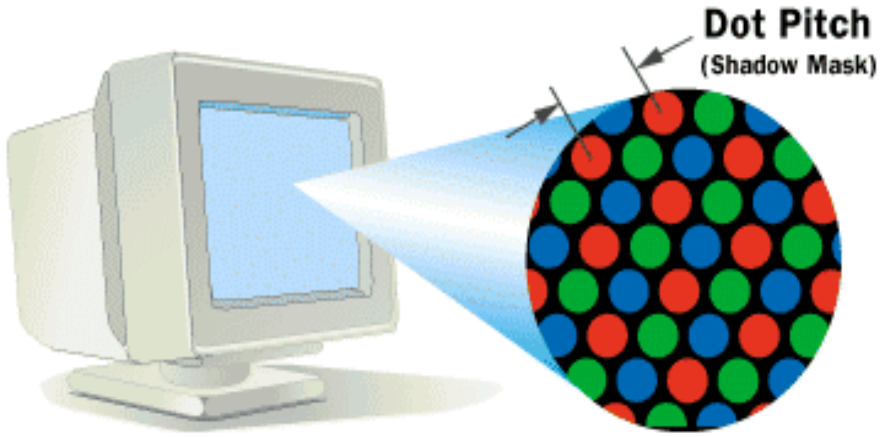

Electron Gun
Inner Magnetic Shield
Electron Beam
Shadow Mask
Funnel Glass
Frame
Phosphor Screen
Panel Glass



Video-card

- Interprets and controls what is to appear on the screen
- Own memory, determines the maximum resolution and color depth

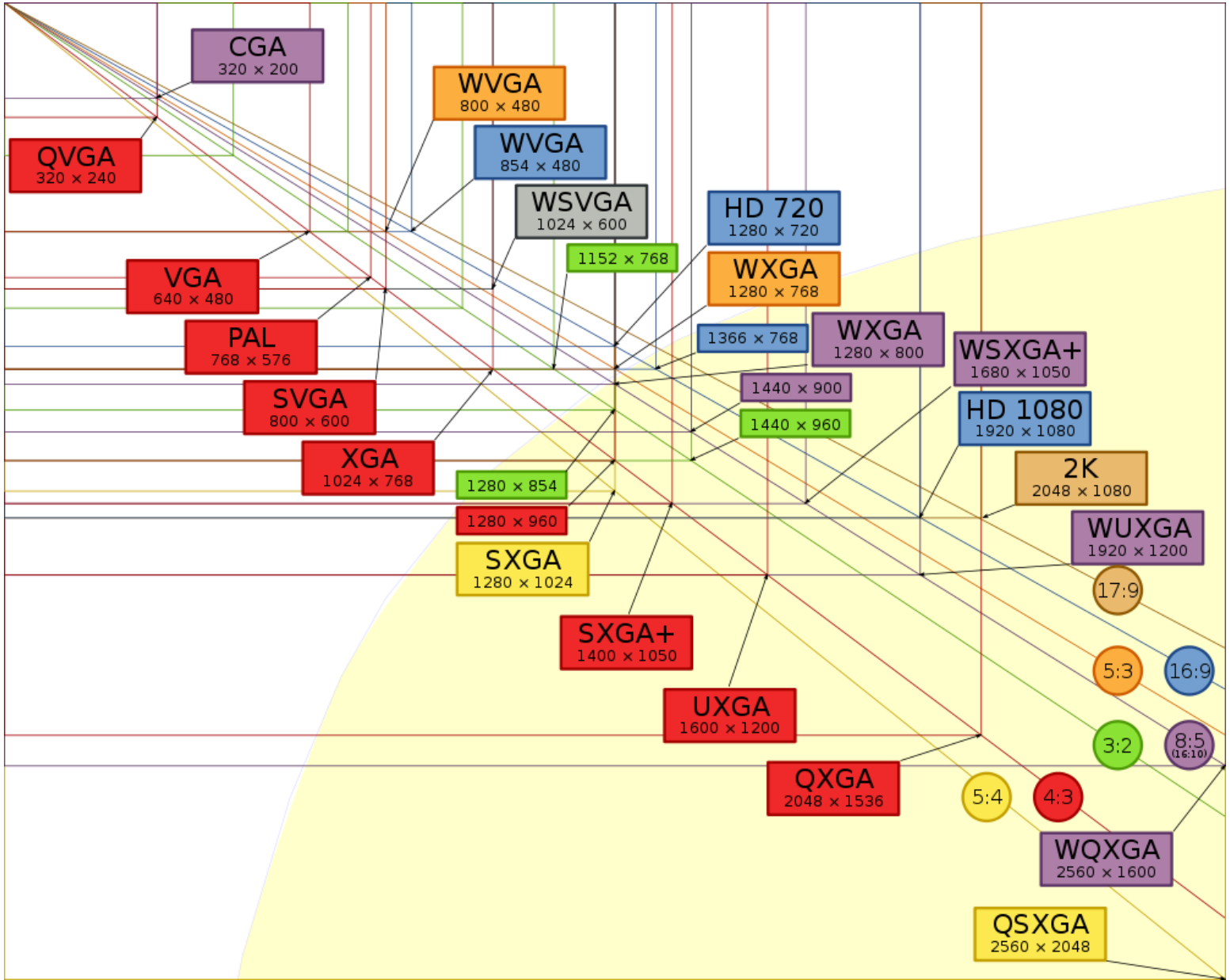
Dot pitch; the distance between two pixels(0,25 mm)



Graphics

- There are many standards for on-screen graphics.
- Mostly, the standards evolve after the development of screen technology.
- Example: SVGA (***S***uper ***V***ideo ***G***raphics ***A***rray)
  - Resolution : 800*600 → 1600*1200 pixler
  - Color depth : 256(8 bit) → ca. 16 millioner (24 bit)
  - Refreshment rate : 50 → 100 Hz
- The number of possible simultaneous colors depends on the size of the video memory.

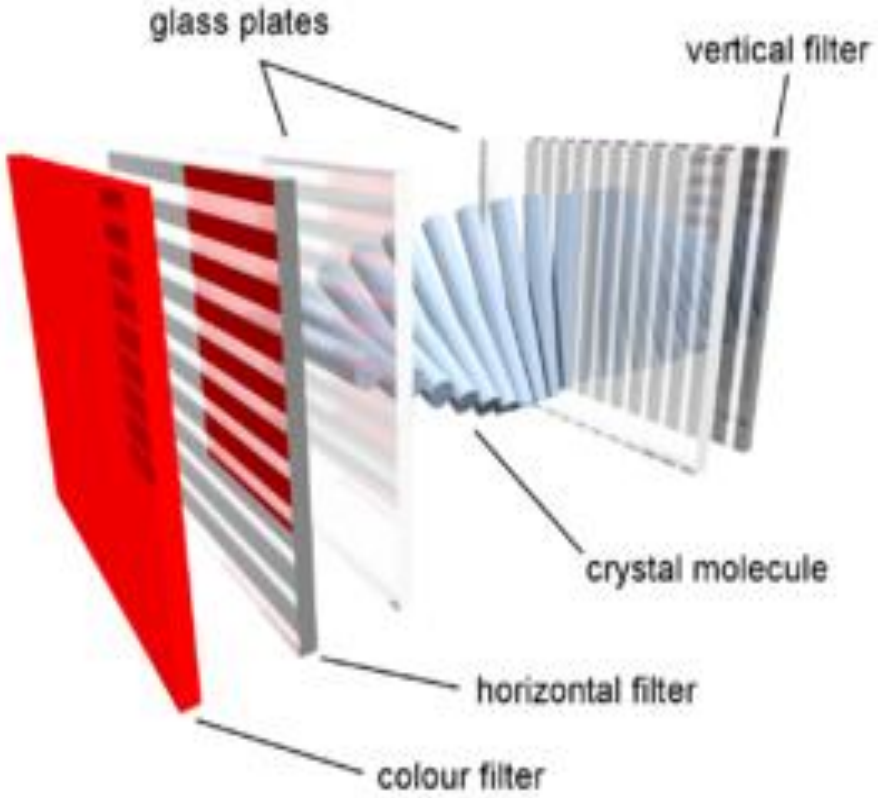
«Countless »standards (px, colors)



Flat panel (LCD)

- Each pixel has an address
- Only changed pixels are updated
- Very stable image of good quality
- Problematic in sunlight

Example: An LCD subpixel

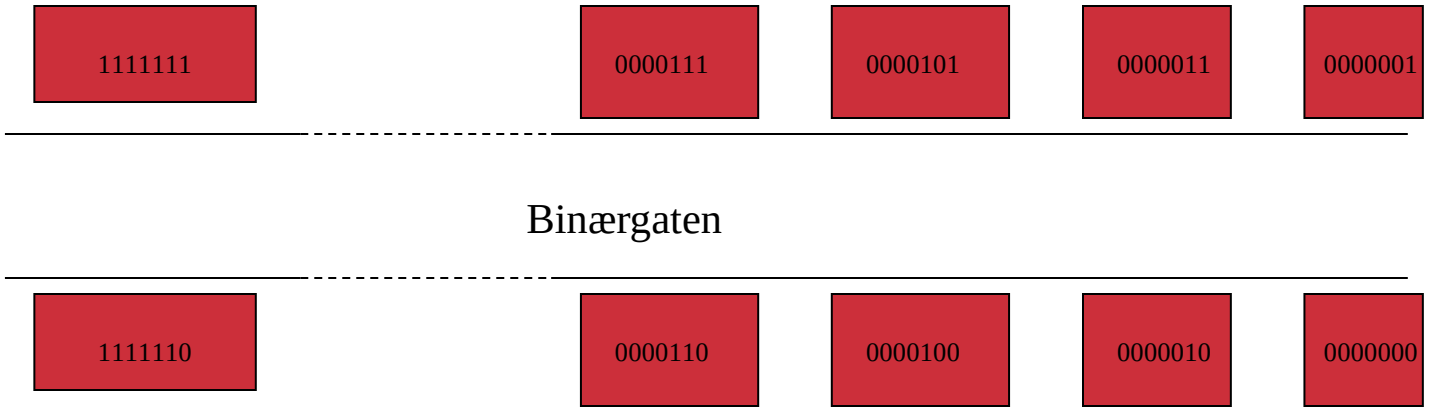


- Light from background board
- Polarizing filter (vertical)
- Liquid crystal that "twists" the polarization when you "turn on power"
- Polarizing filter (horizontal)
- Colour

So far

- Generally
  - Digital vs analog, def computer
- Data types
  - Tall, text, images, sound
- CPU
  - Structure
  - Register
  - Instructions

Addressing binary



With 7 binary digits (bits), 27 = 127 + 1 = 128 = «house» can be addressed.

At each address "lives" a byte.

