RAM, ROM (understanding) and explanation

CASEST

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Assignment No. 1

MV403: Digital VLSI System Design

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Contents

1 | Introduction

Memory is a fundamental component of computing systems that serve the purpose of storing information during various processes and calculations that happen during the operation of a computer. Computer memory along with a processing unit and a control unit make up the most basic computer. Computer memory often refers to the memory that stores information that is required for immediate or frequent use during the functioning of a computer. This is called primary memory or Random Access Memory (RAM) and it requires by definition to be read and written an indefinite amount of times, with faster read/write times and low latency being preferred for maximum performance.
But in some cases in a computer certain information is required to be permanently stored in a read-only fashion. This could include things like the BIOS, firmware, essential drivers and so on that are required for the low level interfacing which are baked in during the design and manufacturing process. Any modifications to this critical data might result in the computer not being able to function. This necessitates the use of a 'read-only' memory.

2 | Random Access Memory (RAM)

2.1 | Definition and Purpose

RAM, or Random Access Memory, is a volatile type of computer memory that serves as a temporary data storage area. Here 'volatile' refers to the fact that the memory depends on uninterrupted power supply to store data, once the power is cut off the data cannot be retained. RAM can be both written to and read from and allows the computer to access stored data quickly.

2.2 | Physical Characteristics

RAM is comprised of integrated circuits (ICs) that are organized into modules or chips. These ICs are typically made up of transistors and capacitors, allowing them to store and manipulate binary data. Based on technology used in the IC, RAM can be classified as either SRAM or DRAM. SRAM uses flip-flops to store bits whilr DRAM uses charge in capacitors to store bits.
DRAM requires periodic refreshment for retaining data, typically in the 800-5000MHz range depending on the make and model. Higher values result in improved performance. DRAMS are used as the primary memory in computers as they are cheaper and provide the required performance.
SRAMs do not require refreshing and are considerably faster than DRAMs, but they are very expensive, hence their use is primarily limited to use as cache storage adjacent to the CPU due to the high speed and low latency.

2.3 | Operation and Functionality

When the computer is powered on, the operating system and active applications are loaded into RAM. This allows the processor to access data quickly, as opposed to retrieving it from slower secondary storage devices like hard drives. Data in RAM is stored in cells, each of which has an address. This enables the CPU to access any cell directly, hence the term "random access". Modern DRAMs (DDR3 and up) have transfer speeds of upwards of 13GBper second.

2.4 | Capacity and Speed

The capacity of RAM is determined by the number of memory cells it contains. A higher capacity allows for the simultaneous storage of more data. RAM speed is also important for ensuring fast data retrieval. It is measured in megahertz (MHz) and affects the overall responsiveness of the computer. The latest DDR4 RAMs have a typical refresh rate of 3200-3600 MHz.

2.5 | Applications and Use Cases

Adequate amount of RAM is crucial in various computing tasks, especially those that require quick data access. For instance, in gaming, a higher amount of RAM ensures smoother gameplay by allowing the system to load and process game data faster. Similarly, in video editing and graphic design, ample RAM

is essential for handling large files and complex processes. The same is true for scientific computing applications.

3 | Read-Only Memory (ROM)

3.1 | Definition and Purpose

Read-Only Memory, or ROM, is a non-volatile type of computer memory that contains information that is permanently written during the manufacturing process. Unlike RAM, the content of ROM cannot be modified or overwritten by design during operation of a computer.

3.2 | Types of ROM

There are several types of ROM, including Programmable ROM (PROM), Erasable Programmable ROM (EPROM), and Electrically Erasable Programmable ROM (EEPROM). Each type has different properties and applications. PROM, for example, can be programmed by the user once, while EPROM and EEPROM can be programmed multiple times.

3.3 | Contents of ROM

ROM typically contains firmware and essential instructions that are critical for the computer's operation. This includes the BIOS (Basic Input/Output System) which interfaces with hardware components during the boot-up process. Some peripherals may have their own ROM to store device specific firmware.

