
# Computer Structure

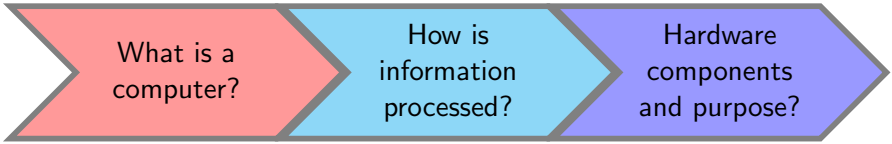
Rasmus Dahlberg

# Motivation

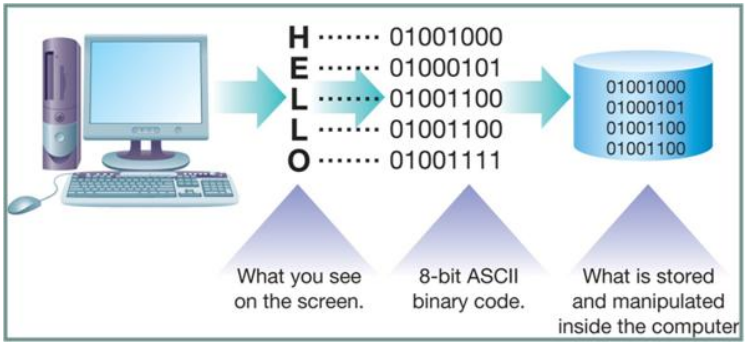

- What can a computer do?
- How do you choose one?

# Learning outcome based on syllabus

- Describe the components of a computer and their interaction (ISGA01)
- Give an account of the components of a computer and their interaction (ISGA06)
- Give an account of the components of a computer and how they interact (ISGA90)



# A typical computer



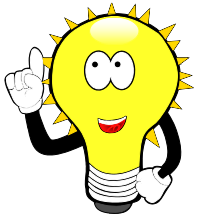
# Current computer definitions in Swedish and English

- Digital enhet för beräkning, symbolbehandling och kommunikation[1]
- An electronic device for storing and processing data, typically in binary form, according to instructions given to it in a variable program[2]
- A computer is a device that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming[3]

[1] https://www.ne.se/uppslagsverk/encyklopedi/l%C3%A5ng/dator
[2] https://en.oxforddictionaries.com/definition/computer
[3] https://en.wikipedia.org/wiki/Computer

# Information theory

- The smallest piece of information is binary
- One ‘bit’ represents a zero or a one
- Example of sending a single bit?
- Example of sending multiple bits?



# What does this mean?

01011001011011111011001000110000 1

# What does this mean?

01011001011011110110010001100001

Many different things...

- 32-bit unsigned integer: 1500472417
- 32-bit floating point: $4.21143045 \cdot 10^{15}$
- Groups of 8 bits: 89, 111, 100, 97
  - Byte
  - Number between 0–255 (why?)

# Information theory continued

Decimal numbers as we know them:

$$\begin{aligned} 107 &= 1 \cdot 100 + 0 \cdot 10 + 7 \cdot 1 \\ &= 1 \cdot 10^2 + 0 \cdot 10^1 + 7 \cdot 10^0 \end{aligned}$$

A position is associated with 0–9
A position is weighted by $10^i$, $i \geq 0$
This is known as base 10

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Why is this intuitive for us?

# Information theory continued

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Binary numbers follow the same idea:

$$\begin{aligned} 1101 &= 1 \cdot 8 + 1 \cdot 4 + 0 \cdot 2 + 1 \cdot 1 \\ &= 1 \cdot 2^3 + 1 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0 = 13 \end{aligned}$$

A position is associated with 0–1
A position is weighted by $2^i$, $i \geq 0$
This is known as base 2

Why is this intuitive for us?