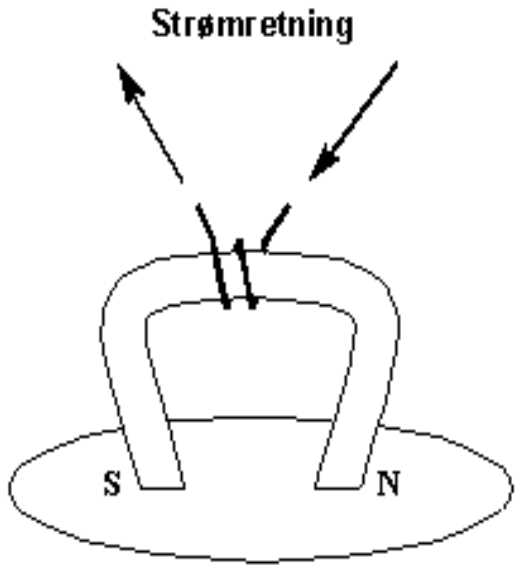
System resources

- The buses use one or more types of system resources
  - I / O port addresses
  - IRQ= Interrupt Request
  - DMA channels=Direct Memory Access (DMA)

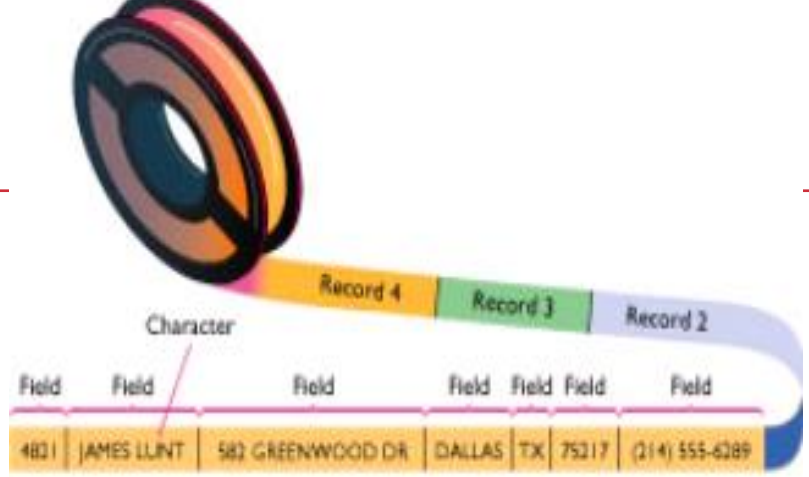
- Resource conflicts can arise when two different subjects try to use the same Object (resource)
- Plug-and-Play (PnP): Configuration standard that automatically allocates system resources to expansion cards and equipment

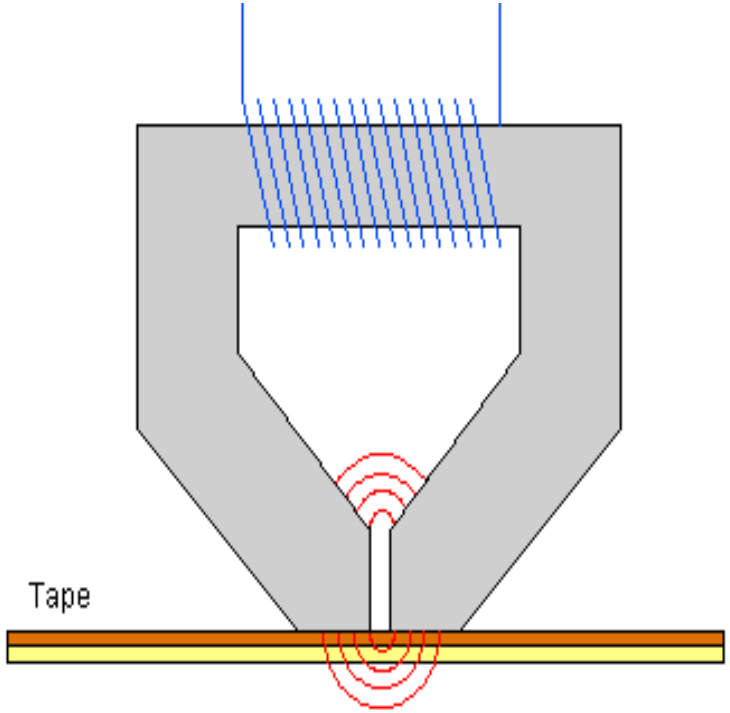
Magnetic storage / reading

- Storage
  - When the electromagnet is supplied with power, the surface under the magnet is magnetized.
- Reading
  - When the surface under the magnet magnetized and passes the magnet, power will be generated (induced).
- Magnetized area = 1
- Not magnetized = 0



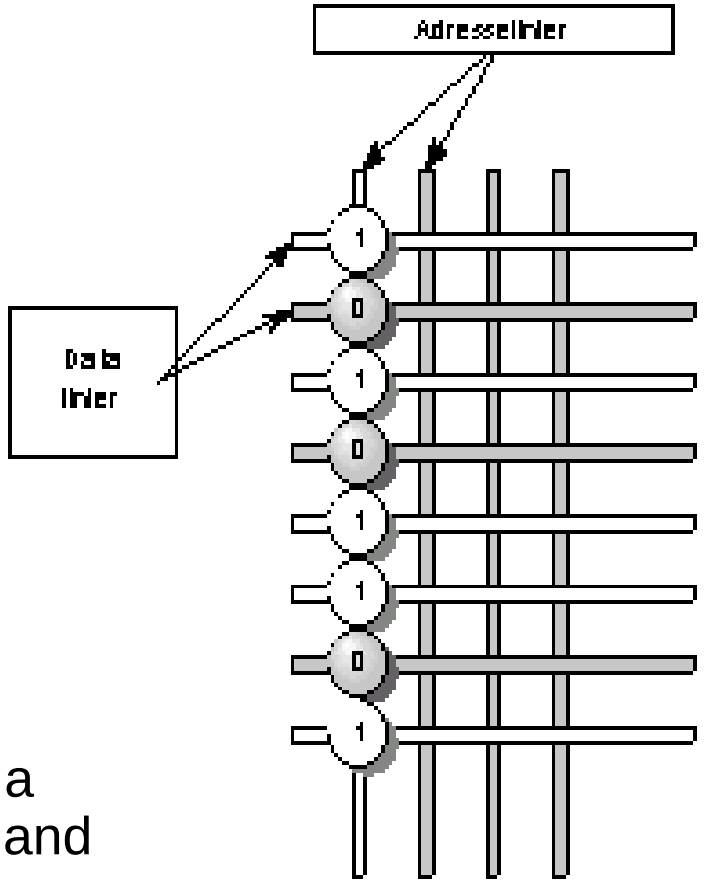
Magnetic tape





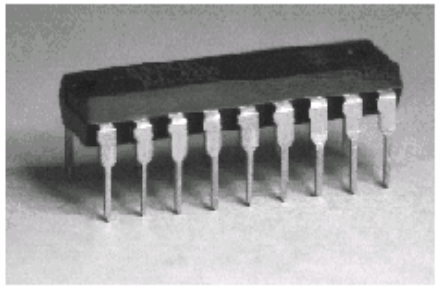
RAM for PC

- Addresses
  - 16 bit = 65536 = 64 KiB
  - 20 bit = 1MiB
  - 32 bit = 4 GiB
  - 64 bit = 16 EiB
- DRAM - Dynamic RAM
  - Must be refreshed; read / rewrite.
- **SD**RAM - Synchronous DRAM
  - In step with the CPU.
- SRAM - Static RAM
  - Does NOT need to be refreshed, faster a DRAM, but more expensive to produce and needs more transistors per bit stored



Physical organization

- **DIP** (Dual In-line Pin) right on the motherboard.



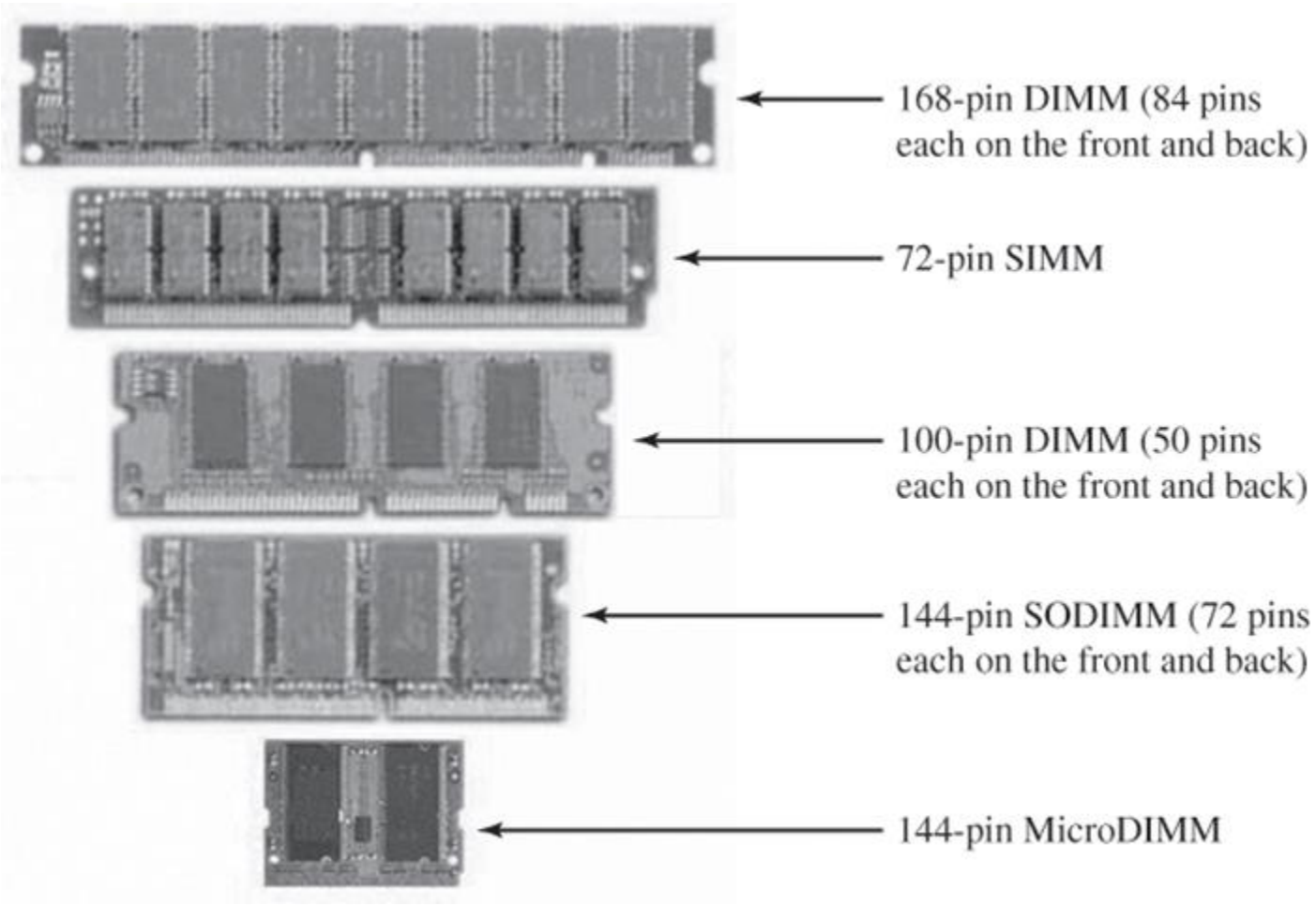
DIP

- **SIMM** (Single In-line Memory Module)
  - Snapped on the motherboard
  - DRAM; 60 to 120 ns
  - SRAM and cache; 20 ns
  - Odd Parity
    - **10010110 1**
    - **Used to check if errors have occurred.**

72 pin SIMM 4.25" x 1"

- **DIMM** (Dual In-line Memory Module)
  - Contact points on both sides
  - 64 bit bus connection.
    - 168, 184, eller 240 bus connection
  - RDRAM is a variant
    - There are many variants in terms of number of connection points, type of bus etc.

