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Executive Summary

In this lab I will discuss computer hardware – including issues of waste and standards, how the central processing unit (CPU) works, building one's own computer, and the physical safety of computer/information systems.

Converting Binary to Decimal and Decimal to Binary

Before I do two conversions – one from binary to decimal, then one from decimal to binary – I will lay out the basics of what binary represents.

Binary digits here: _ _ _ _ _ _ _ _

Each represents a multiple of 2: 128 64 32 16 8 4 2 1 [the one is 2-to-the-1 = 1]

If the binary digit shows a 1, you count the corresponding multiple of 2. If it shows a zero, you don't count it. Then you add all of the relevant numbers to get the conversion.

So converting 11000101 to a decimal is: 128+64+0+0+0+4+0+1 = **197**

Converting decimal to binary requires finding which multiples of two "fit inside" the binary number, then marking 1 or 0 until the total equals the binary.

Converting 97 to binary means:

- 128 does not fit inside 97, so 0.
- 64 fits inside 97, so 1. And 97 – 64 = 33
- 32 fits inside 33, so 1. And 33 – 32 = 1.
- 16 does not fit inside 1 (neither does 8, 4, or 2) so 0, 0, 0 and 0.
- 1 fits inside 1, so 1.

Result: **01100001**

CPU Components and Functioning

One of the most important components of a CPU is the Arithmetic Logic Unit (ALU), which performs all of the math inside the CPU, such as addition, subtraction, and comparing two numbers. Basically, the ALU does this by receiving two inputs plus an instruction with that to do with those inputs (for example, "add them") then produces an output based on the instruction.

The AND gate functions when conditions for two pieces of information or instructions are met. More specifically, if the two output wires leading to the AND gate are both "on," the AND gate will take the next step. For example, if the ALU determines that two numbers are equal *and* the instruction about the result is "jump if equal", then the CPU will trigger a jump that retrieves the next piece of data from RAM, which will then move through its own set of instructions in the CPU. This instruction might result in a message on screen saying "you guessed correctly."

Hardware

The most significant components that determine a computer's speed are the CPU, the RAM, and motherboard buses. The CPU and RAM determine how fast information is calculated, and the buses control how quickly information moves from one part to another. As someone who enjoys videogames, I'll also note that the speed of the graphics card also matters, as it separately calculates extremely complex visual outputs, and therefore needs a lot of power and speed as well.

I built my own desktop computer in December, 2016. I will use the parts I purchased then to discuss a reasonably good build. I spent many hours researching the components, and went for the "sweet spot" of cost versus speed, knowing that in about 2-3 years, I will want to start replacing some parts and adding more RAM. I know this based on my previous experience with owning desktops and because of Moore's law, which says that the speed of processors doubles every two years (and therefore the cost of a new processor compared to its power will drop). When I debated between two pieces of hardware that were close in speed (say, the Intel 6600 CPU vs the Intel 6700 CPU), I usually went with the less expensive one, because the more expensive one wasn't so much faster that it justified the much greater cost.

The total cost was approximately $1100. I estimate I saved between $200 and $400 by building my own machine instead of buying a pre-made desktop, although some of that savings was from reusing two parts from a previous build (see below). On the other hand, I spent about 8 hours building the rig and troubleshooting it when it didn't start right away, so what I saved in money I paid for in time. But I also learned a lot in the process, so I did not mind.

- Mobo: ASUS Z170-A ATX DDR4 Motherboards $140
- CPU: Intel Core i5-6600K 6M Skylake Quad-Core 3.5 GHz LGA 1151 91W BX80662I56600K Desktop Processor Intel HD Graphics 530 $220

- CPU fan: Cooler Master Hyper 212 LED CPU Cooler $20(plus thermal compound $6)
- Power supply: EVGA SuperNOVA 750W $100
- Case: reused from previous build; new case would have cost approx. $80
- GPU: ZOTAC GeForce GTX 1060 Mini, ZT-P10600A-10L, 6GB GDDR5 $225
- SSD: Crucial MX300 750GB SATA 2.5 Inch Internal Solid State Drive$170
- RAM: CORSAIR Vengeance LPX 16GB (2 x 8GB) 288-Pin DDR4 SDRAM 3200 (PC4 25600) $100
- Optical drive: reused from previous build; new one would have cost approx. $25
- OS: Windows 10 (this is software, but it costs a lot, so I include it in the cost of the computer) $100
- Monitor, speakers, keyboard, mouse and a few other peripherals were all reused.