3.4 | Characteristics and Limitations

ROM is usually limited to several KBs or few MBs in capacity because most firmware demand only such capacities. One of the key characteristics of ROM is its non-volatile nature, meaning that the information stored in ROM is retained even when the computer is powered off. So ROM is useful if you want to store instructions or data permanently.

4 | Comparison between RAM and ROM

4.1 | Key Differences

Memory type	**RAM**	**ROM**
Type	Volatile	Non-volatile
Function	Temporary Data Storage	Permanent Data Storage
Read/Write	Read and Write	Read-only
Physical Structure	Integrated Circuits	Integrated Circuits
Contents	Temporary Data and Instructions	Permanent Instructions (Firmware, BIOS)
Modifiability	Can be Modified	Cannot be Modified
Capacity	Varied Capacities	Fixed Capacity
Speed	Faster Access	Slower Access compared to RAM
Usage	Stores data actively used by the CPU	Contains essential instructions for system operation

Table 4.1: Comparison between RAM and ROM

4.2 | Complementary Roles

RAM and ROM work together for the smooth operation of a computer system. During startup, the BIOS (stored in ROM) initializes hardware components, and the operating system is loaded into RAM. The operating system and applications then utilize RAM for storing and processing data during the computer's operation.

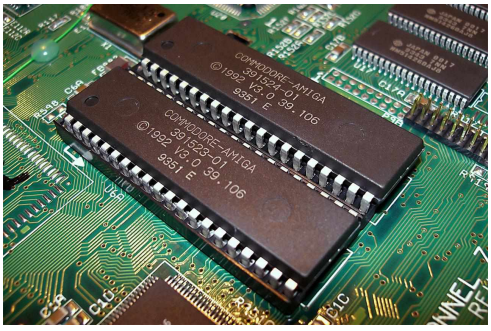
5 | Real-World Applications

Memory Type	Application
5RAM	Computer Main Memory Video Editing Gaming Consoles Virtual Machines Web Browsers
5*ROM	BIOS in Computers Firmware in Embedded Systems Car Control Units (ECUs) Medical Devices (e.g., MRI) Smart TVs (for firmware)

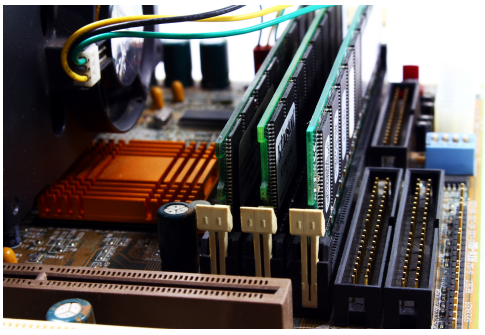
Table 5.1: Real World Applications of RAM and ROM

6 | Conclusion

RAM and ROM are different kinds of computer memory that serve different purposes and have different characteristics, but both of them are required for the proper functioning of computer systems.[2][3][4][1]



(a) An embedded ROM chip on a motherboard.



(b) RAM sticks inserted into slots on a motherboard.

Figure 6.1: RAM (b) and ROM (a)

7 | References

[1] Micron. *DDR2 vs DDR3 vs DDR4 vs DDR5*. Crucial (Micron): https://www.crucial.in/articles/about-memory/difference-among-ddr2-ddr3-ddr4-and-ddr5-memory, 09-2023.

[2] Wikipedia. *Computer Memory*. Wikipedia: https://en.wikipedia.org/wiki/Computer_memory, 09-2023.

[3] Wikipedia. *Random Access Memory*. Wikipedia: https://en.wikipedia.org/wiki/Random-access_memory, 09-2023.

[4] Wikipedia. *Read Only Memory*. Wikipedia: https://en.wikipedia.org/wiki/Read-only_memory, 09-2023.