DRAM form factors (some)



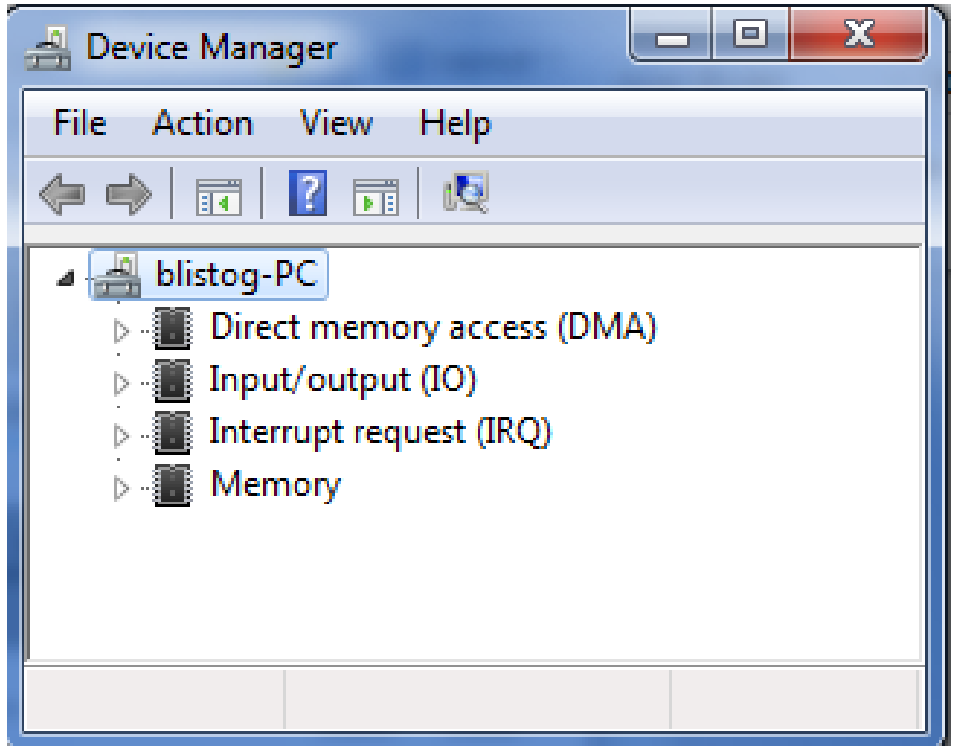
DRAM technologies

- Previously
  - Asynchronously, the system clock did not follow
  - FPM, EDO, etc..
- Current
  - Single Data Rate RAM
    - One read / write per clock / bus pulse
  - Double Data Rate RAM (DDR, DDR2, DDR3)
  - RAMBUS
- RAM performance depends more on the package and bus, than on the RAM itself.

DRAM characteristics

- CAS (Column Adress Strobe) latency
  - Number of clock cycles it takes to move requested data to the legs of the RAM module
  - For example. CL2 (two clock cycles)
- Dual or quad channel
  - Motherboard-dependent - number of parallel RAM channels.
- Single vs double row
  - Double-ranked has two separate groups of RAM chips that are accessed separately by the RAM controller.

Win7: devmgmt.msc

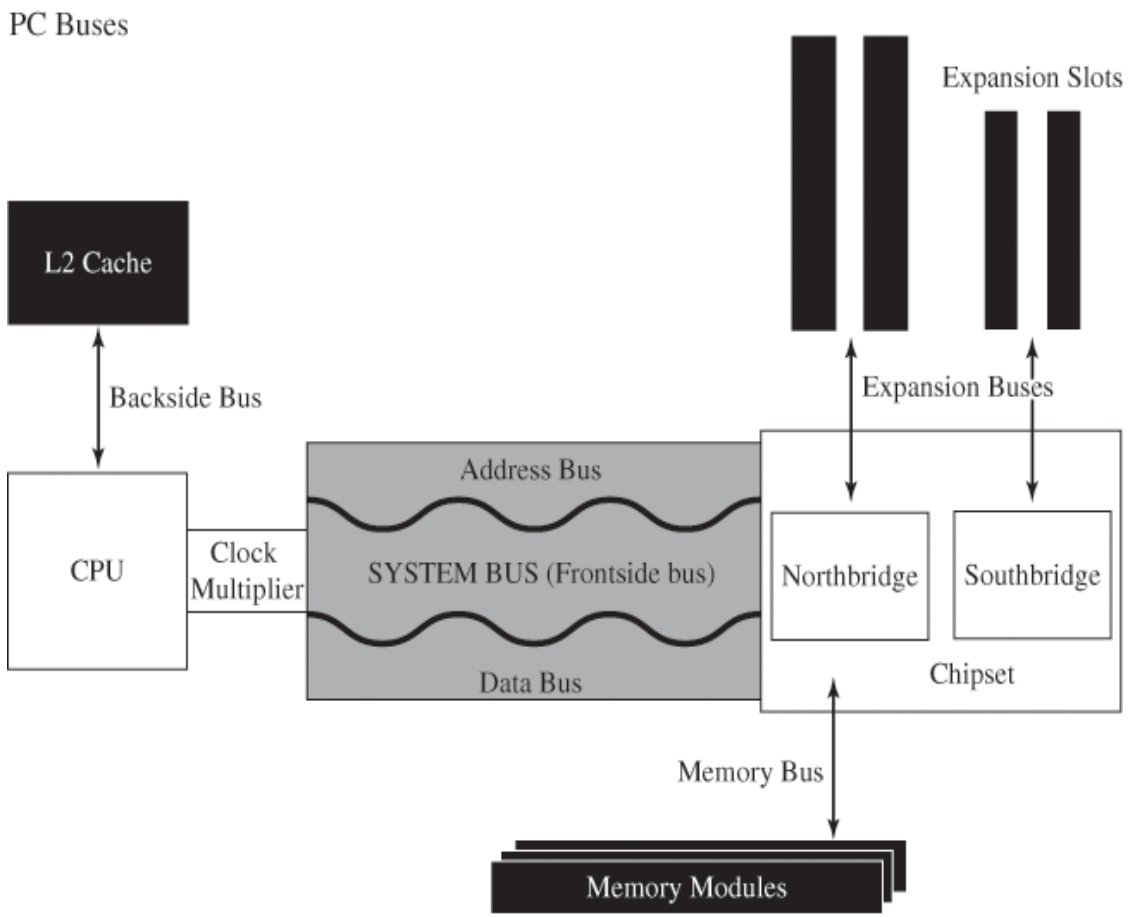


- In win7 / 8/10 you can inspect which resources in MMC snapin devmgmt.msc

Høyskolen Kristiania

Data buses

Motherboard: Buses



- Serial vs parallel
- Data / Address / Control / Power
- Width (#bit), tempo (Hz)
- Two main buses:
- System / FSB
- connects CPU to Northbridge / RAM
- Expansion
- Connects the chip to expansion slots

Chipset

- The controllers that control the exchange of data / instructions / interrupt signals between the CPU and other equipment are often referred to as the motherboard chipset
- In the last ten years, these have typically been two main controllers
  - Northbridge (Intel: Memory Controller Hub)
    - CPU and memory (RAM)
    - High speed equipment: graphics card
    - Communication with Southbridge.
  - Southbridge (Intel: IOController Hub)
    - Peripherals (typically outside the cabinet)
    - Minor controls
    - Secondary and old-fashioned buses

The transport system

- "Cables" with parallel and serial "wires"
- Width * Speed = Bandwidth

The tasks of the buses

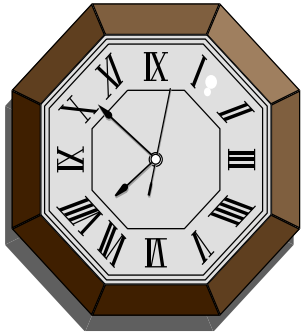
- Addressing of data
- Shipping of data
- Synchronization of machine components
- Flow control between the components
- Signaling between the components
- Power supply for some components

Addressing

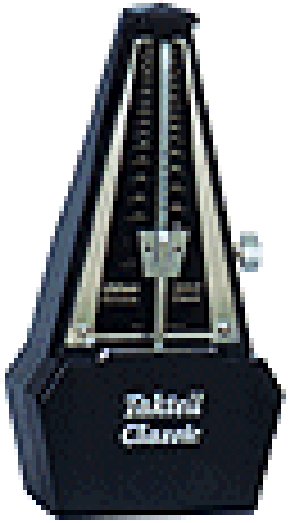
- Width from 20 to 64 bits
  - 32 bit allows to address (2^{32}=) 4 GB
- There are techniques of sending multiple bits / bytes at a time.
  - Needs less width on the bus
  - Needs more control in the components

Synchronization

- Internally in the machine there will be several clocks
- CMOS (BIOS) has a "regular" (real-time) clock
- All other clocks are actually clockmakers.



