Von Neumann Architecture

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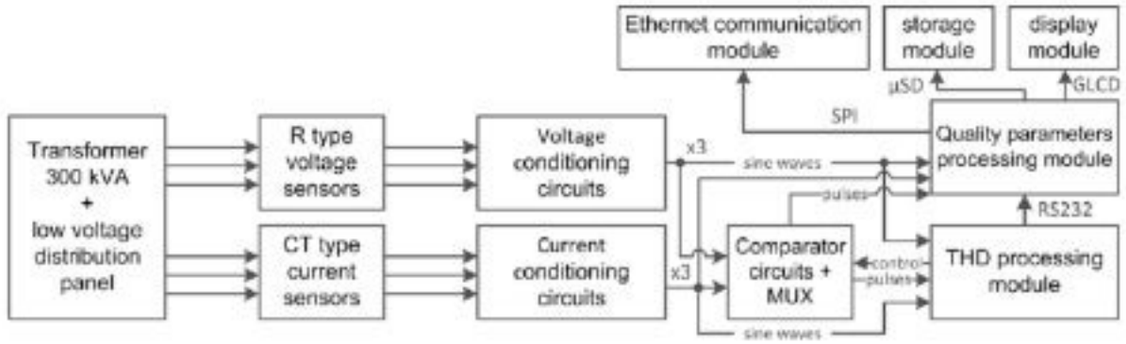
for Northshore College of Business & Technology

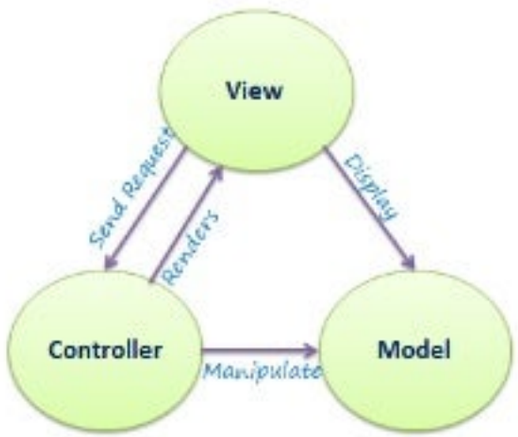
Learning Objectives

- Understand the origin of von Neumann Architecture
- Understand von Neumann Architecture
- Understand its components and functionalities
- To be aware of other architectures

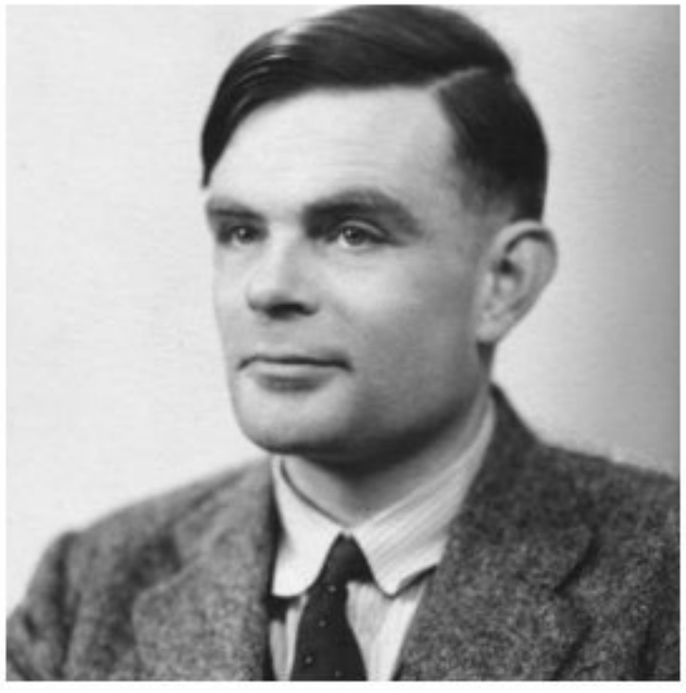
What is an architecture?