# Information theory continued

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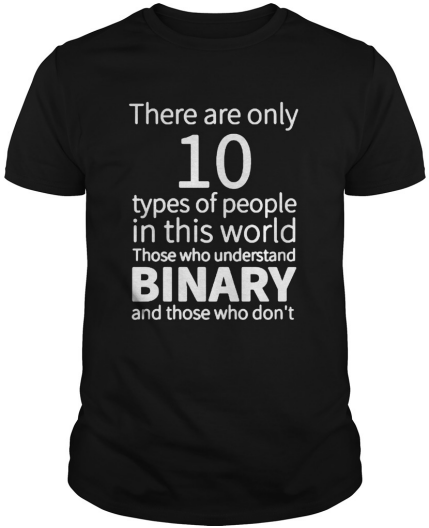
Why is this intuitive for a computer?

# Now you can proudly wear this T-shirt!



# Be aware of different unit systems

| unit | abbreviation | meaning |
|---|---|---|
| kilo | k | $10^3$ |
| mega | M | $10^6$ |
| giga | G | $10^9$ |
| tera | T | $10^{12}$ |

(Decimal numbers as we know them)

| unit | abbreviation | meaning |
|---|---|---|
| kibi | Ki | $2^{10}$ |
| mebi | Mi | $2^{20}$ |
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(Binary numbers, note $2^{10} = 1024$)

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(Binary numbers, note $2^{10} = 1024$)

"I bought a 500 GB hard drive, but Windows says it is 465.7 GB?"

# ASCII TABLE

| Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | [NULL] | 32 | 20 | [SPACE] | 64 | 40 | @ | 96 | 60 | ` |
| 1 | 1 | [START OF HEADING] | 33 | 21 | ! | 65 | 41 | A | 97 | 61 | a |
| 2 | 2 | [START OF TEXT] | 34 | 22 | " | 66 | 42 | B | 98 | 62 | b |
| 3 | 3 | [END OF TEXT] | 35 | 23 | # | 67 | 43 | C | 99 | 63 | c |
| 4 | 4 | [END OF TRANSMISSION] | 36 | 24 | $ | 68 | 44 | D | 100 | 64 | d |
| 5 | 5 | [ENQUIRY] | 37 | 25 | % | 69 | 45 | E | 101 | 65 | e |
| 6 | 6 | [ACKNOWLEDGE] | 38 | 26 | & | 70 | 46 | F | 102 | 66 | f |
| 7 | 7 | [BELL] | 39 | 27 | ' | 71 | 47 | G | 103 | 67 | g |
| 8 | 8 | [BACKSPACE] | 40 | 28 | ( | 72 | 48 | H | 104 | 68 | h |
| 9 | 9 | [HORIZONTAL TAB] | 41 | 29 | ) | 73 | 49 | I | 105 | 69 | i |
| 10 | A | [LINE FEED] | 42 | 2A | * | 74 | 4A | J | 106 | 6A | j |
| 11 | B | [VERTICAL TAB] | 43 | 2B | + | 75 | 4B | K | 107 | 6B | k |
| 12 | C | [FORM FEED] | 44 | 2C | , | 76 | 4C | L | 108 | 6C | l |
| 13 | D | [CARRIAGE RETURN] | 45 | 2D | - | 77 | 4D | M | 109 | 6D | m |
| 14 | E | [SHIFT OUT] | 46 | 2E | . | 78 | 4E | N | 110 | 6E | n |
| 15 | F | [SHIFT IN] | 47 | 2F | / | 79 | 4F | O | 111 | 6F | o |
| 16 | 10 | [DATA LINK ESCAPE] | 48 | 30 | 0 | 80 | 50 | P | 112 | 70 | p |
| 17 | 11 | [DEVICE CONTROL 1] | 49 | 31 | 1 | 81 | 51 | Q | 113 | 71 | q |
| 18 | 12 | [DEVICE CONTROL 2] | 50 | 32 | 2 | 82 | 52 | R | 114 | 72 | r |
| 19 | 13 | [DEVICE CONTROL 3] | 51 | 33 | 3 | 83 | 53 | S | 115 | 73 | s |
| 20 | 14 | [DEVICE CONTROL 4] | 52 | 34 | 4 | 84 | 54 | T | 116 | 74 | t |
| 21 | 15 | [NEGATIVE ACKNOWLEDGE] | 53 | 35 | 5 | 85 | 55 | U | 117 | 75 | u |
| 22 | 16 | [SYNCHRONOUS IDLE] | 54 | 36 | 6 | 86 | 56 | V | 118 | 76 | v |
| 23 | 17 | [ENG OF TRANS. BLOCK] | 55 | 37 | 7 | 87 | 57 | W | 119 | 77 | w |
| 24 | 18 | [CANCEL] | 56 | 38 | 8 | 88 | 58 | X | 120 | 78 | x |
| 25 | 19 | [END OF MEDIUM] | 57 | 39 | 9 | 89 | 59 | Y | 121 | 79 | y |
| 26 | 1A | [SUBSTITUTE] | 58 | 3A | : | 90 | 5A | Z | 122 | 7A | z |
| 27 | 1B | [ESCAPE] | 59 | 3B | ; | 91 | 5B | [ | 123 | 7B | { |
| 28 | 1C | [FILE SEPARATOR] | 60 | 3C | < | 92 | 5C | \ | 124 | 7C | \| |
| 29 | 1D | [GROUP SEPARATOR] | 61 | 3D | = | 93 | 5D | ] | 125 | 7D | } |
| 30 | 1E | [RECORD SEPARATOR] | 62 | 3E | > | 94 | 5E | ^ | 126 | 7E | ~ |
| 31 | 1F | [UNIT SEPARATOR] | 63 | 3F | ? | 95 | 5F | _ | 127 | 7F | [DEL] |