- Synchronous components
  - Keeps the same or similar pace
- Asynchronous components
  - Each keeps his own pace

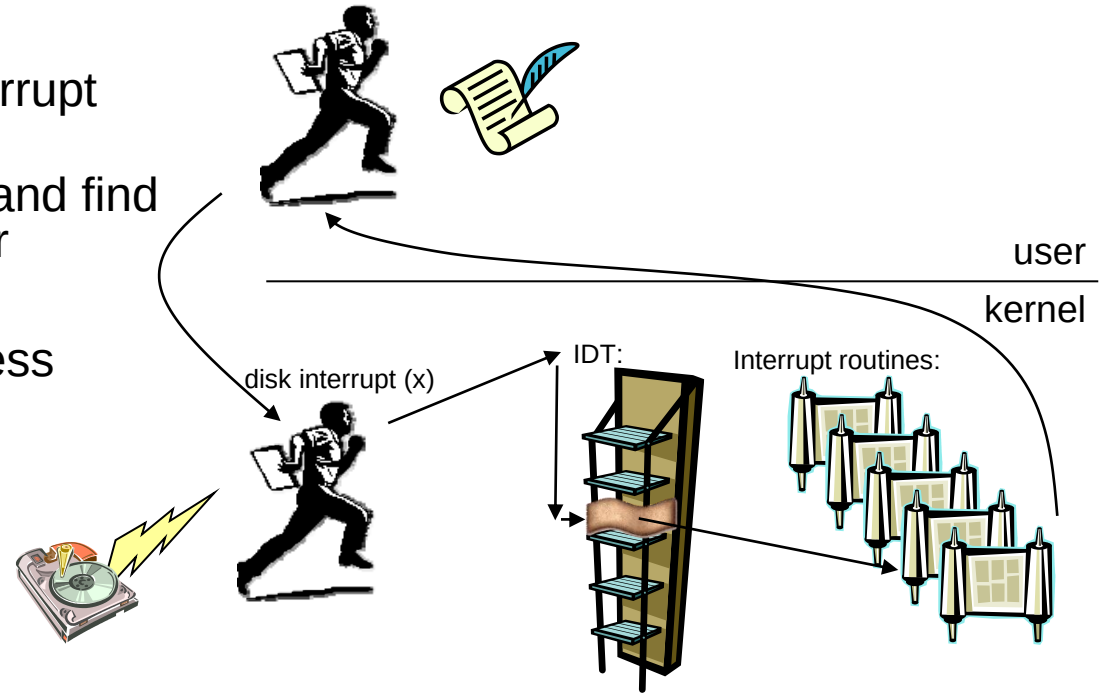


Interrupt signals

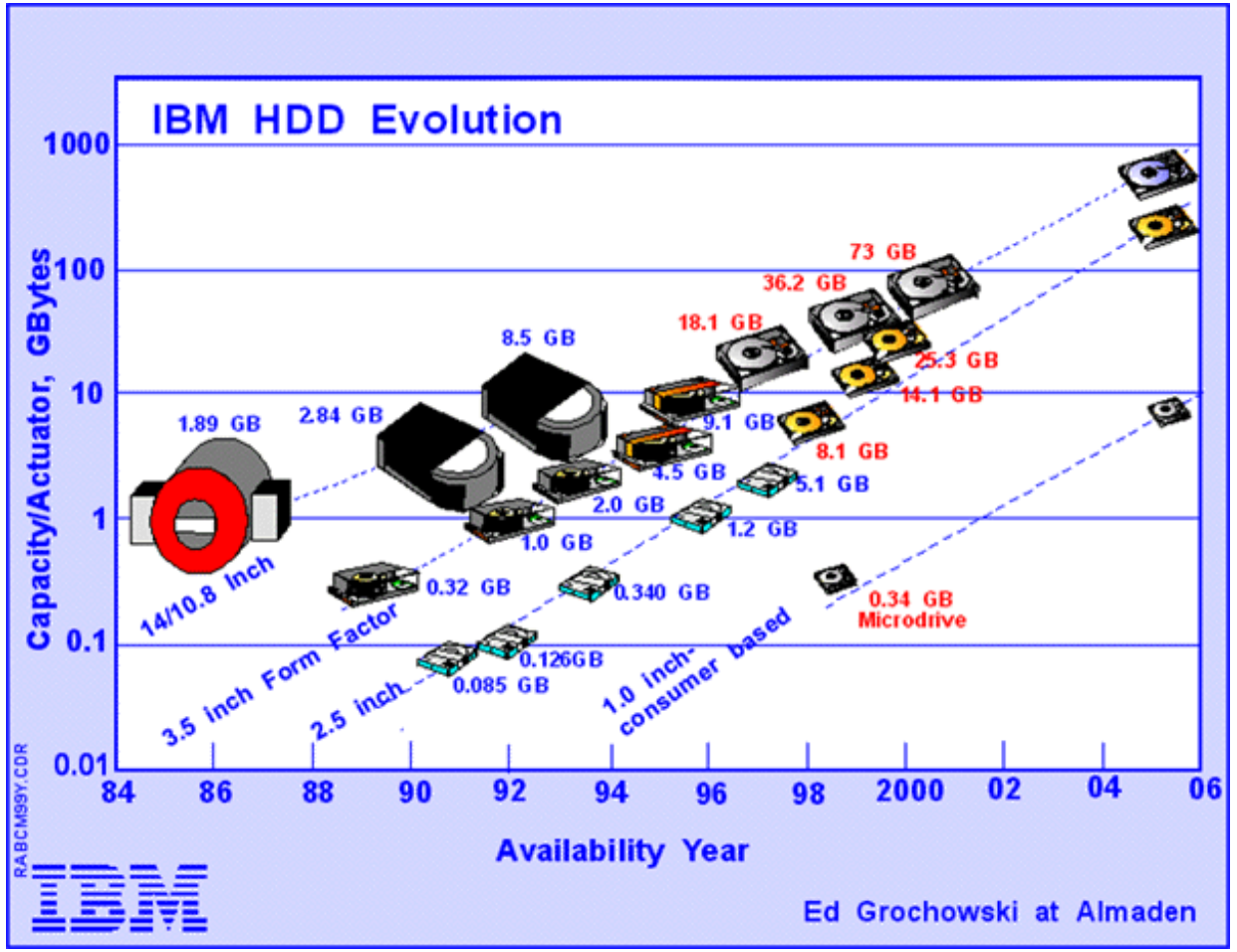
- Interruption signal is a message that something has happened.
  - It's the mechanism that lets the CPU and controllers know that something / someone wants something done.
- IRQ - Interrupt Request
- Such signals can be given different priority
- Own components for registration and further processing

Interrupt (and Exception) Handling

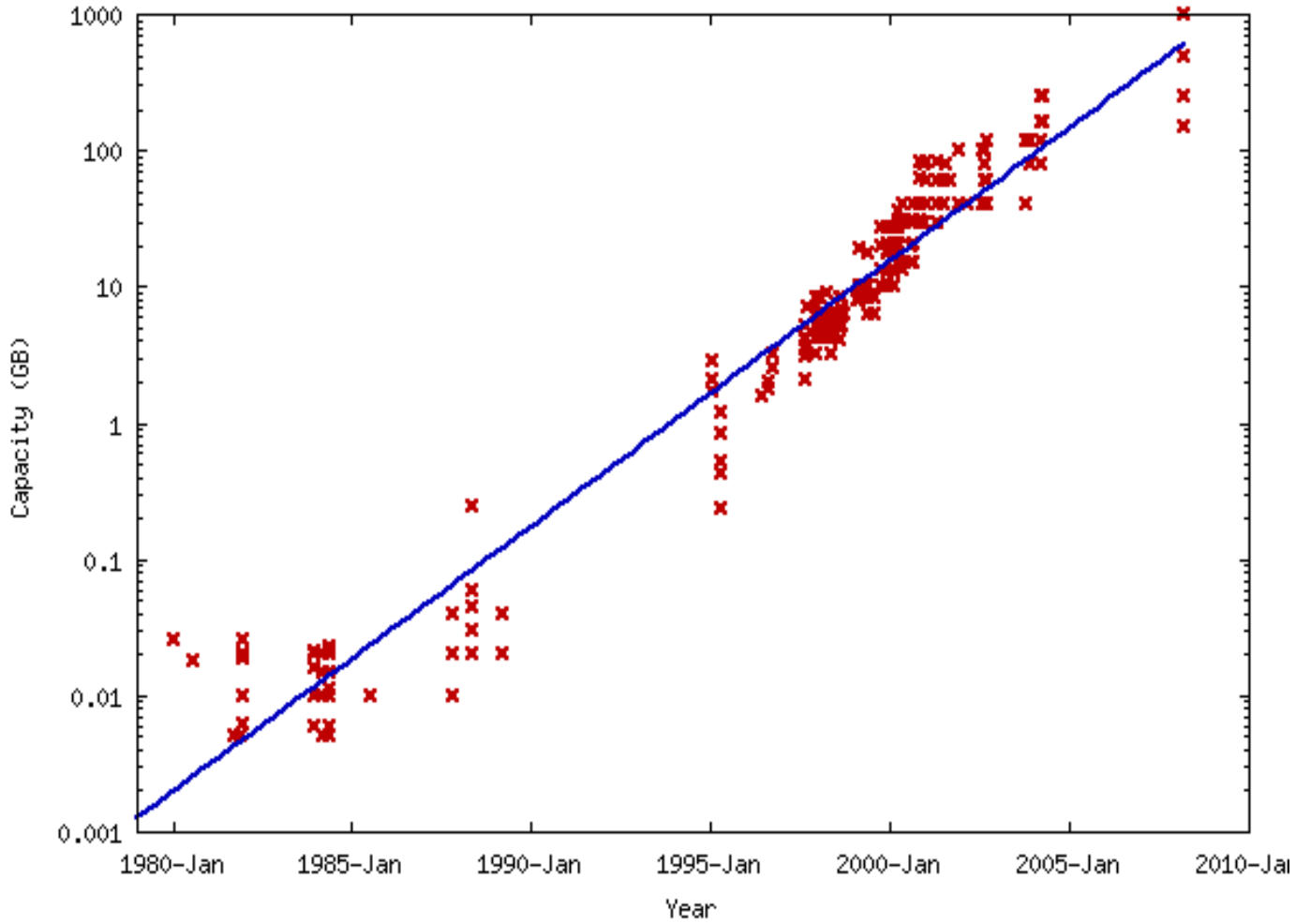
- The IA-32 architecture has an IDT with pointers to 256 different interrupts and exceptions
- 32 (0 - 31) predefined and reserved
- 224 (32 - 255) user / OS defined.
- Each interrupt has a pointer in the Interrupt table (IDT) and a unique index value that provides handling as follows:
  1. Process runs when the interrupt occurs
  2. Save state, context switch and find the correct interrupt handler
  3. Execute interrupt trades
  4. Recover (interrupted) process
  5. Continue execution



Storage development (1)