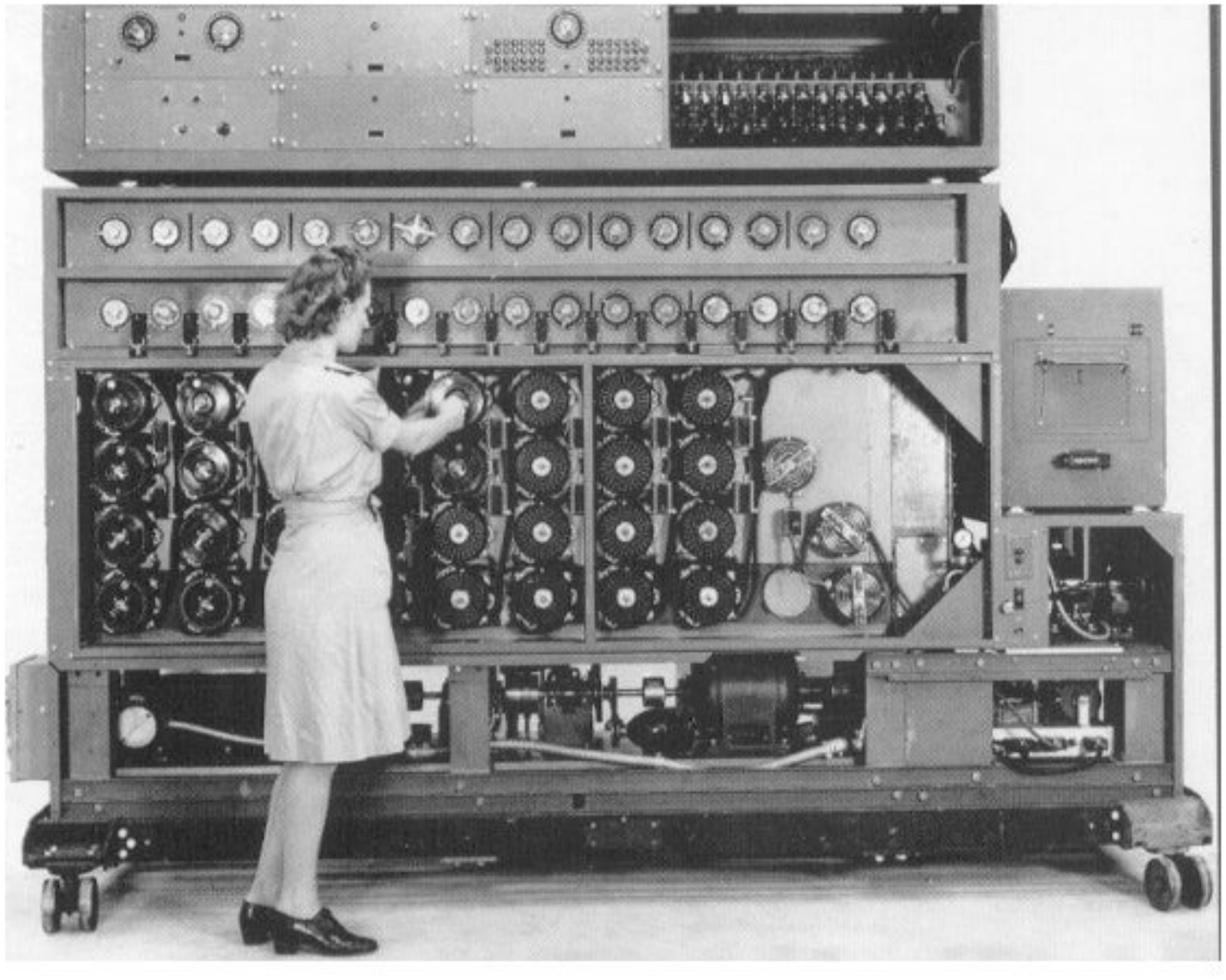
- "The complex or carefully designed structure of something."