- 89: Y
- 111: o
- 100: d
- 97: a

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- 89: Y
- 111: o
- 100: d
- 97: a
- å, ä, ö?
  - UTF-8
  - UTF-16
  - UTF-32

# Divide yourself into small groups

Interactive exersice

# My office setup[4]

Computer case containing:

- Central Processing Unit (CPU)
- Random Access Memory (RAM)
- Solid State Drive (SSD)
- Hard drive (HDD)
- Power Supply Unit (PSU)
- Fan for CPU cooling
- Motherboard

[4] https://www.dustinhome.se/favorites/index/9620211

# Central Processing Unit (CPU) ‘Processor’

- Does most of the computing
- Instruction set
  - load
  - store
  - add
  - conditional jump
  - ...
- Registers
- Clock speed
- Number of cores


Intel Core i7 7700K / 4.2 GHz processor LGA1151 Socket

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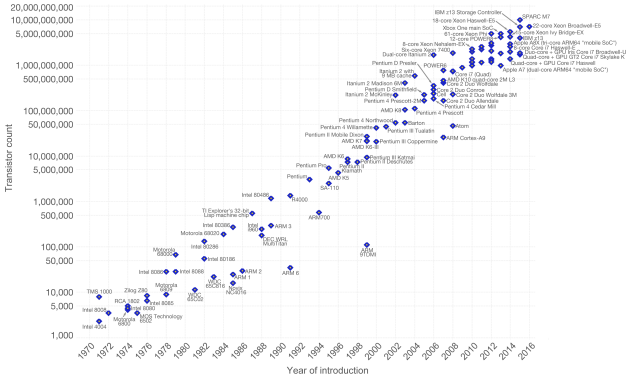
Intel Core i7 7700K / 4.2 GHz processor LGA1151 Socket

Is faster clock speed always better?

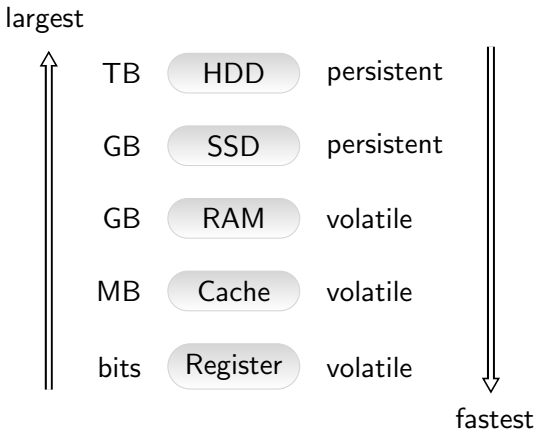
# Gordon Moore predicted the number of transitors on a dense integrated circuit




https://en.wikipedia.org/wiki/Moore%27s_law#/media/File:Moore%27s_Law_Transistor_Count_1971-2016.png