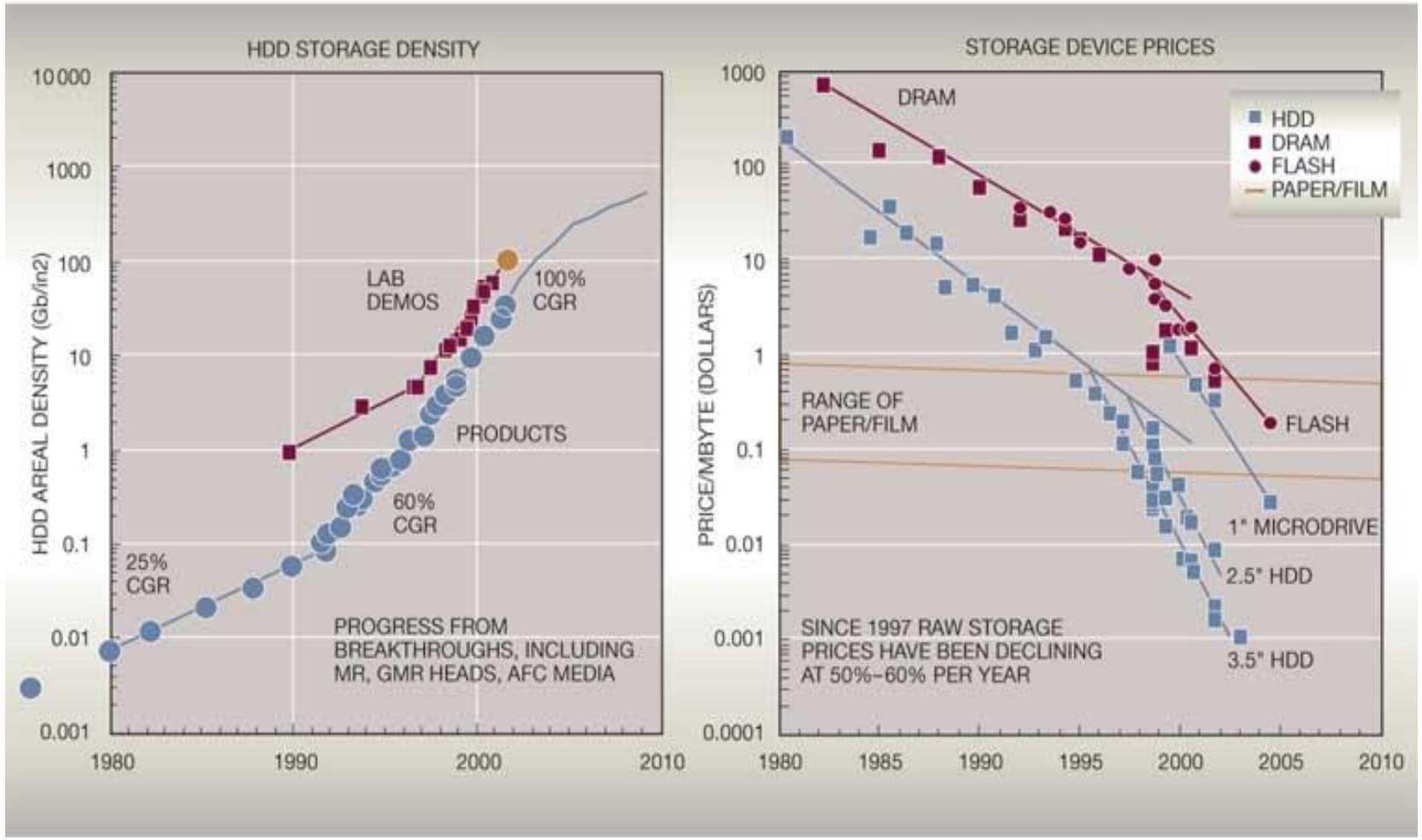


Storage capacity (2)

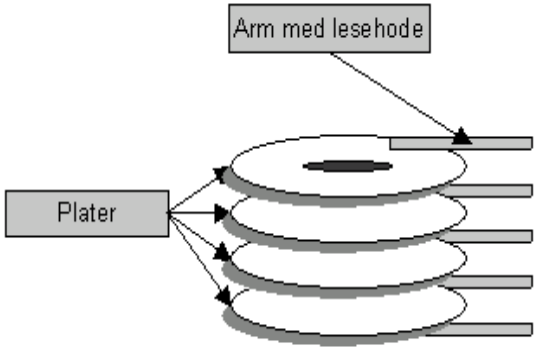


Density and price (3)

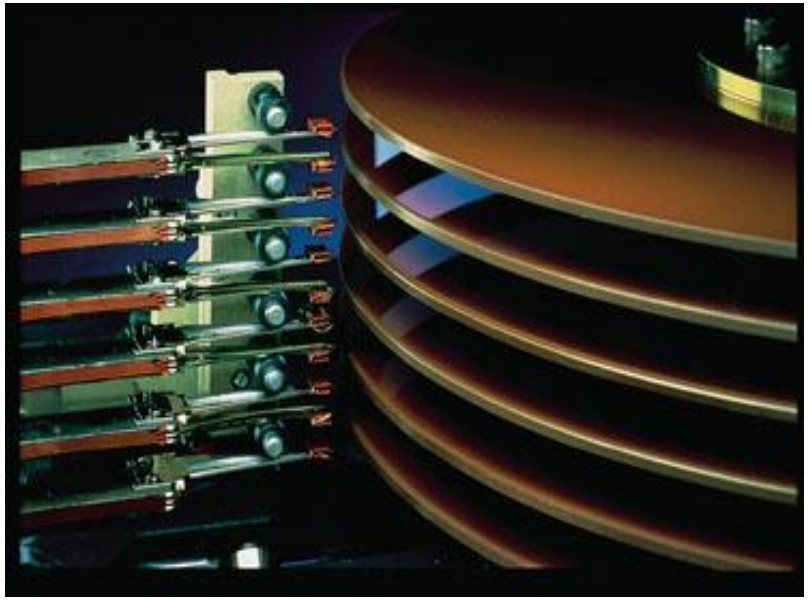
Figure 1 HDD storage density is improving at 100 percent per year (currently over 100 Gbit/in2). The price of storage is decreasing rapidly and is now significantly cheaper than paper or film.



The structure of the disk

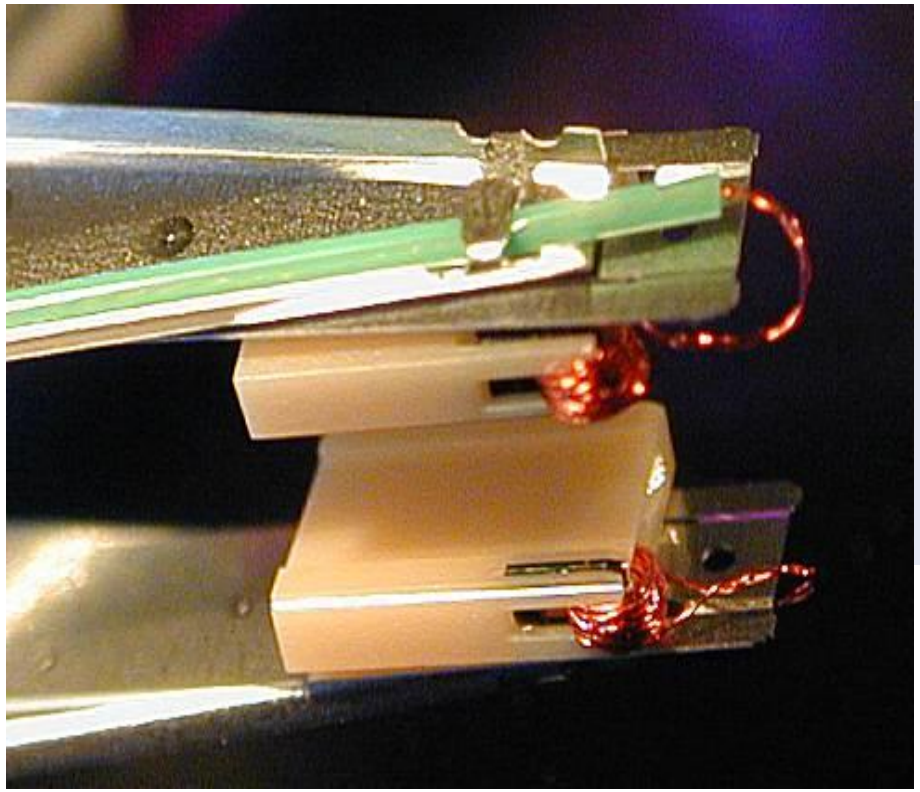


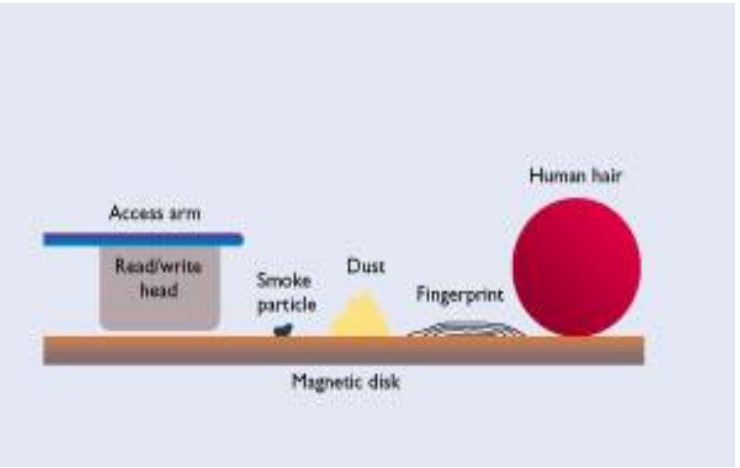
- All arms move at the same time
- Each arm has 2 heads
- In / out 50 times / sec
- Spin: 3600-7200 (15000) RPM
- Search time: 10-20 ms
- Data rate: 5-40 MB / sec ~ 300Mbps w / SATA)



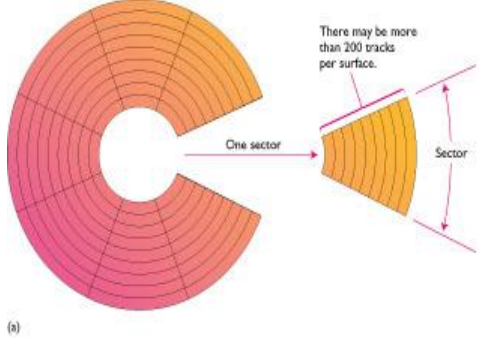
Reading heads

- The reading heads float on the air above the plate (0.001 mm)

