Noakhali Science & Technology University

Department of Information and Communication Engineering

Assignment

Course Name: Peripheral Interfacing and Embedded System
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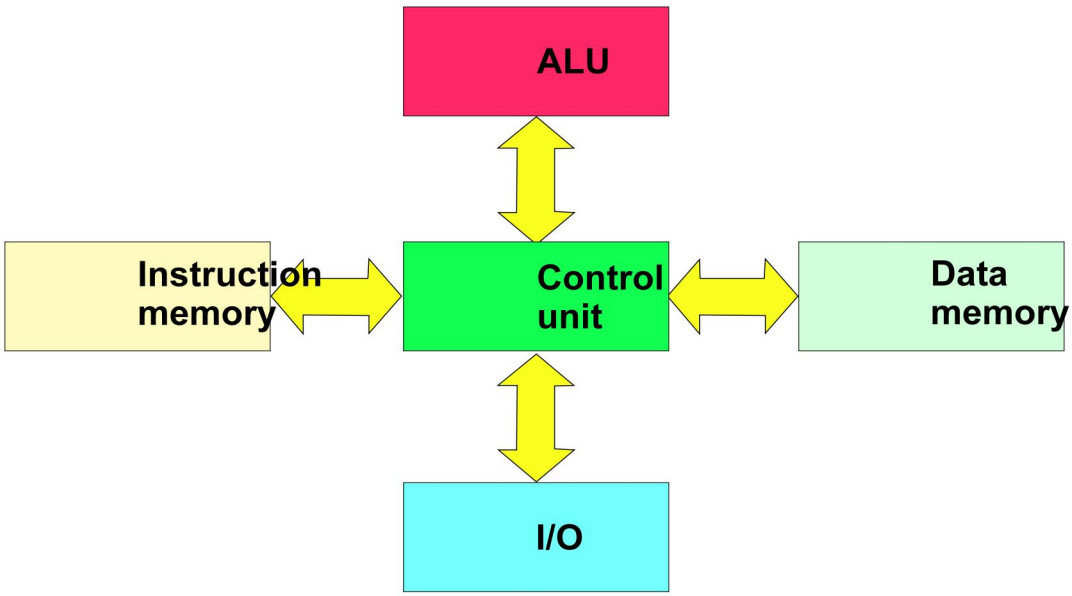
1. Basics of Harvard and Princeton Architecture

Harvard Architecture

The Harvard architecture is a computer architecture with separate storage and signal pathways for instructions and data. It contrasts with the von Neumann architecture, where program instructions and data share the same memory and pathways.
The term originated from the Harvard Mark I relay-based computer, which stored instructions on punched tape (24 bits wide) and data in electro-mechanical counters. These early machines had data storage entirely contained within the central processing unit, and provided no access to the instruction storage as data. Programs needed to be loaded by an operator; the processor could not initialize itself.
Modern processors appear to the user to be von Neumann machines, with the program code stored in the same main memory as the data. For performance reasons, internally and largely invisible to the user, most designs have separate processor caches for the instructions and data, with separate pathways into the processor for each. This is one form of what is known as the modified Harvard architecture.



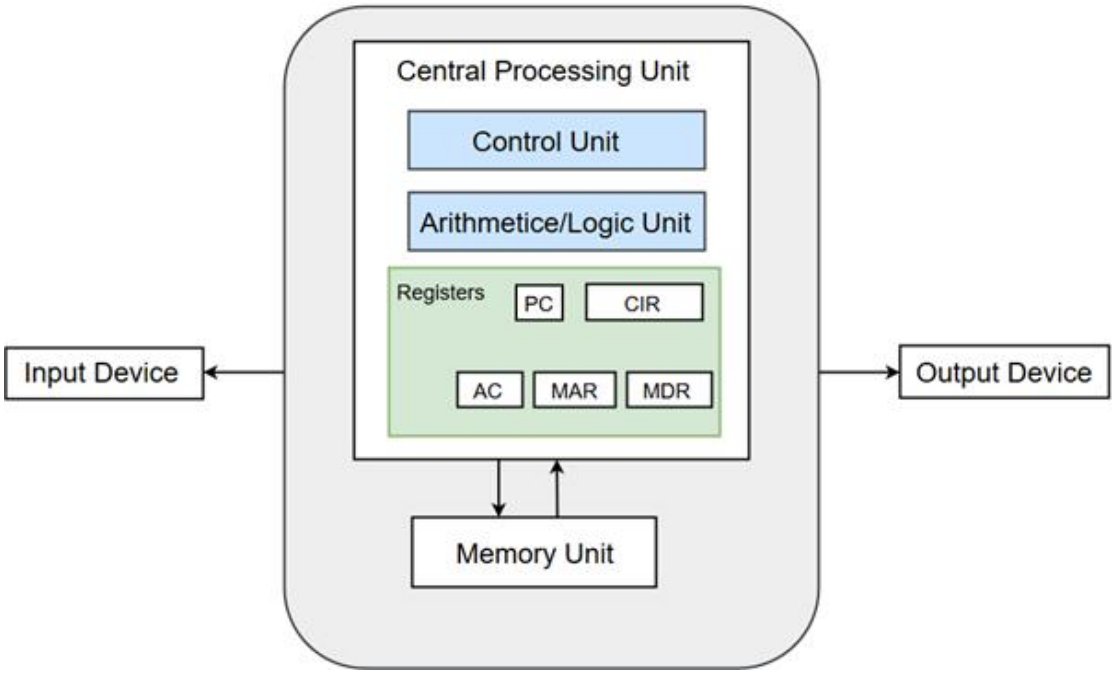
In a Harvard architecture, there is no need to make the two memories

