COMPUTER ORGANIZATION AND ARCHITECTURE

Lecture 3

Components of the System Unit

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INTRODUCTION

We have covered a lot on the evolution of a computer and the future of computing in the previous lecture. This lecture will cover one of the hardware components of a computer, the system unit. We will review the components found within a system unit.

Learning objectives

By the end of this topic, you should be able to:

1. Identify and determine the use of the components of the system unit
2. Understand how the CPU components work
3. Understand the term memory and its purpose in a CPU

OVERVIEW

When we think of a computer, typically a desktop, we think of four main parts. The monitor (display – output device), keyboard and mouse (input device) and finally the system unit. The system unit is the focus of this lecture. The system unit houses what is referred to as the internal components of the computer. The system unit can be looked at as the main case of the computer. The system unit is also known as the housing of the electronic components of the computer in charge of processing [1]. The system unit material is generally metal, although some are made of plastic or even fibreglass. All the other devices, monitor, keyboard, mouse, and other peripherals are connected directly to the system unit. We will discuss the various components within the system unit.

1. MOTHERBOARD

As the name suggests it oversees all the other components or in other words it is the glue that holds all the components together. A motherboard is a circuit board that holds all the electronic circuitry necessary for processing. The motherboard is also called the system board [1]. Remember we reviewed the third generation of computers that used integrated circuits during lecture 2? Well, a motherboard contains several integrated circuits that are used to aid the CPU during processing. If you remember we also indicated that these ICs contain quite many transistors. In addition, they also contain resistors and capacitors. Figure 1 shows an example of a motherboard with various ICs, and slots.

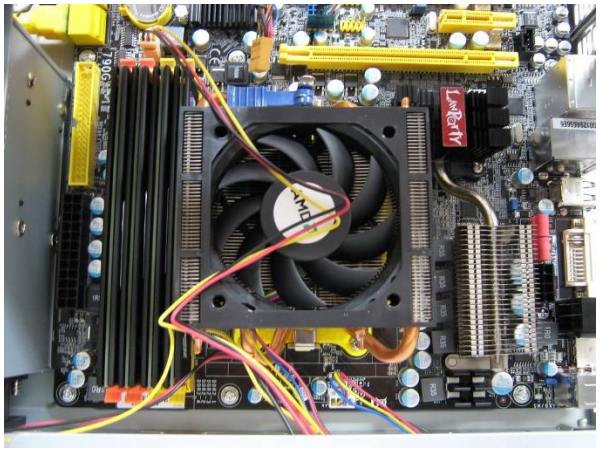

Figure 1: "motherboard" by fsse8info is licensed under CC BY-SA 2.0

2. CENTRAL PROCESSING UNIT

Also known as the CPU, microprocessor or just processor. A CPU is considered the brain of a computer. It oversees processing, coordination and ensuring that all instructions issued are followed. This is somewhat like the human brain that manages our reflexes, thoughts, coordination, and overall well-being. Processors currently are manufactured with several core processors [1]. This means that the CPU has several cores within the same CPU chip. In the not so distant past, CPUs were manufactured with only a single core [4].

In recent times, we have seen manufacturers developing dual-core (two cores), quad-core (four cores) and octa-core (eight cores). Through competition of the manufacturer, the highest cores available are 24-core and 32-core. The two most common CPU manufacturers include Intel and AMD. CPU normally have 7 core components as shown in figure 2.

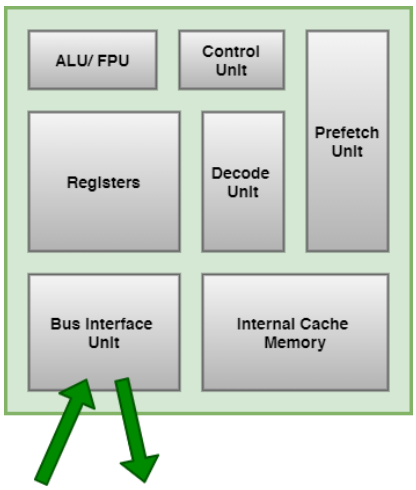

Figure 2: Components of the CPU (Adapted [4])

1. **ALU/FPU**

The Arithmetic Logic Unit and the Floating-Point Unit are components of the system unit that oversee processing. The ALU processes whole numbers and logical statements while the FPU processes decimal point numbers. For instance, if a word processor runs spellcheck, the ALU would oversee that and could get help from the FPU [4].