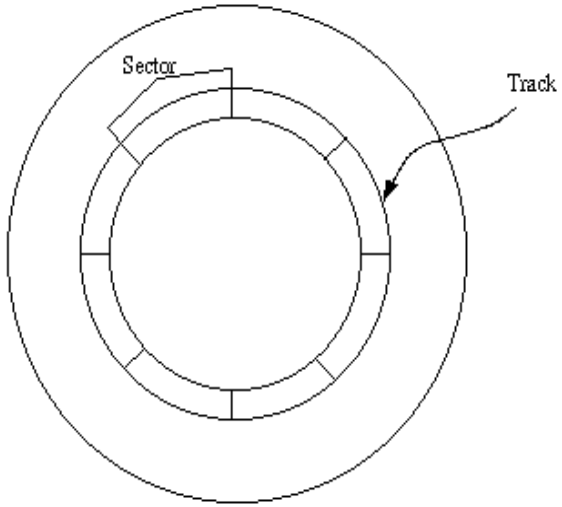


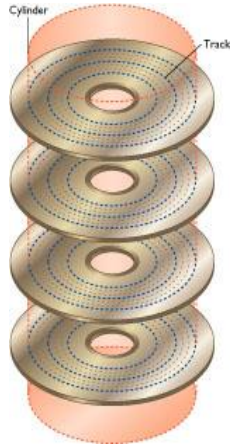


Disk organization



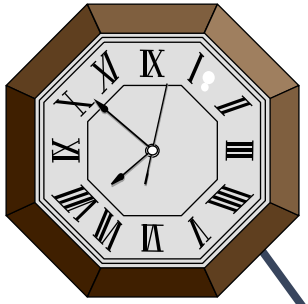
- Track
  - The area the reading head covers on a rotation.
- Sector
  - The smallest part of a track that can be read
- Cylinder
  - All tracks in the same position on the disc

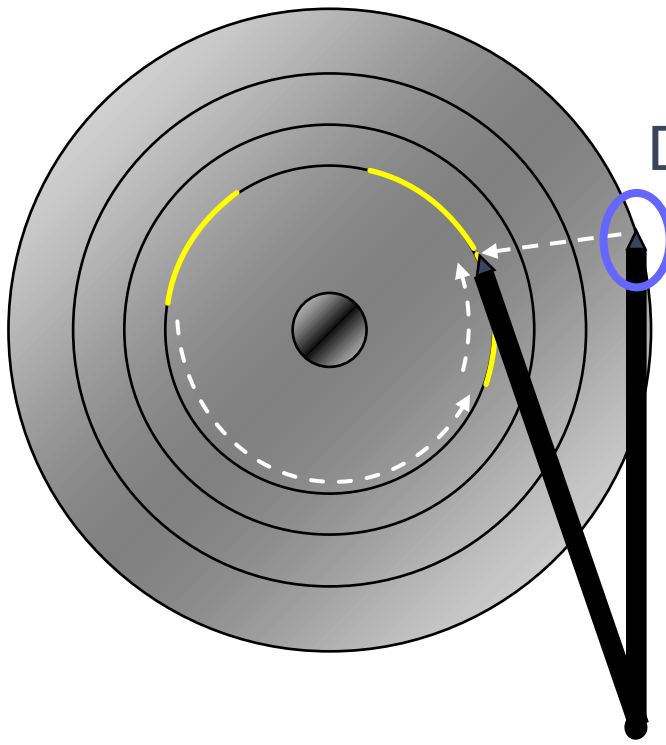




512 bytes per sector * 51 sectors per track * 723 cylinders * 14 read heads = 264305664 B = 252 MB

Disk Access Time

Will have block X →  → block X in memory



Disk access time =

Search time

\+ Rotation delay

\+ Transfer time

\+ Other delays

H-Disk addressing of sectors

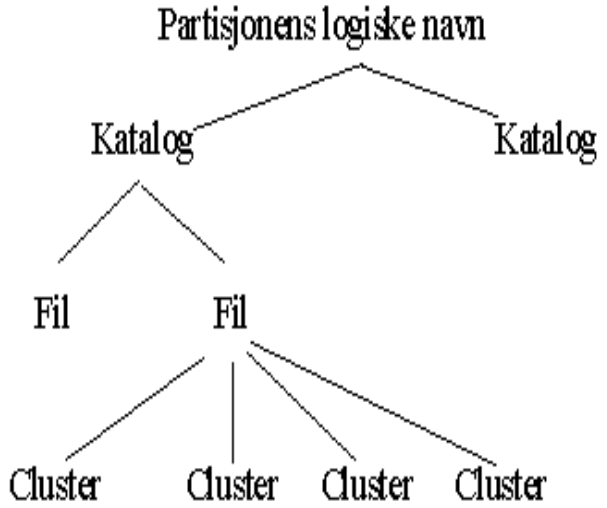
Høyskolen Kristiania

- Previously (and due to backward compatibility) CHS (Cylinder, Head, Sector) or Extended CHS was used.
  - Originally limited to 1024 C, 16 H, 63 S = 528 MB
  - BIOS Interrupt 0x13 extended to 8G at 0-254 Head
  - 24 bit address, 512 B sector = 8G hard drive
- Now used LBA (Logical Block Adressing)
  - Originally for SCSI, then for ATA / SATA
  - The sectors have logical linear LBA addresses 0,1,2,3…
  - C 0, H 0, S1 = LBA 0, …
  - 32 bit addresses give max size 2TB
  - LBA is supported by all modern OS and BIOS
- In the future, GUID seems to take over
  - Supported by UEFI
  - 64 bit addresses
  - allows in principle disks up to 8 ZiB (assuming 512 Byte blocks)

The logical organization of the disk (hierarchy)

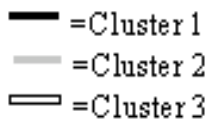
Høyskolen Kristiania

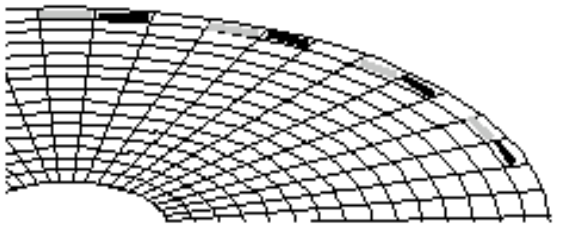
- Cluster
  - Minimum unit read by the operating system, minimum 1 sector.
- File
  - Minimum device referenced by the operating system, minimum 1 cluster.
- Catalog
  - File for organizing files
- Partition.
  - Organization of directories; e.g. C :



Low-level formatting

- Low level formatting is done by the manufacturer
- Addresses are written on each secto
- The disk is initialized with zero value
- Defective areas are marked
- The interleave pattern is set
- The example shows 3: 1 interleave





Partitioning

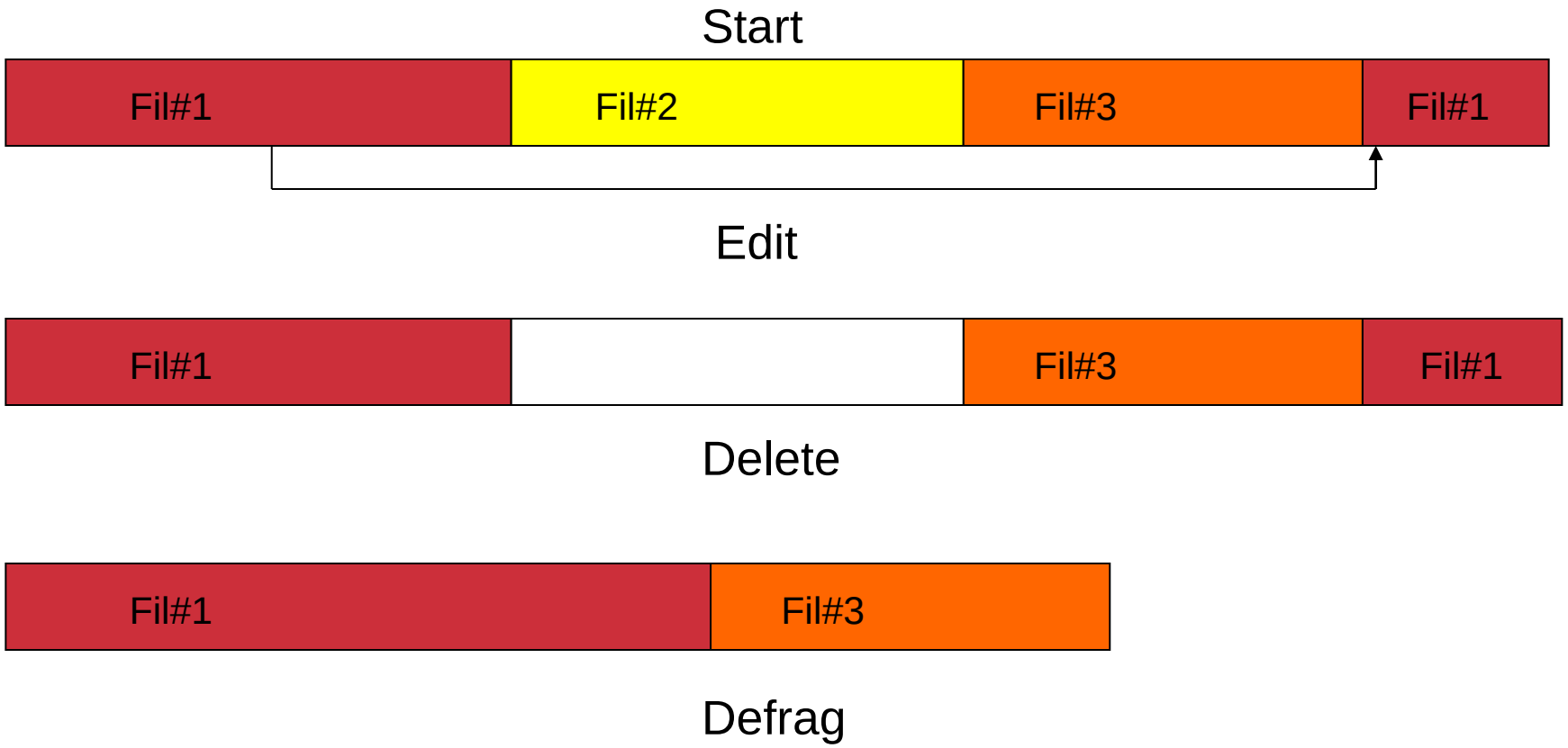
- Partitioning is done by supplier (or user)
- Made from «DOS» with the program FDISK
- Creates MBR (Master Boot Record) at the start of the disk
- Used by the BIOS to boot the operating system
- Minimum 1 partition (primary)
- Can add secondary (extended) partitions
- Cannot have two operating systems in the same partition (other than as Virtual Machine)