Early days





Fixed Programs

- They were designed to do very specific operations
- A calculator is a fixed program computer.
- It can do basic mathematics, but it cannot be used as a word processor or a gaming console.
- Changing the program of a fixed-program machine requires rewiring, restructuring, or redesigning the machine.
- It could take three weeks to set up a program on ENIAC and get it working.

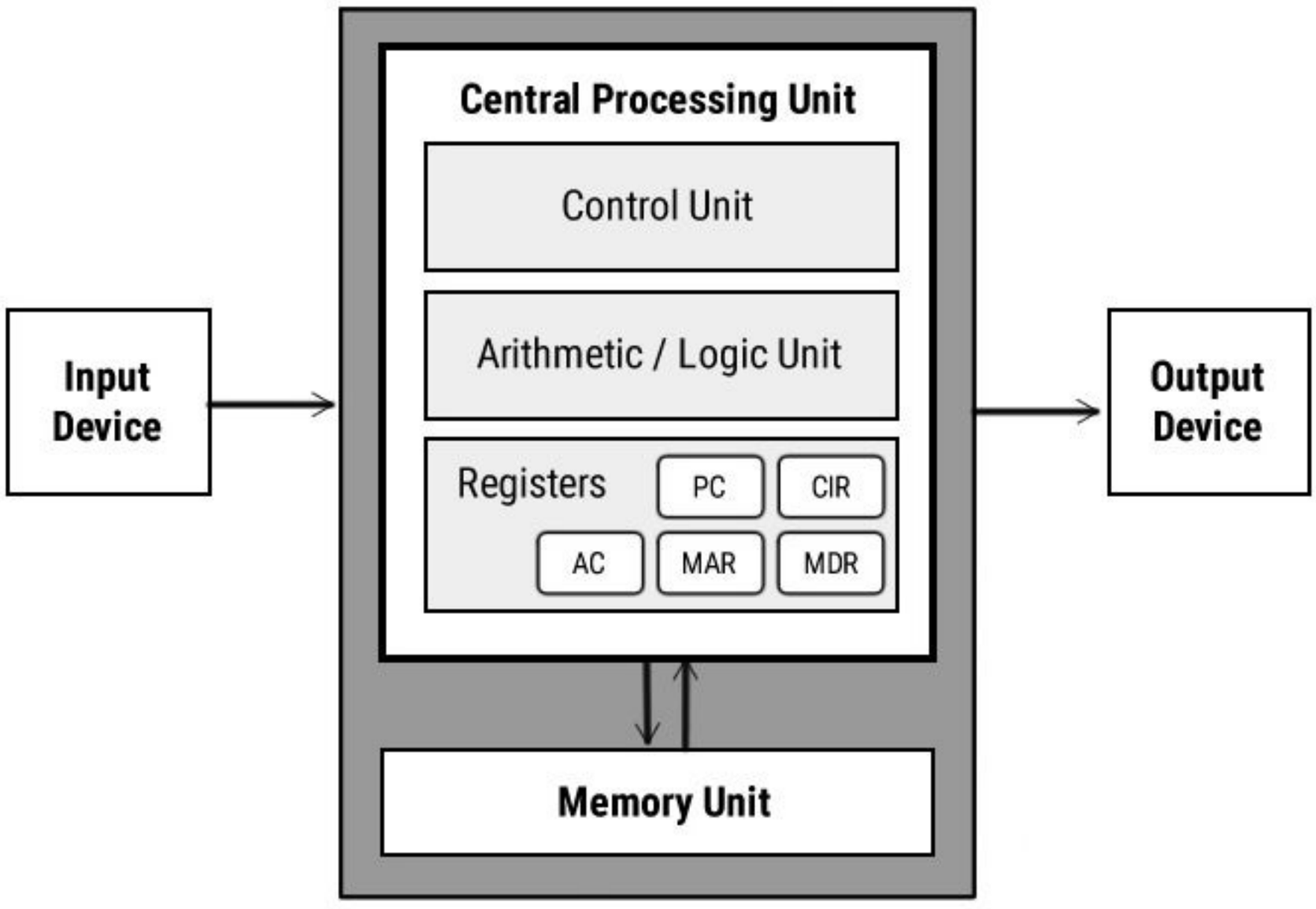
Stored Programs

- **A stored-program computer is one that stores program instructions in electronic memory**

- Therefore easily reprogrammable

- Von Neumann is a stored program architecture (also known as **Princeton architecture**) introduced by John von Neumann, a Hungarian-American mathematician, physicist, and computer scientist.

