
Hard and Soft Ware

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Some pics provided by Wikimedia Commons

Agenda

Definitions

Chips and their building blocks

Processors and instructions

Layers of software

Conclusion

Hard and soft ware?

Hardware?

- Physical
- Electronic chips: electricity in, electricity out

Software?

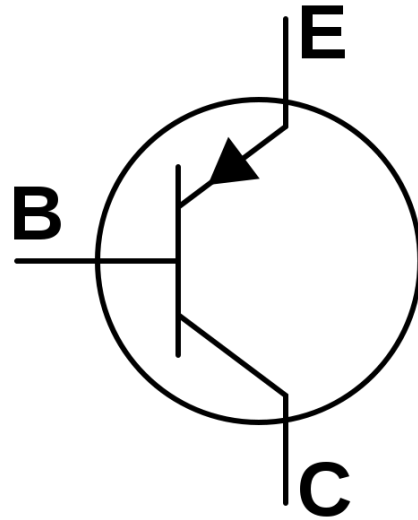
- Programs, frameworks, libraries, files, code, data
 - Numbers, bits stored on media and memory
 - Voltages inside chips: on and off
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Numbers

0000000	2123	622f	6e69	622f	7361	0a68	230a	4320
0000010	7268	6d6f	7569	206d	616c	6e75	6863	7265
0000020	0a0a	2023	7541	6874	726f	3a73	230a	2020
0000030	6843	6461	4d20	6c69	656c	2072	633c	6168
0000040	2e64	696d	6c6c	7265	6340	6e61	6e6f	6369
0000050	6c61	632e	6d6f	0a3e	2023	4620	6261	6569
0000060	206e	6154	7373	6e69	3c20	7466	4061	6f73
0000070	6166	6172	6177	2e79	726f	3e67	230a	4c20
0000080	6369	6e65	6573	203a	5047	764c	2032	726f
0000090	6c20	7461	7265	0a0a	2023	7845	6c70	6369
00000a0	7469	796c	7320	7465	7420	6568	5020	5441
00000b0	2048	6f74	7420	6168	2074	666f	4520	564e
00000c0	535f	5055	5441	2048	6e69	2f20	7465	2f63
00000d0	6f6c	6967	2e6e	6564	7366	6120	646e	7520
00000e0	736e	7465	230a	7620	7261	6f69	7375	6f20
00000f0	6874	7265	7620	7261	6169	6c62	7365	202e
0000100	4c28	3a50	2320	3031	3534	3839	2936	202e
0000110	6854	7369	6320	6e61	6220	2065	6572	6f6d
0000120	6576	2064	6e6f	6563	4120	7070	7241	6f6d
0000130	0a72	2023	7573	7070	726f	7374	6520	766e
0000140	7269	6e6f	656d	746e	6620	6c69	6574	6972
0000150	676e	2820	504c	203a	3123	3430	3935	3538
0000160	0a29	7865	6f70	7472	5020	5441	3d48	752f
0000170	7273	6c2f	636f	6c61	732f	6962	3a6e	752f

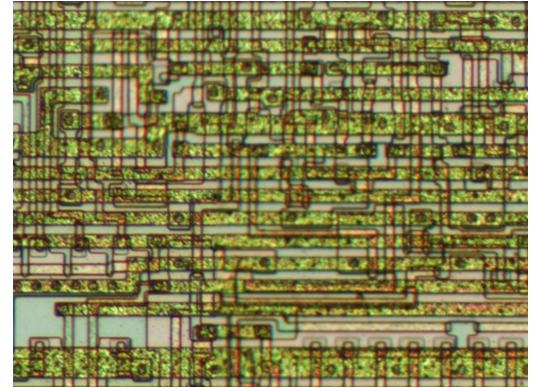
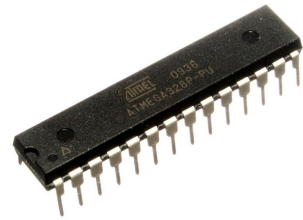
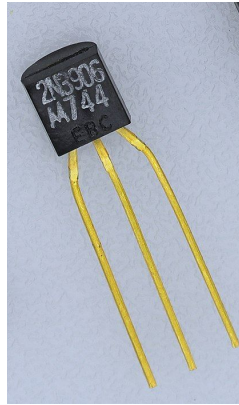
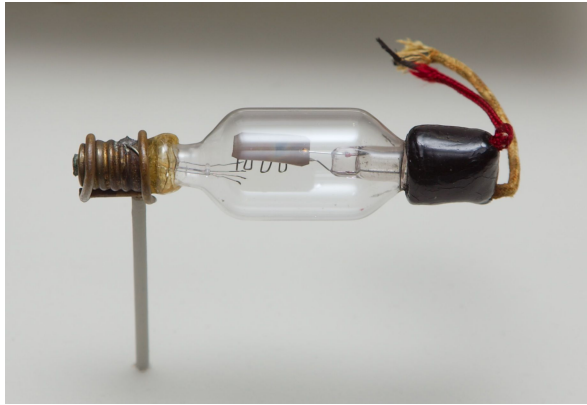
The beginning of the *Chromium* browser on my machine

The transistor



Electronic amplifier or switch, here of the bipolar junction (BJT) type: emitter, base and collector