High-level formatting

Høyskolen Kristiania

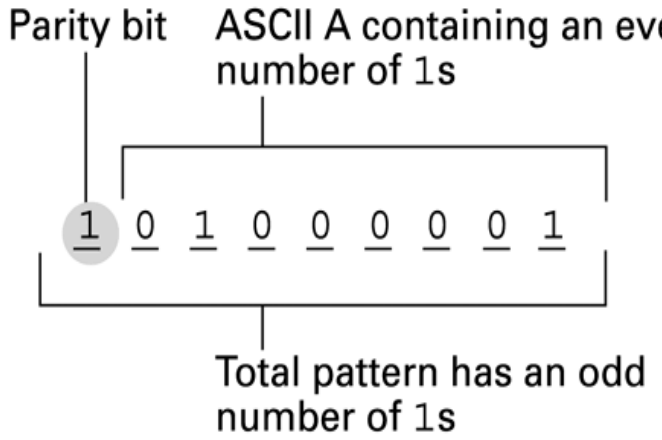
- High-level formatting is done by the supplier (or user)
- Can be done from DOS with the program FORMAT
- Receives warning from operating system if it is primary partition
- Adds content from MBR into the startup sector
- Not all disks can be booted
- Stock root directory
- Defines how many sectors there are in a cluster
- Builds file allocation tables (FAT)
- FAT12, FAT16, FAT32, (NTFS, Ext3)

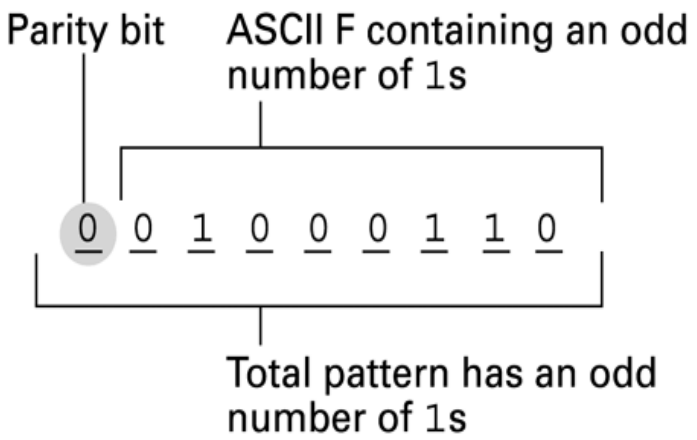
Fragmentation



Parity bit

- In order to be able to identify "bad blocks" (sectors with errors), each sector has a parity byte that is used to check whether errors have occurred.
- Parity check was part of 7bit ASCII:

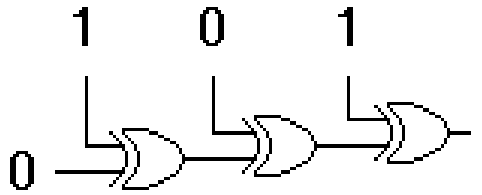




Parity bit

- 1 parity bit can only detect odd number errors!
- Uses CRC checksums that provide the opportunity to detect far more errors (more in the penultimate lecture)
- Parity can be easily generated with XOR!

- Using smart coding, you can create better checksums. (cf. social security number)



parity?

Error Correcting Codes (ECC)

- Based on the Hamming distance between the codes

Symbol	Code
A	000000
B	001111
C	010011
D	011100
E	100110
F	101001
G	110101
H	111010

Example

In this code set, there is always at least three bits difference between all the codes

The hammering distance between A and B is 4, B and C 3, etc.

ECC (2)

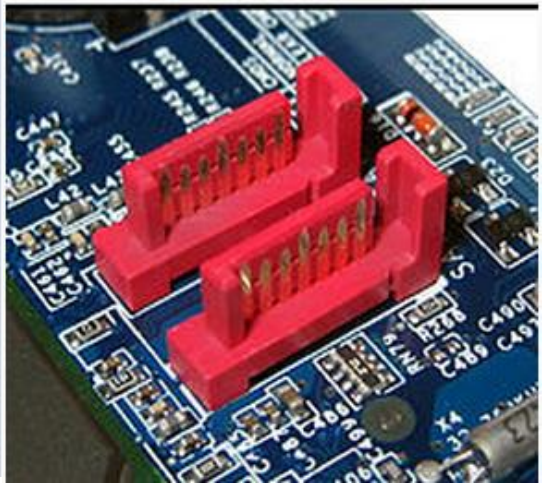
Character	Code	Pattern received	Distance between received pattern and code
A	0 0 0 0 0 0	0 **1** 0 **1** 0 0	2
B	0 0 1 1 1 1	0 **1** **0** 1 **0** **0**	4
C	0 1 0 0 1 1	0 1 0 **1** **0** **0**	3
D	0 1 1 1 0 0	0 1 **0** 1 0 0	**1** — Smallest distance
E	1 0 0 1 1 0	**0** **1** 0 1 **0** 0	3
F	1 0 1 0 0 1	**0** **1** **0** **1** 0 **0**	5
G	1 1 0 1 0 1	**0** 1 0 1 0 **0**	2
H	1 1 1 0 1 0	**0** 1 **0** **1** **0** 0	4

- Reading 010100, which letter should it (probably) have been?
  - The one with the least Hamming distance in the code set.
- With Hamming-distance 3 in the code set, you can detect up to two error codings (bit-flips) and correct one.
- With Hamming distance 5 in the code set, you will be able to detect up to four errors per pattern and correct two

Buses / sections: ATA, SATA

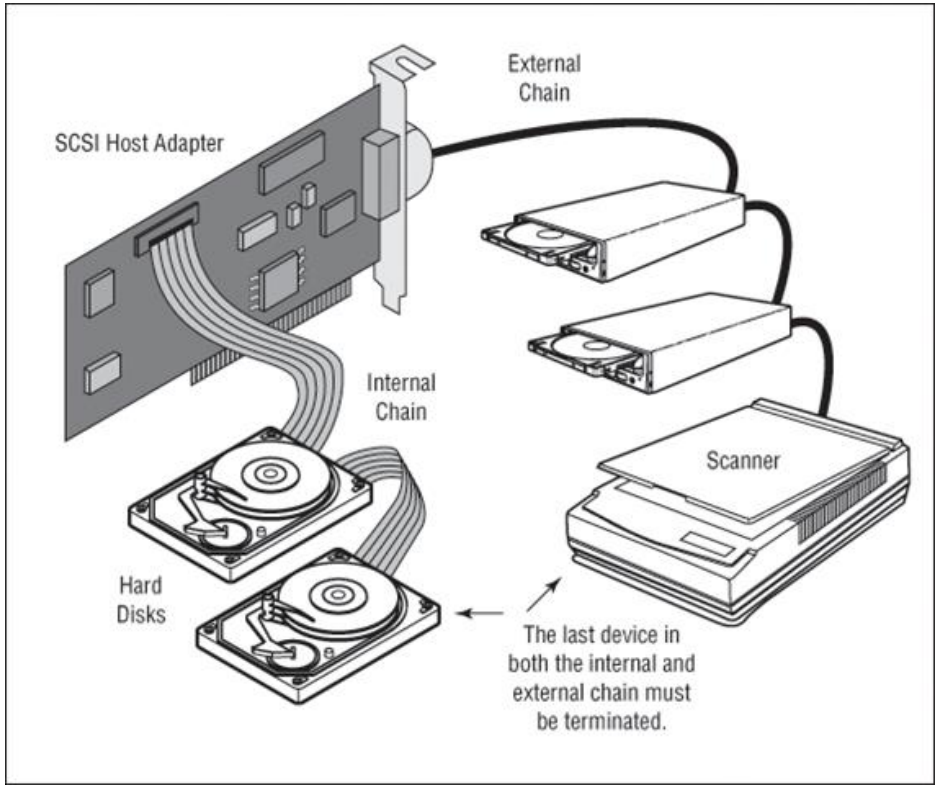
- (Parallell) ATA
  - (Parallel) ATA
  - Versions 1-7
  - Original IDE
  - Supported LBA and DMA
  - Cable with 80 parallel conductors
  - Max 133 MBps.

  - SATA: Serial
  - Latest version supports up to 6 Gbps (v. 3.0)
  - Cables up to 8 m
  - eSATA for external connection
  - HotPlug!



SCSI

- Allows series connection of equipment.
  - Each must have their own ID.
- Most used on servers
- Versions 1-3
- A collection of different standards!
- iSCSI is e.g. a combination of Etrhernet and SCSI