Von Neumann Architecture



Von Neumann Architecture cntd…

- The basic concept behind the von Neumann architecture is the ability to store program instructions in memory along with the data on which those instructions operate.
- The von Neumann architecture describes a general framework, or structure, that a computer's hardware, programming, and data should follow.
- Evan all the most modern computers and mobile devices are designed based on this fundamental concept.
- It had 3 basic components:
    1. **I/O Interfaces**
    2. **CPU**
    3. **Memory**
- Buses (denoted by the arrows) carries the data around

I/O Interfaces

- The I/O interfaces allow the computer's memory to receive information and send data to output devices.

- Allow the computer to communicate to the user and to secondary storage devices like disk and tape drives

Central Processing Unit

- Can be considered the heart of the computing system
- Includes three main components:
  1. Control Unit (CU)
  2. Arithmetic Logic Unit (ALU)
  3. Registers

CPU: Control Unit

- Responsible for decoding the instructions and controlling how data moves around the computer system
- The execution of each instruction is determined by a sequence of control signals produced by the control unit.

CPU: Arithmetic Logic Unit

- Carries out the calculations and logical decisions required by the program instructions.

- The inputs to an ALU are the data to be operated on, called **operands**, and a code indicating the operation to be performed; the ALU's output is the result of the performed operation.

CPU: Registers

- Registers are memory locations with specific purpose
- **Accumulator (AC)**- Stores the results of calculations made by the ALU (temporary)
- **Program counter (PC)**- Keeps track of the location for the next instruction to be dealt with. The program counter then passes this next address to the memory address register (MAR)
- **Memory Address Register (MAR)**- Stores memory location for data or instructions that needs to be fetched from memory or stored into memory
- **Memory Data Register (MDR)**- Stores data or instructions fetched from memory or any data that is to be transferred and stored in memory
- **Current Instruction Register (CIR)**- Stores the most recently fetched instruction while it is waiting to be decoded and executed

Memory

- The computer's memory is used to store program **instructions** and **data**.

- Consists of many memory cells (storage units) of a fixed size. Each cell has an address associated with it.

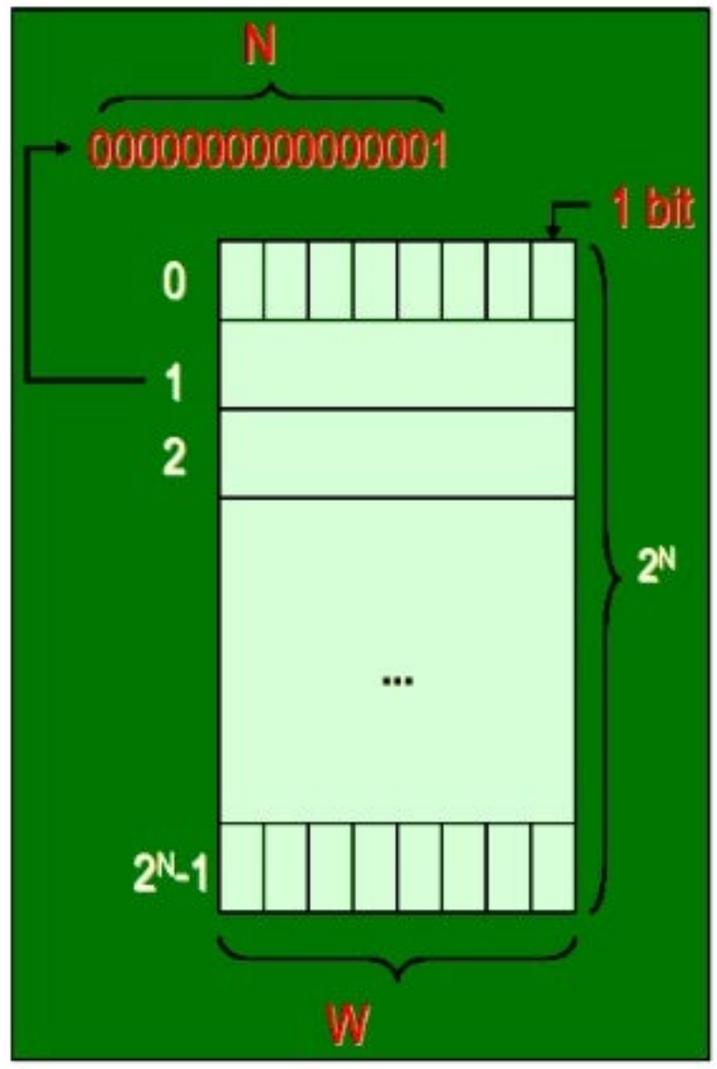
- Two of the commonly used type of memories are RAM (random-access memory) and Secondary memory