The transistor



Vacuum tube (1906), single transistor and integrated circuit

The Transistor

Transistors can be combined to form *gates*

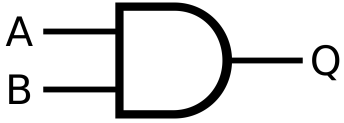
Logical operations NOT, AND, OR, XOR, NAND and more

Gates can be combined to achieve higher-level operations

A modern processor contains milliiards (billions) of transistors

Let's see a *ripple carry adder*:

<https://www.multisim.com/content/r4ardeyWfW4ZzstFt9BjWS/3-bit-ripple-carry-adder/>



A full processor (CPU)

Combination of different blocks responsible for different kinds of operations:

- Decoding
- Calculations (ALU)
- Branching (CU)
- Input and output
- And more

Let's see a simple(ish) example: [6502 SVG Schematic](#)

Instructions

The CPU executes *instructions*

Numbers that dictate what happens next: add, subtract, compare, jump, read from memory, write to memory, ...

The *instruction decoder* decides where the instruction goes

An instruction may also contain data to be processed with it

Let's see an example of how they are: [Online assembler](#)

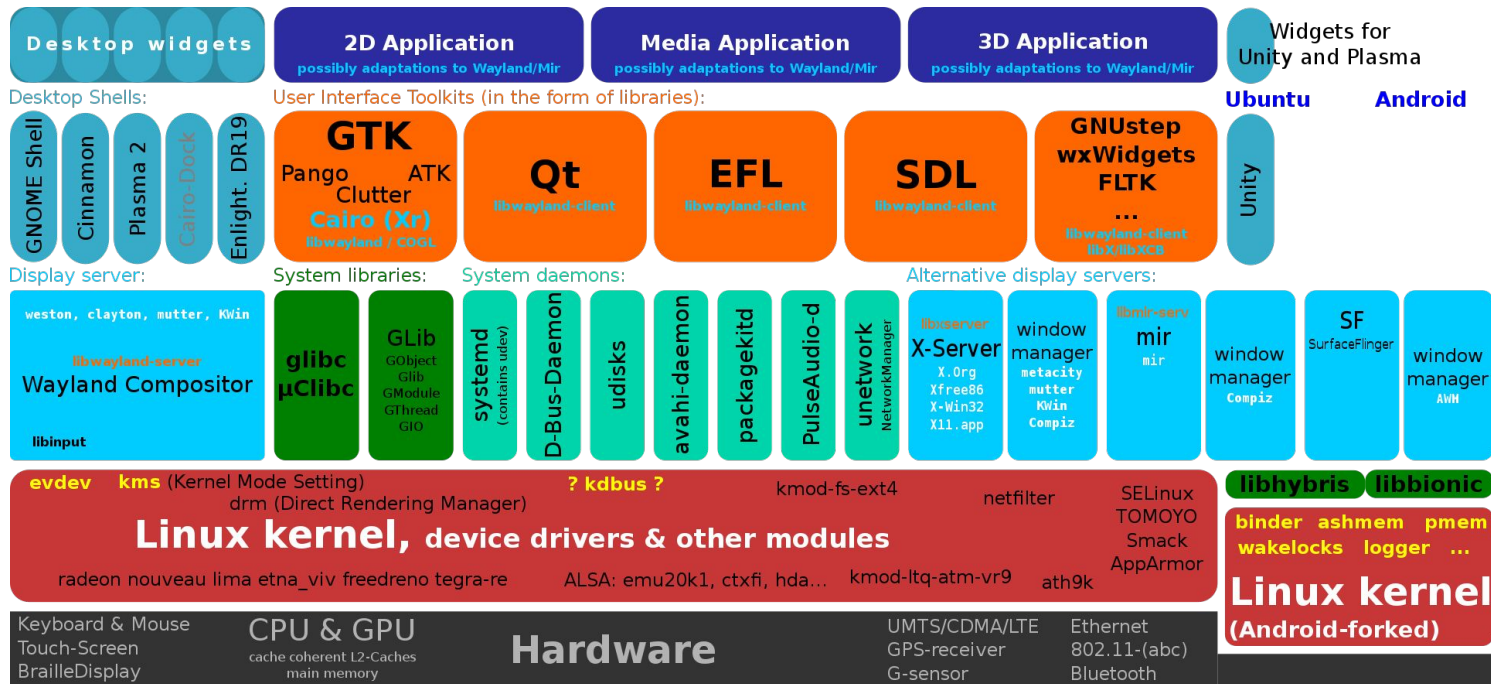
Different layers

Today's platforms consist of different layers

- Hardware
- Operating system kernel and drivers
- System services
- Libraries and frameworks
 - They too have different levels
- Applications

On old or embedded systems less or effectively no layers

Different layers



Linux software layers (by Shmuel Csaba Otto Traian, CC)

Gray areas

Usually it's clear which is which, but some technologies blend the border between software and hardware

Emulators and virtual machines – software pretending to be hardware

Field-Programmable Gate Arrays (FPGA) – (re)configurable chips

Microcode – very low-level instructions describing how normal instructions are processed, can be modified

Conclusion

Stuff to remember:

- Software is numbers – instructions – executed by a processor
 - At the end of the day, voltages on and off
 - Transistors are the basic building blocks of computers
 - Combined into higher-level blocks
 - A CPU consists of multiple such blocks
 - The layered software model
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