SIT315 – Seminar 1 Real Time Systems

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Activity 1 – Von Neumann VS Harvard Architecture

1. **List at least four main differences between Von Neumann and Harvard architecture.**
    - With Von Neumann, the instructions and data are stored in the same physical memory, whereas with Harvard the instructions and data are stored in different and separate memory.
    - Von Neumann uses the same bus for information transfer whether it is instruction or data transfer. Harvard uses individual and separate buses to transfer data and instructions to the control unit.
    - Von Neumann architecture is used primarily in every machine (PCs, Laptops, Tablets, etc.) nowadays for high performance computers and workstations. On the other hand, Harvard architecture is the new concept mainly used in microcontrollers and digital signal processing (DSP).
    - Von Neumann architecture has only one bus which is used for instruction fetching and data transferring. Therefore, the operations must be scheduled since they cannot be performed at the same time. In contrast, Harvard architecture implements separate memory spaces for data and instructions. Therefore, all the operations can be performed simultaneously.

2. **Discuss advantages and disadvantages of Harvard architecture.**

Advantages [1]:

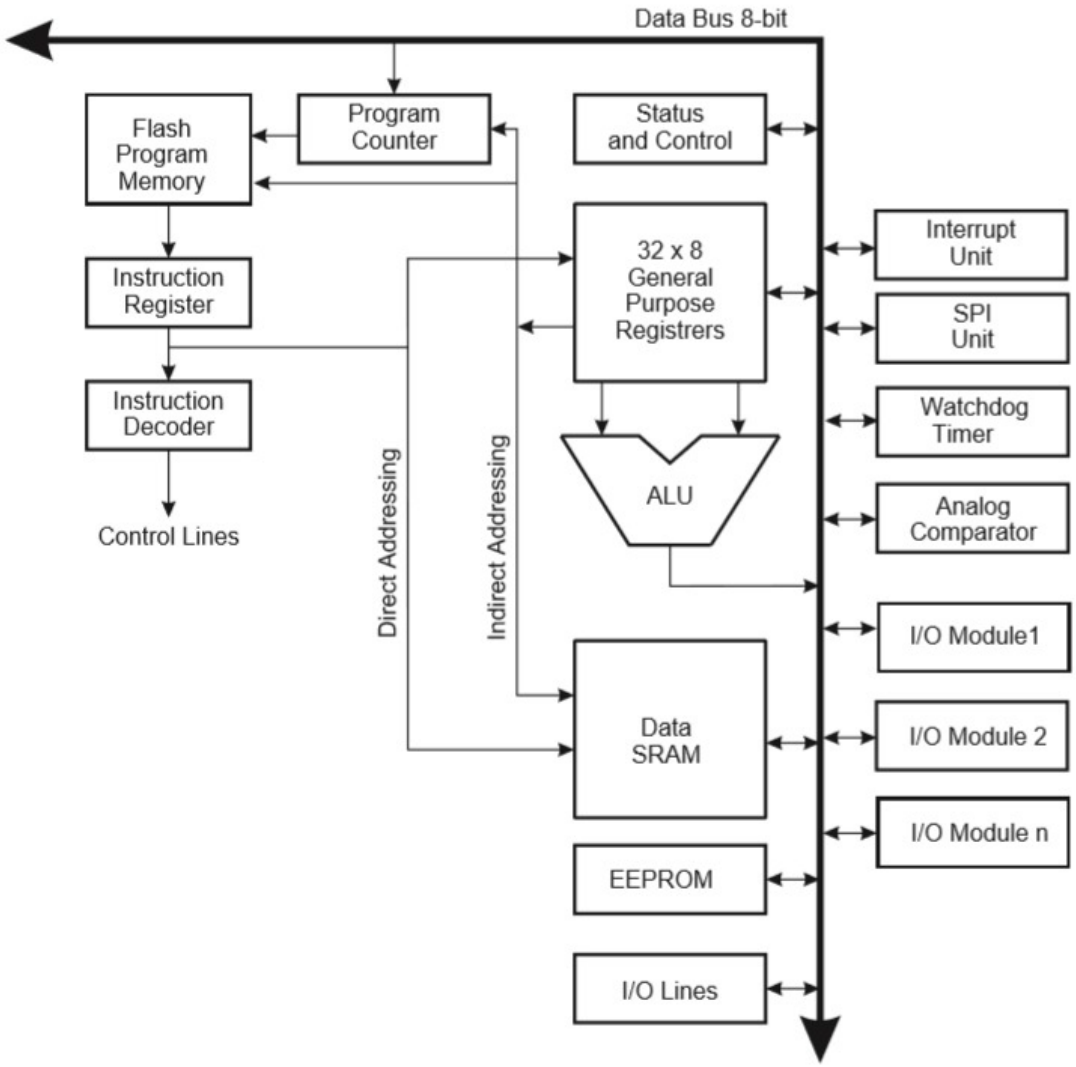
- Instructions and data can be acquired at the same time using the separate buses, increasing system speed.
- Reduced likelihood of data or instruction corruption as they are stored in separate physical locations.
- Efficient use of resources by the two different memories having different cell sizes to suit what is being stored (data or instructions).
- Bandwidth is more predictable as the information fetched is more consistent in size due to storing of data and instructions separately.
- No scheduling required as instructions and data are accessed on individual buses.
- We can attach malware by directly changing memory (Instruction memory) for Von Neumann architecture whereas in Harvard Architecture the instruction is read-only, and it cannot be modified, thus decreasing chances to attack the system.