Memory cntd…

- **Memory width (W)**- How many bits is each memory cell, (typically one byte =8 bits)

- **Address width (N)**- How many bits used to represent each address

- **Address space**- the number of uniquely identifiable memory locations (2^N)



Advantages of von Neumann Architecture

- Control Unit gets data and instruction in the same way from one memory. It simplifies design and development of the Control Unit.

- Data from memory and from devices are accessed in the same way.

- Memory organization is in the hands of programmers.

Disadvantages of von Neumann Architecture

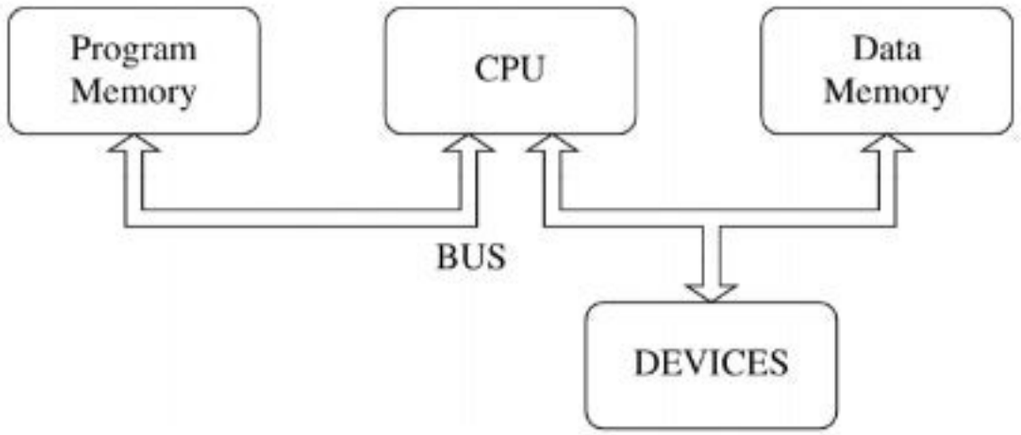
- Serial instruction processing does not allow parallel execution of program. Parallel executions are simulated later by the Operating system.

- One bus is a bottleneck. Only one information can be accessed at the same time.

- Instruction stored in the same memory as the data can be accidentally rewritten by an error in a program.

Alternative Architectures

Harvard Architecture



- Memory for data was separated from the memory for instruction.
- Two memories with two Buses allow parallel access to data and instructions. Execution can be 2x faster.
- But control unit for two Buses is more complicated and more expensive.

Summary

- Von Neumann architecture is based on stored programs concept.
- Has 3 main components.
- All modern computers still use this 70 year old fundamental concept
- Has its own advantages and disadvantages
- Availability of alternative architectures

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