- Moore's law
  - 1965: doubles every year
  - 1975: doubles every two years
  - ≈2025: dead
- David House
  - 18 months → 2x performance

# Different types of memory, all storing zeros and ones only!




- HDD: ‘hårddisk’
- SSD: ‘typ en hårddisk’
- RAM: ‘internminne eller arbetsminne’
- Cache: on and nearby the CPU
- Register: on the CPU

# Different types of memory continued

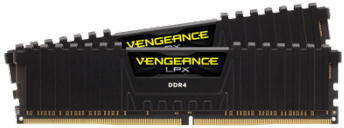
HDD


WD Blue 4TB 3.5" Serial ATA-600

SSD


Crucial MX500 500GB Serial ATA-600

RAM




CORSAIR V LPX 32GB (2X16) DDR4 2400MHZ

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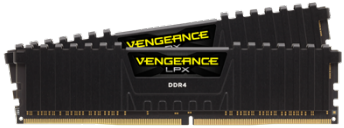
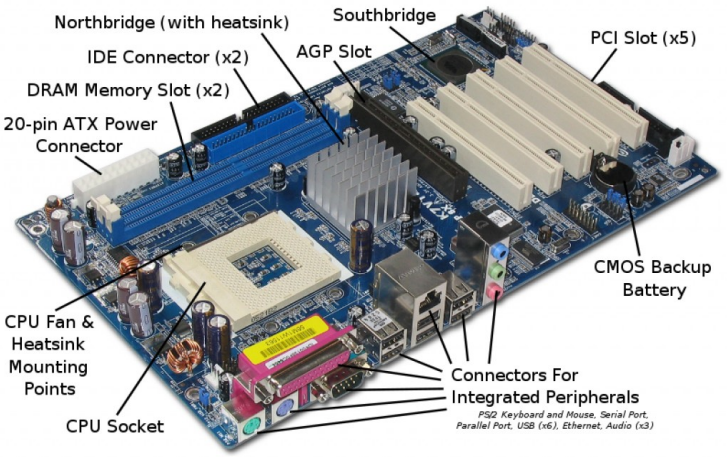



CORSAIR V LPX 32GB (2X16) DDR4 2400MHZ

- Trade-offs between SSD and HDD?
- How much RAM do you need?

# Motherboard (or, the thing everything is attached to) 'Moderkort'




Contains at least:

- Processor slot
- Memory slot
- Connectors, e.g.,
  - Power
  - SATA
  - SCSI
  - ...
- Control circuits
  - BIOS
  - Cache
  - ...

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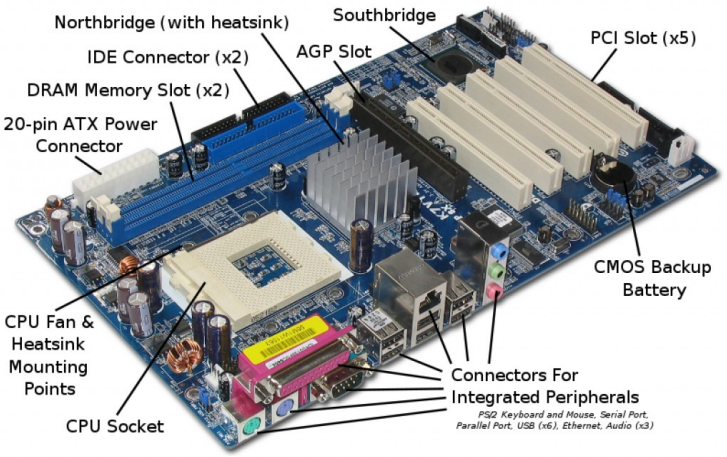


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- Control circuits
  - BIOS
  - Cache
  - ...