As noted above, I expect to start replacing certain parts in about 2-3 years. Probably the graphics card (which has its own processing unit). And I will either add more sticks of RAM or will replace what I have with faster pieces. And eventually I will "max out" the RAM by doing both.

Electronic Waste[1]

Electronic equipment contains heavy metals such as lead, mercury, cadmium and chromium, beryllium, chromium, and chemical flame retardants which, in large amounts, can be dangerous to the environment and humans. These metals are not dangerous in the small quantities contained in our computers and other electronics, where they are safely trapped behind liners and barriers. But when millions of electronic parts are put into landfills and the liners and barriers deteriorate and allow the metals to leak out, the total amount becomes dangerous. The sheer amount of electronic waste is particularly large because electronics are updated so often, and consumers replace items quickly. Hence, it is important to recycle old computer parts, not just throw them away.

In addition to keeping dangerous metals out of landfills, recycling can put useful metals back into production. For example, aluminum, copper, gold, silver, plastics, and ferrous metals are all valuable and re-useable; there is no reason to just dump them into the

1 Sources: http://www.aeconline.org/why-e-waste-recycling-important; https://www.thebalance.com/e-waste-and-the-importance-of-electronics-recycling-2877783; http://www.ksewaste.org/ewaste_why.htm

earth. Sometimes, entire components can be passed on to other people who need them, such as old cell phones that still work but are not state-of-the-art.

IEEE Standards

I looked up some hardware standards on the IEEE website, and I selected standard 1823-2015: IEEE Standard for Universal Power Adapter for Mobile Devices. This standard governs cords that connect laptop computers and other electronics to their power adapter. It applies to devices needing a moderate amount of power (between 10 and 240 watts). The goal of the standard is to create one type of cord usable for all/many/most portable devices that will last for at least 10 years. Such a cord will reduce waste from people having to purchase new cords along with new devices. And by using a direct current power plug, it will eliminate the need for users to match the cord to the voltage (important for people traveling in multiple countries).

I find the matter of incompatible or non-standard cords to be very annoying. For example, Apple's latest iPhone no longer allows the 3.5 earbuds plug that has been in existence for decades. Instead, Apple now requires either an adapter or Apple-only headphones. This forces people to spend more money to replace something they already own, and creates waste as old headphones are discarded. Or clutter as people save them in their junk drawers.

Physical Security

The "rings approach" to physical security of computer systems can be applied to a bank. The first and outer ring is the area around the perimeter of the business building, such as parking lots, other buildings, woods, etc. A bank needs to be wary of robbers, and would want all approaches to the bank to be well-lit and visible, with few or no hiding spaces.

Next is the ring of the immediate area around the building and environmental considerations such as fire or floods. The same physical considerations as in ring one would apply to a bank. Plus the bank would want to take steps to help catch wrongdoing, such as by installing cameras or doors that lock quickly. The bank will also want to guard against non-human threats, such as fire that could burn down a bank's holdings, or floods that could ruin electronic systems.

The third ring is the internal security of the building. In a bank, this means things like, do tellers' drawers have locks; is the safe locked; are there cameras at all doors and stations; are there tape measures on the wall next to the door, so witnesses can estimate a robber's height, etc.

Finally, there is the human ring. This would include things like hiring security guards, making sure tellers know how much (or rather, how little) cash they can keep in their drawers, and training staff to watch for suspicious behavior.

Conclusion

In this lab, I demonstrated I can convert binary to base ten, and base ten to binary. I discussed how a CPU works, what hardware components are most important to the speed of a computer, and my recent experience of building a computer for myself. I also explored the topics of electron waste, IEEE standards for hardware, and physical security of information systems, using the practical example of a bank.