2. **Control Unit**

The control unit is the coordinator of the CPU. It coordinates the activities and operations of the CPU. It ensures that information is where it is needed throughout processing. The control unit tells the ALU and FPU what to do and ensures that everything is done at the right time and in the right manner [4].

3. **Prefetch Unit**

For the CPU to process information fast it relies on the prefetch unit to pick instructions that might be required in advance. The prefetch unit acts as a predictor of what might be required next for processing.

4. **Decode Unit**

Computers normally require all the data, instructions and commands to be converted to a form that the CPU can understand. The work of the decode unit is to convert the data, instructions and commands to a form that the ALU and FPU can understand and work with [4].

5. **Registers and Cache**

Data that is yet to be worked on, or data that has been processed but may be required for later operations need to be stored somewhere. The work of the registers and cache memory is to store data that will be worked on as well as instructions needed frequently to prevent having to retrieve these out of the CPU.

6. **Bus Interface Unit**

The CPU needs to communicate with all the other ICs and circuits and devices within the motherboard. To do this, the bus interface unit acts as the communicating pathway to retrieve and send out communication and instructions.

Machine Cycle

Based on the components of the system unit, we have seen that CPU's have specific operations that are performed. The machine cycle comprises four operations that are repeated every time the CPU runs an instruction as shown in figure 3.

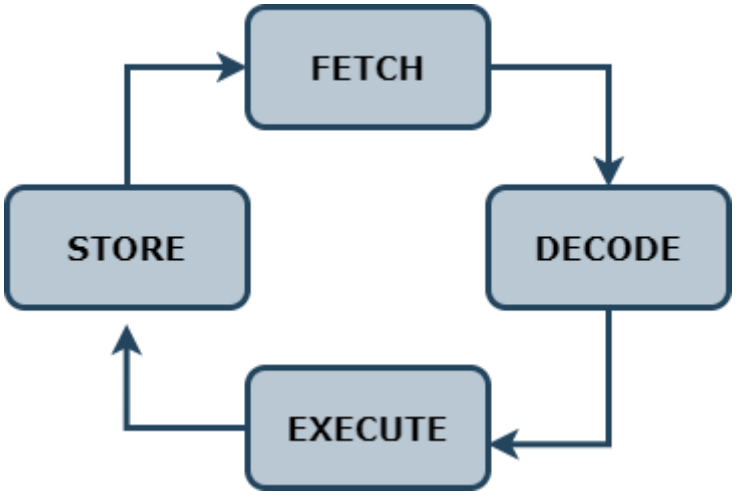

Figure 3: Operations of the machine cycle

The machine cycle starts with the fetch instruction. The control unit will fetch instructions from memory. Next, the decode unit converts the instructions into a form readable by the ALU/FPU. The execute step involves the ALU/FPU processing or executing the instructions. Finally, the store is the step where the processed instructions are either placed in the registers or sent for long term storage. Once the CPU is done with the cycle, it starts all over again.

3. MEMORY

Memory is considered as chip-based or electronic components that store instructions that may be needed by the processor. Memory is categorized into two based on how long it can hold the information. This introduces a term known as volatility. Memory is known as volatile if the content is erased when power ceases [4] or non-volatile since it stores content even in the absence of power. Two main types of memory are discussed herein.

Read-Only Memory

ROM is a non-volatile chip located on the motherboard. For most ROM chips, it is not possible to write or change the data written on them unless special equipment is used.

ROM is used to store data permanently that is required by the computer such as bootup data. There are three main ROM chips.

Programmable Read-Only Memory (PROM): This memory cannot be modified or changed by the user once the manufacturer has written on it. It is only programmable once by the manufacturer. This chip was found in older computers.

Erasable Programmable Read-Only Memory (EPROM): Unlike PROM information on EPROM can be rewritten or erased. The only caveat is that special equipment is used. Ultra-Violet light is used to delete the contents within EPROM and rewrite them.

Electrically Erasable Programmable Read-Only Memory (EEPROM): This is a chip that allows for data to be written, erased, and rewritten using an electrical charge. Flash memory is a type of EEPROM memory. Flash memory is mainly used to hold the start-up instructions of a computer. Some flash disks (flash memory cards allow for storage of various files on a removable device [1].