share characteristics. In particular, the word width, timing, implementation technology, and memory address structure can differ. In some systems, instructions for pre-programmed tasks can be stored in read-only memory while data memory generally requires read-write memory. In some systems, there is much more instruction memory than data memory so instruction addresses are wider than data addresses.

Princeton or Von Neumann Architecture

The Von-Neumann Architecture or Von-Neumann model is also known as **"Princeton Architecture"**. This architecture was published by the Mathematician **John Von Neumann** in **1945**.
It is a design model for modern computers which has a Central Processing Unit(CPU) and the concept of Memory which is used for storing both data and instructions. This architecture implemented the stored program concept in which the data and instructions are stored in the same memory. This architecture consists of a Control Unit, CPU, Arithmetic and logic unit(ALU), Register, I/O(Input Output Devices), and Memory
unit.

Von-Neumann Basic Structure:



2. Advantages & Disadvantages of Both Architecture

Advantages of Harvard Architecture:

- There is less chance of corruption since data and instructions are transferred via different buses.
- In this architecture, data and instructions are accessed in the same way.
- This architecture offers higher performance since Harvard allows for simultaneous fetching of data and instructions - they are kept in separate memory and travel via separate buses.
- Both memories can use different cell sizes making effective use of resources.
- Greater memory bandwidth that is more predictable (separate memory for instructions and data).

Disadvantages of Harvard Architecture:

- When there is free data memory it cannot be used for instructions and vice versa. o Memory dedicated to each must be carefully balanced in manufacture.
- Production of a computer with two buses is more expensive and takes more time to manufacture.
- Harvard architecture has more pins so more complex for main board manufactures to implement.
- This architecture is not widely used because of its difficult implementation.
- Harvard architecture requires a control unit for two buses that is more complicated and development of which is expensive and needs more time.

Advantages of Princeton Architecture:

- In this architecture, both data and instructions of programs are stored within the same memory. This makes it easier to re-program the memory.

- Memory organization is within the hands of the programmer.
- Data from memory and devices is accessed in the same way in this architecture.
- The control unit gets data and instructions in the same way from one memory so simplifies the design and development of the control unit.

Disadvantages of Princeton Architecture:

- This architecture has only one data bus shared from the transfer of data transfers and instruction fetches; they must be scheduled because they cannot run simultaneously.
- Serial instruction processing of this architecture does not allow for parallel execution of programs. Paralleled executions must be simulated later by the operating system (i.e., no pipelining)
- Higher chance of corruption or error as the instructions and data are stored and transferred in the same way so may be accidently rewritten by bugs in programs.
- All memory cell sizes are the same and so can't be different for instructions/data making it less efficient.

3. Comparison between Harvard and Princeton Architecture:

Basis of Comparison	Harvard Architecture	Princeton Architecture
1. Memory	It has separate memories for code and data	It has a single memory which has to be shared by data and code(program)
2. Clock Cycle	Processor requires only one clock cycle as it has separate buses to access both data and code	Processor requires two clock cycles, one for fetching the code and another for fetching the data
3. Design	Complex	Simple

4. Feature	Data transfer and instruction fetch take place at the same time.	Data transfer and instruction fetching do not occur simultaneously.
5. Performance	Better than Princeton	Low

4. Which architecture is better for general purpose embedded system?

Basically these two types of architecture i.e., Harvard architecture and Princeton or Von Neuman architecture are used in embedded systems. Architecture of the embedded system includes sensor, analog to digital converter, memory, processor, digital to analog converter, and actuators etc.

General purpose embedded systems:

Embedded systems are computer systems that carry out a small number of tasks. When designing an embedded system, manufactures will focus on the dedicated functions that the system needs to perform. They will optimize the system until it performs each of these tasks very efficiently.

In these two architecture, the Von Neuman architecture is better than Harvard architecture. Because, Von Neuman architecture features simple hardware design and flexible program and data storage and is usually the one chosen for general purpose and most embedded systems.

5. In multiprocessor and distributed computing system which architecture works better?

In a multiprocessor Harvard architecture is working better than Von Neuman architecture. The Von Neuman architecture developed for the ENIAC uses the same memory and data paths for both program and data storage. The Harvard architecture characterized by the Harvard Mark 1 used physically separate memory and data paths for program and memory.

Harvard architecture computer can thus be faster for a given circuit complexity because instruction fetches and data access do not contend for a single memory pathway. Also a Harvard architecture machine has distinct code and data address spaces that instruction address zero is not the same as data address zero. Harvard architecture is the digital computer architecture whose design is based on the concept where there are separate storage and separate buses for instructions. So, we can say Harvard architecture is better.