- Harvard architecture has two separate buses for instruction and data. Hence, CPU can access instructions and read/write data at the same time.

Disadvantages [1]:

- Unused memory in data or instructions cannot be repurposed for the opposite information.
- Programs cannot run automatically or be written by the machine (need a second computer to compile code).
- More costly control unit to access two separate physical memory locations.
- Leads to more complex motherboard as there are multiple buses to connect to.
- More pins on the IC making it harder to implement.
- Not in wide use making development more time consuming and costly

Activity 2 – Arduino Board Architecture



1. **Based on the diagram, what architecture is used in the Arduino board? Justify your answer.**

The Arduino board uses the Harvard architecture. This can be seen by the program and data memory being separate and having individual buses. In details, the data is stored in the Data SRAM, while the instructions are stored in Flash Program Memory.

2. **Identify different types of memory in the Arduino architecture, discuss their usage, and sort them based on speed.**

In the diagram there can be seen three types of memory: Flash memory (Program space), Static Random Access Memory (SRAM) and EEPROM [2].

Flash Memory is used to store the program instructions as mentioned in the previous question. This data cannot be modified while the code is running [3]. This memory is non-volatile meaning it will remain when power is removed to the system [2].

SRAM is used for data storage such as variables initiated throughout the program. This type of memory can be written to and read, meaning it can be changed during program execution [3].

This memory is volatile, meaning it is lost once power is removed from the system [2]. This memory also includes the program stack for function calls and interrupts, as well as the heap and static data mentioned earlier.

EEPROM can be used to store long term information which does not want to be lost when power is turned off, making this memory non-volatile [2]. This memory can also be written and read during program execution, albeit byte-by-byte and at slower speeds than SRAM [3].

The quickest of these memories is SRAM, then Flash memory, with EEPROM being the slowest.

This can be justified according to the following image.

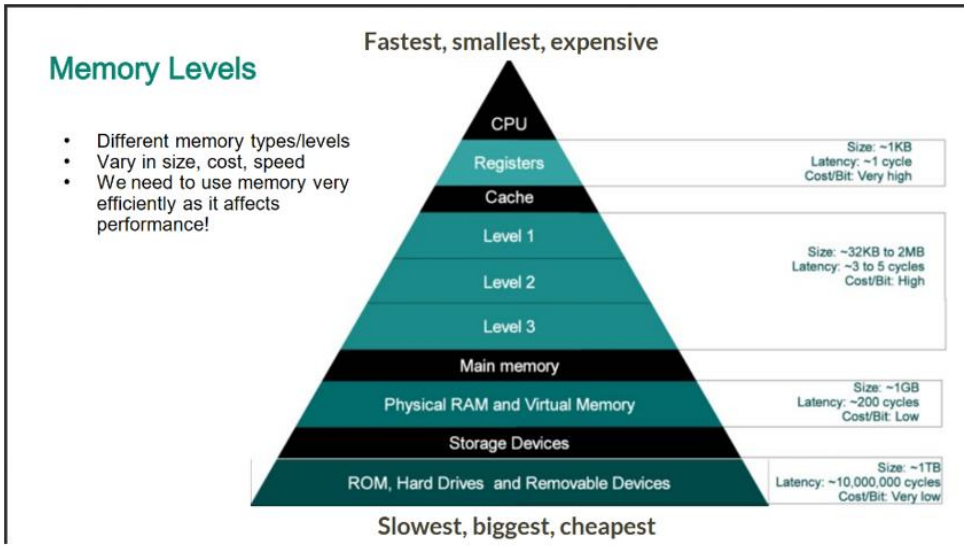


Figure 1 - SIT 315 Learning Resources

As we can see, SRAM is a type of RAM, Flash memory and EEPROM are those types of ROM. ROM has the latency higher than RAM. Therefore, SRAM will have the fastest speed over the three memories.

On the other hand, there is a minor or no big difference between Flash Memory and EEPROM. It is known that Flash memory is faster than EEPROM according to the resource [4].

References

[1] Teach Computer Science (n.d.). *Harvard Architecture* [Website]. Available: https://teachcomputerscience.com/harvard-architecture/

[2] Arduino (2018, Feb. 5). *Memory* [Website]. Available: https://www.arduino.cc/en/Tutorial/Foundations/Memory

[3] B. Earl (2013, Aug. 2). *Arduino Memories* [Website]. Available: https://learn.adafruit.com/memories-of-an-arduino/arduino-memories

[4] Stack Overflow (n.d.). Stack Overflow [Website]. Available: https://stackoverflow.com/questions/14728968/speed-comparison-eeprom-flash-sram