Random Access Memory

RAM is volatile memory that is found attached to slots within the motherboard. This means that anytime the computer is switched off, the memory gets wiped off. When someone talks of memory, they are normally referring to RAM not ROM. The more the RAM the better the processing speed leading to the efficiency of the computer. This is of course dependent on the processor capabilities. Several types of RAM exist, some not in use anymore. The most common include

Dynamic Read-Only Memory (DRAM): This is used as main memory and requires constant refreshing using electrical pulses to ensure data is not erased from the memory

Synchronous Dynamic Read-Only Memory (SDRAM): This is the memory that works for hand in hand with the memory bus which is the data path between the CPU and main memory [1].

Double Data Rate (DDR) SDRAM: This memory transfers data two times faster than SDRAM.

Double Data Rate 2 (DDR2) SDRAM: This memory is faster than DDR2 and decreases noise and crosstalk between wires during data transfer [1].

Static Read-Only Memory (SRAM): This is mainly used as Cache memory. It does not require to be refreshed constantly like DRAM.

Magnetoresistive Read-Only Memory (MRAM): This is used to store data using magnetic charges. It is claimed that it has greater storage capacity, uses less power, and has faster access times than RAM [1].

Cache Memory

As we saw previously, cache memory is used to aid the computer to ensure faster processing of information. There are three types of cache memory.

L1: This is built directly on the CPU chip. It can hold very small amounts of information.

L2: It is slower than L1 but can hold more information than it. Ideally, L2 was built or embedded near the CPU but processors nowadays contain both L1 and L2 directly on the chip.

L3: This is found in newer computers. In processors with several cores, L1 and L2 will be built in each core with L3 being shared by all the cores. [4].

4. POWER SUPPLY

Computers are electronic devices and require power for their components to run. The power supply is used to supply power to the motherboard which then supplies the power to the rest of the components. The power supply has a fan that is used to cool it and to ensure that it does not overheat. Portable computers come with a rechargeable battery which then supplies power to the motherboard.

5. DRIVE BAYS

A drive bay is a rectangular opening that holds disk drives or other additional devices. For instance, the hard disk, cd-drive and other card readers would be installed in the drive bay.

6. EXPANSION SLOT AND EXPANSION CARDS

These are areas directly on the motherboard where expansion cards can be inserted. Expansion cards give computers additional features such as allowing the desktop computer to connect to wireless internet. Expansion cards are also called adapter cards. Expansion slots are normally found on desktop computers. On portable computers, expansion cards are added through what is known as a PCI card. These are specially designed expansion cards for portable computers.

7. PORTS AND CONNECTORS

Ports are normally connections at the back of the computer or on the sides that allow for various devices to be connected. For instance, to connect a keyboard to a computer, it uses either a keyboard port or a USB port. Various ports and connectors existed and are listed below:

- Universal Serial Bus (USB) – used for various connections like a keyboard, mouse, flash disk.
- Firewire port – like USB but is used for high-speed transfer like from a video camera
- Video Graphics Adapter (VGA) port – Used to connect a monitor to the system unit. Could also use a High-Definition Multimedia Interface (HDMI) port
- Network port – used to connect a network cable to the system unit to provide the computer with internet capabilities.
- Audio Port – Used to connect speakers, headsets, and microphone to the computer

8. BUSES

We saw that the bus interface unit acts as the communicating pathway to retrieve and send out communication and instructions for the CPU. The size of a bus is determined by how much data can be transferred. The wider a bus, the more data it can transfer. Some of the common buses are indicated below:

Memory Bus: This is used to connect the CPU directly to the main memory (RAM).

Frontside Bus: There are several chipsets on the motherboard, The frontside bus is used to connect the CPU to various chipsets.

SUMMARY

During this lecture, we have reviewed several critical components in a computer. We reviewed what is found within a system unit and specifically looked at the components of the CPU and the different types of memory. Next, we will start work on how to data is represented in a computer as well the various coding systems used in computers. We will also learn how to convert numbers into binary.

DISCUSSION TOPIC

As better CPUs are being invented, we can see that more cores are being added within a single CPU chip. Currently in the market, albeit pricey, is the 64-core CPU. At what point do you think the number of cores will reach the peak? What will determine the peak is reached?

REFERENCES

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