Computer Structure

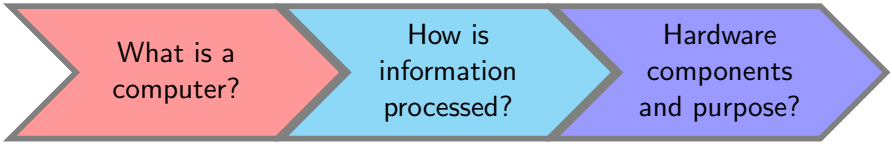
Rasmus Dahlberg

Motivation

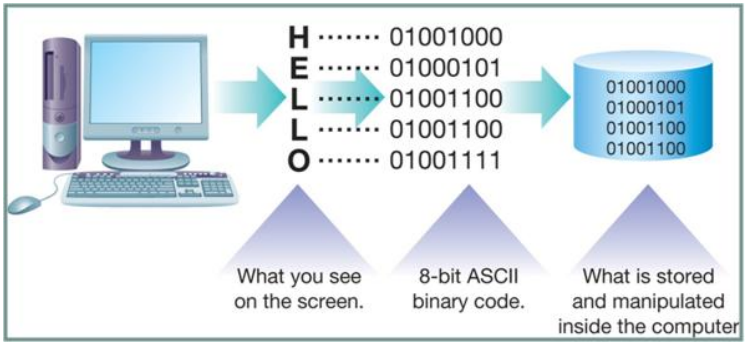
- What can a computer do?
- How do you choose one?

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



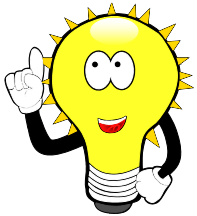
Current computer definitions in Swedish and English

- 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?

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

Why is this intuitive for us?

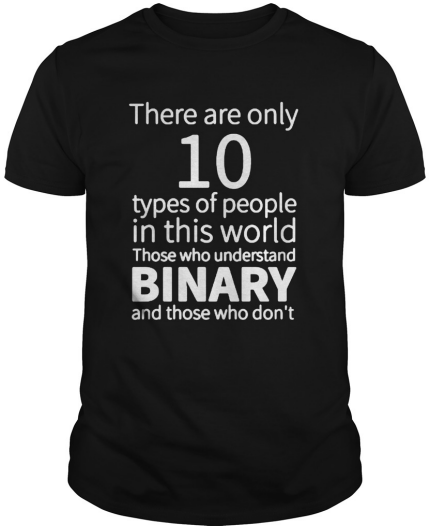
Binary numbers follow the same idea:

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

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 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}
gibi	Gi	2^{30}
tebi	Ti	2^{40}

(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
- 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

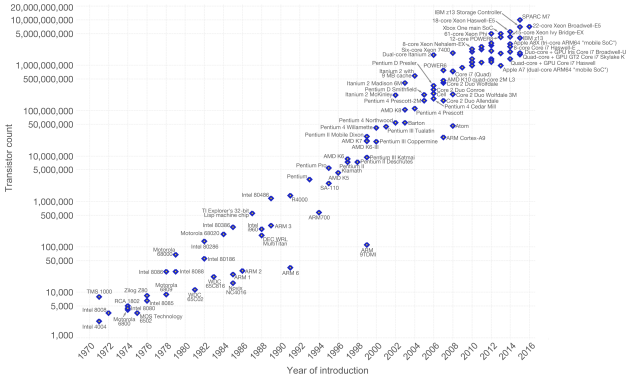
Central Processing Unit (CPU) ‘Processor’

- 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

Is faster clock speed always better?

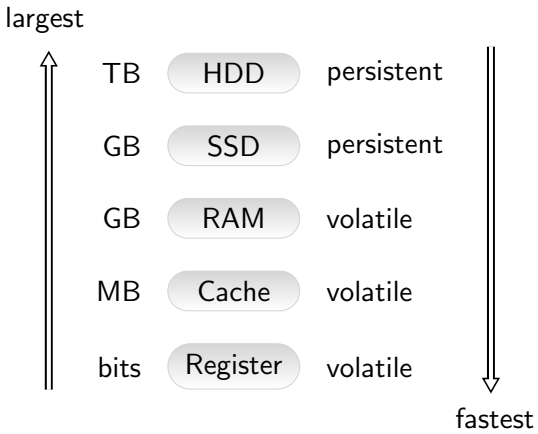
Gordon Moore predicted the number of transitors on a dense integrated circuit