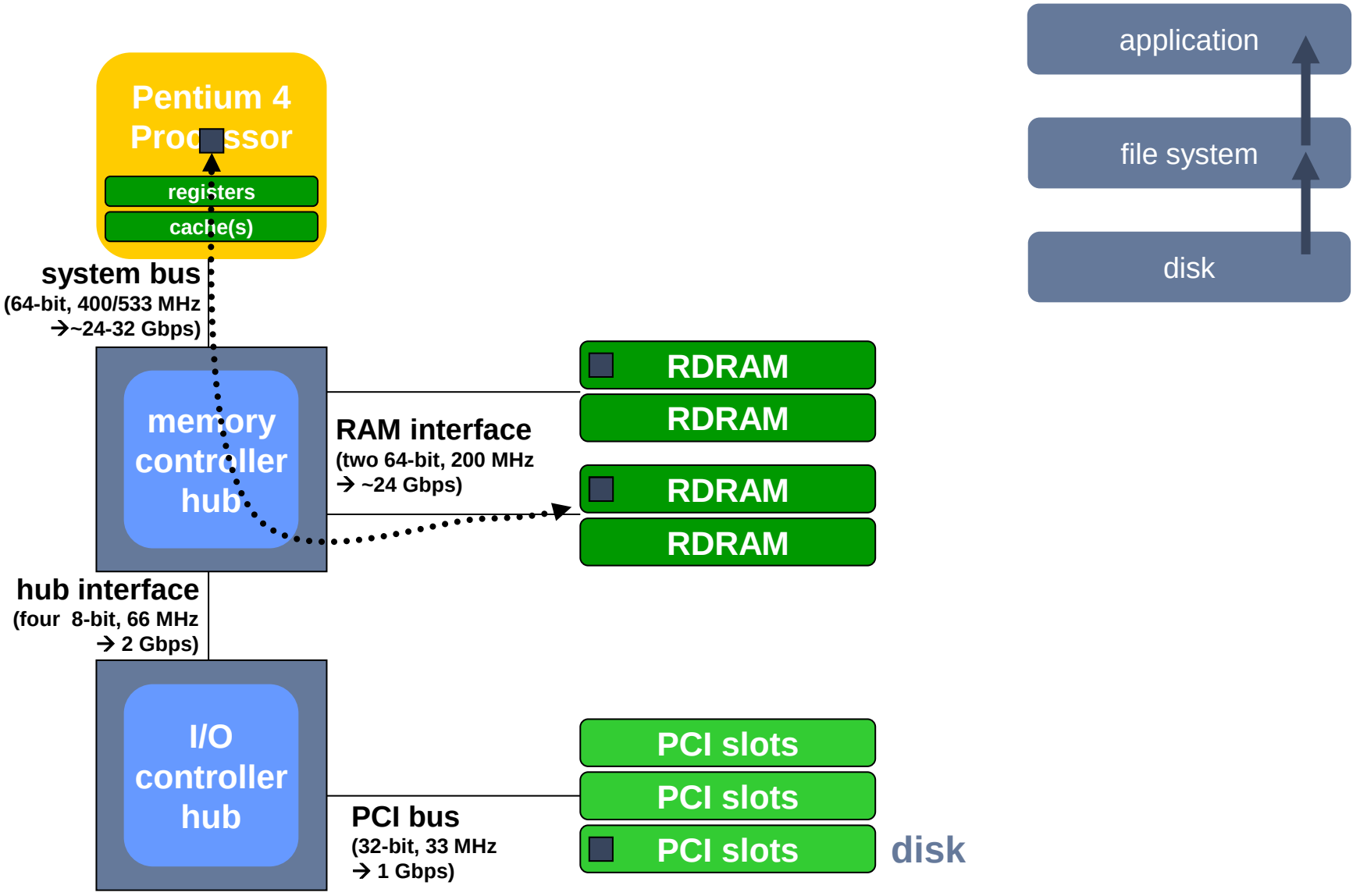
Device controllers

- I / O devices often consist of
  - Mechanical component ("the device itself")
  - Electronic component
- The electronic component is the device controller.
  - "A small microprocessor"
  - Can possibly handle several units
- The tasks of the controller
  - Receive instructions
  - View status
  - Convert serial bitstream to block of bytes
  - Perform error correction as needed
  - Make data available in primary memory (RAM)

I / O ports and addresses

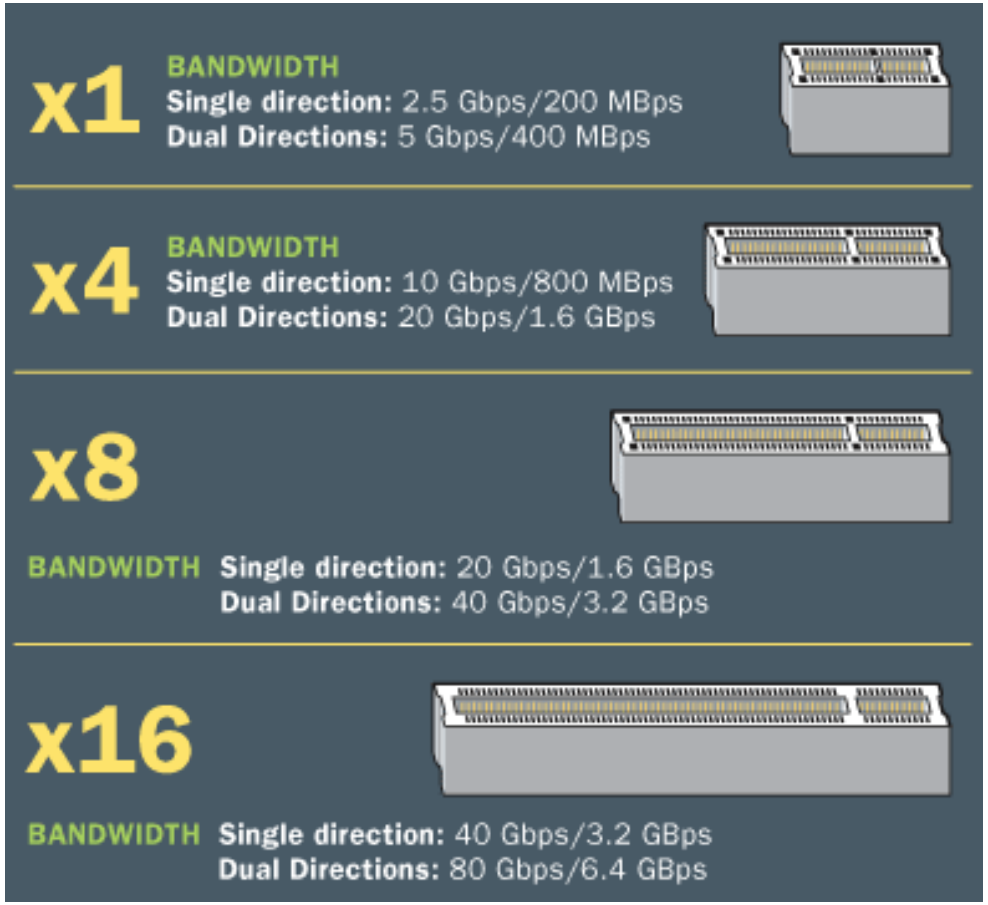
- Each controller has some registers that are used to store status and communicate with the CPU
  - Can write to these to control the device
  - Can read others to find the condition of the device.
- May also have data buffer
  - Video RAM on video card
  - Cache ON disk
- Can write registers / buffer using I / O ports
- Can also use the memory mapped I / O

Ex: read from disk



PCIe

- High speed serial bus architecture
- Supports multiple channels
- Different tracks avh channel number
- Structure
- Point-to-point
- Packet-based and routed a la network
- Addresses and data are in the same package
- High bit rate
- Each channel supports duplex, 2.5 Gbps each way
- SUPPORT FOR SEVERAL GRAPHIC CARDS



Why single direction?

Høyskolen Kristiania

Start-up

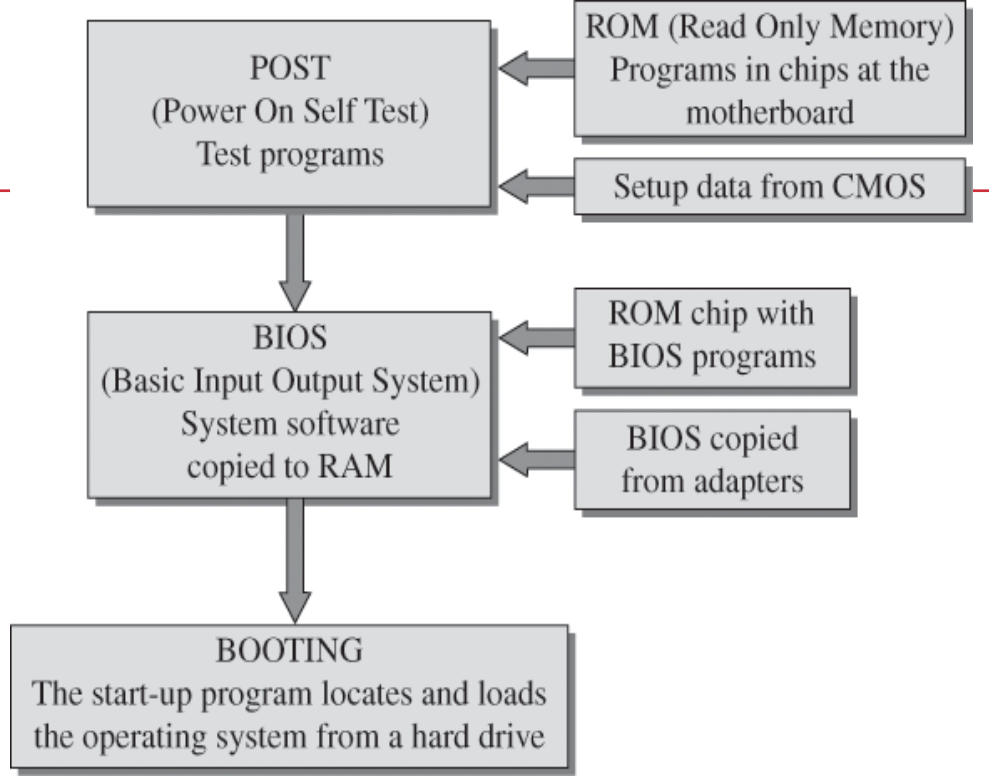
BIOS – BASIC I/O SYSTEM

Høyskolen Kristiania

- Software for controlling essential components
  - For example. Keyboard, screen, disks, serial ports, …
- Stored on ROM chip
- Three main functions
  - Boot PCs
  - Test and verify hardware
  - Provide interfaces between hardware and software.

Boot -the sequence

1. .The power supply starts up
2. The primary part of the BIOS is loaded into RAM
   - The CPU reads the start address of the BIOS boot program.
3. Boot type confirmed.
   - Cold boot: turns on
   - Warm boot: restart / rest, does not run POST
   - When PC restarted or reset, does not run POST.
4. Power On Self Test (POST) begins.
   - Error messages are given as "beep codes"
5. Video adapter software loads.
6. The BIOS for other equipment is loaded
   - BIOS startup screen loads
   - Error messages are displayed as text..
7. CMOS configuration tested.
   - Checks that equipment listed in CMOS is present and working.



8. Ports assigned and equipment configured.
9. Hardware configuration confirmed
10. BIOS displays summary screen
11. Operating system located and loaded (MBR).

<u>Boot fails:</u>

When the PC fails to complete the BIOS and load the OS

Typical causes are loose or missing components, and / or OS / driver errors on disk.

Power On Self Test (POST)

Høyskolen Kristiania

- Error codes are (mainly) dependent on the BIOS manufacturer
- Two types:
  - Beep codes
    - Long and short tones in speaker
  - Error messages
    - To screen
    - 1xx Motherboard, 2xx RAM, 3xx Keyboard, 17xx HD,…
    - 3-4 digits with some explanation
    - «BIOS ROM checksum Error: System halted»
    - Hard disk install failure »
    - Memory Test Fail.
  - Easy BEEP in speaker when POST performed

CMOS

- BIOS setup program: Used to configure settings stored in CMOS.
- CMOS settings ≈ Hardware configuration
- SETUP:
  - Typically has menus to set:
  - Default Settings
  - Boot medium order
  - System date and time
  - Hard disk, floppy, ..
  - Video display
  - Advanced settings: Motherboard, CPU, chipset
  - Plug and Play (PnP) options, power management, security and passwords, integrated controllers for peripherals.

BIOS update

- The BIOS "determines" what kind of equipment the PC may have connected
- Upgrading ("flashing") of the BIOS is occasionally needed to solve special problems
- You can corrupt the BIOS chip by interrupting during updating, or trying to enter the wrong BIOS
- Now replaced by different types of firmware

BIOS->UEFI

Høyskolen Kristiania

- BIOS is for 16 bit machines…
- Supports only 1 MiB of memory.
- Is in the process of being replaced with Unified Extensible Firmware Interface (UEFI)
  - Supports both 32 and 64 bit instructions from startup
  - Supports a minimum of 2GB of memory
  - Supports a new addressing method for partitions and blocks on the Hard Disk (GPT instead of MBR) which allows hard disks larger than 2 TB to be used -> 8 * 2 ^ 70