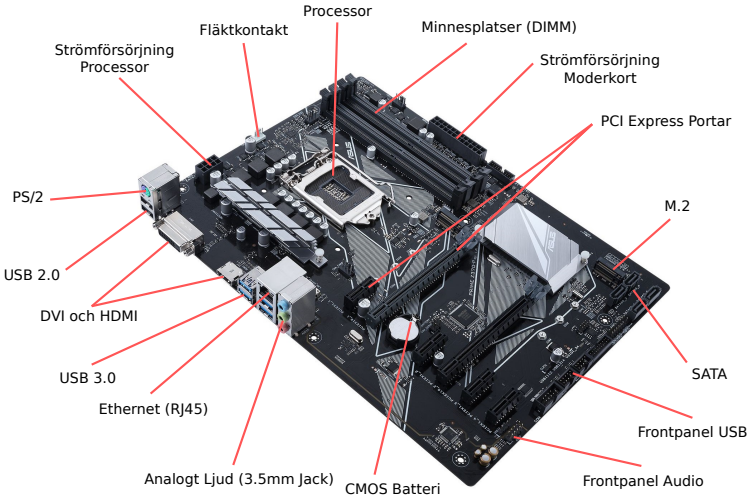
What should you think about when you buy hardware?

# A newer motherboard: ASUS PRIME Z370-P

Manual[5]

[5] https://www.asus.com/us/Motherboards/PRIME-Z370-P/HelpDesk_Manual/

# A newer motherboard continued



# Expantion cards usually use PCI(e) ‘Instickskort’

Graphics card for complex math, geometry, and coloring (‘grafikkort’)


Audio card for enhanced sound experiences (‘ljudkort’)

Network card for data exchange over a computer network (‘nätverkskort’)

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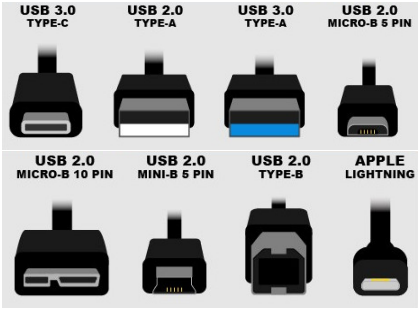
Is my office setup without graphics, sound, and Internet?!

# A few common external connectors

USB



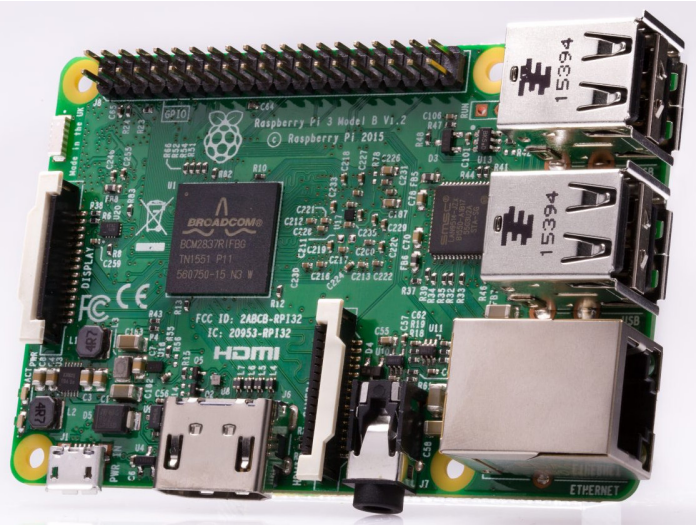

External HDD and devices

HDMI

DP

Mainly video and audio

# You will find the same basic components in every computer—Raspberry Pi




https://www.raspberrypi.org/

All components are embedded on a SoC:

- CPU
- Memory
- Connectors
- Control circuits

# You will find the same basic components in every computer—MBP

https://www.ifixit.com/Teardown/MacBook+Pro+15-Inch+Touch+Bar+Teardown/73395

# You will find the same basic components in every computer—iPhone


https://www.ifixit.com/Teardown/iPhone+5s+Teardown/17383

# In the labs you will (de)assemble a computer

- Be grounded
- Be “stern but fair”
- Be careful with cables
  - Jank? No...
  - Pull? Gently!
  - Wiggle? If you must!
- Attach in the right direction
- Avoid touching circuit boards
- Ask if you need help

# Nervous? Prepare yourself by watching a computer being built


How to Build a PC in 30 minutes with EasyPCBuilder! - Gaming PC

https://www.youtube.com/watch?v=0bUghCx9iso

# Any questions?