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

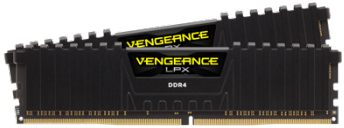
HDD

WD Blue 4TB 3.5" Serial ATA-600

SSD

Crucial MX500 500GB Serial ATA-600

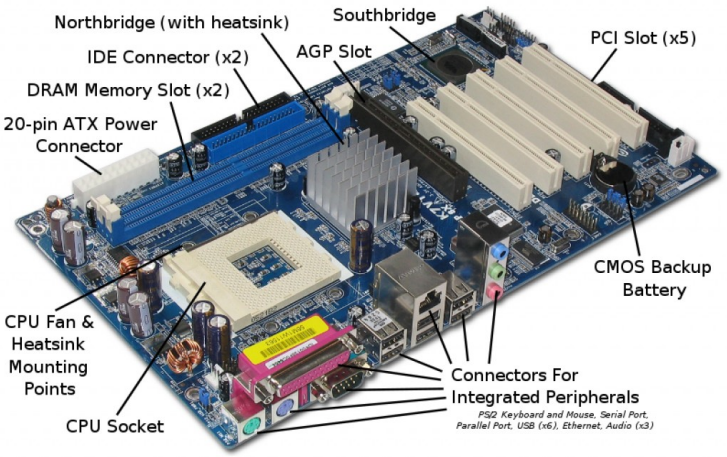
RAM



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

- 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
  - ...

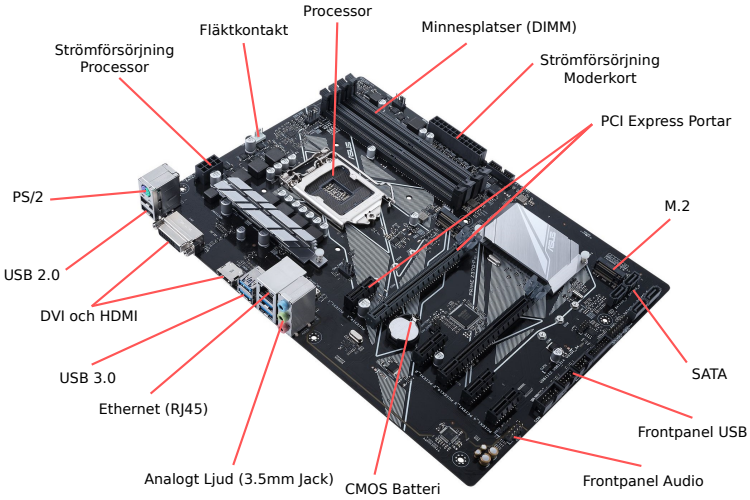
What should you think about when you buy hardware?

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’)

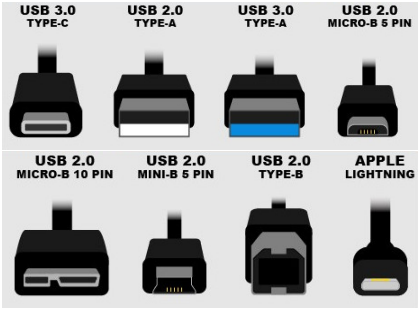
Audio card for enhanced sound experiences (‘ljudkort’)

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

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

A few common external connectors

USB



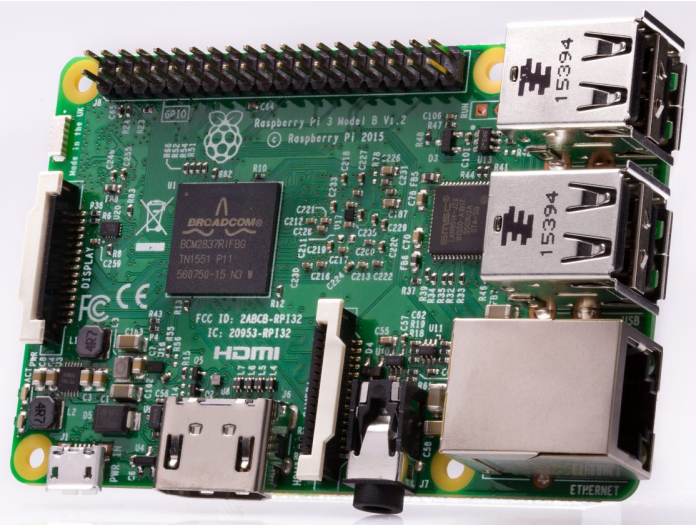
External HDD and devices

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?