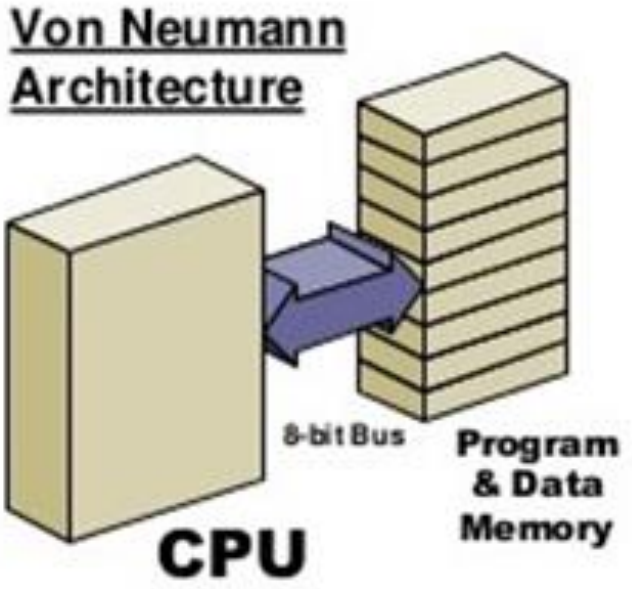
Machine Architecture - Lecture 3



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The von Neumann architecture

Slide material acknowledgements: Magnus Bordewich

von Neumann architecture

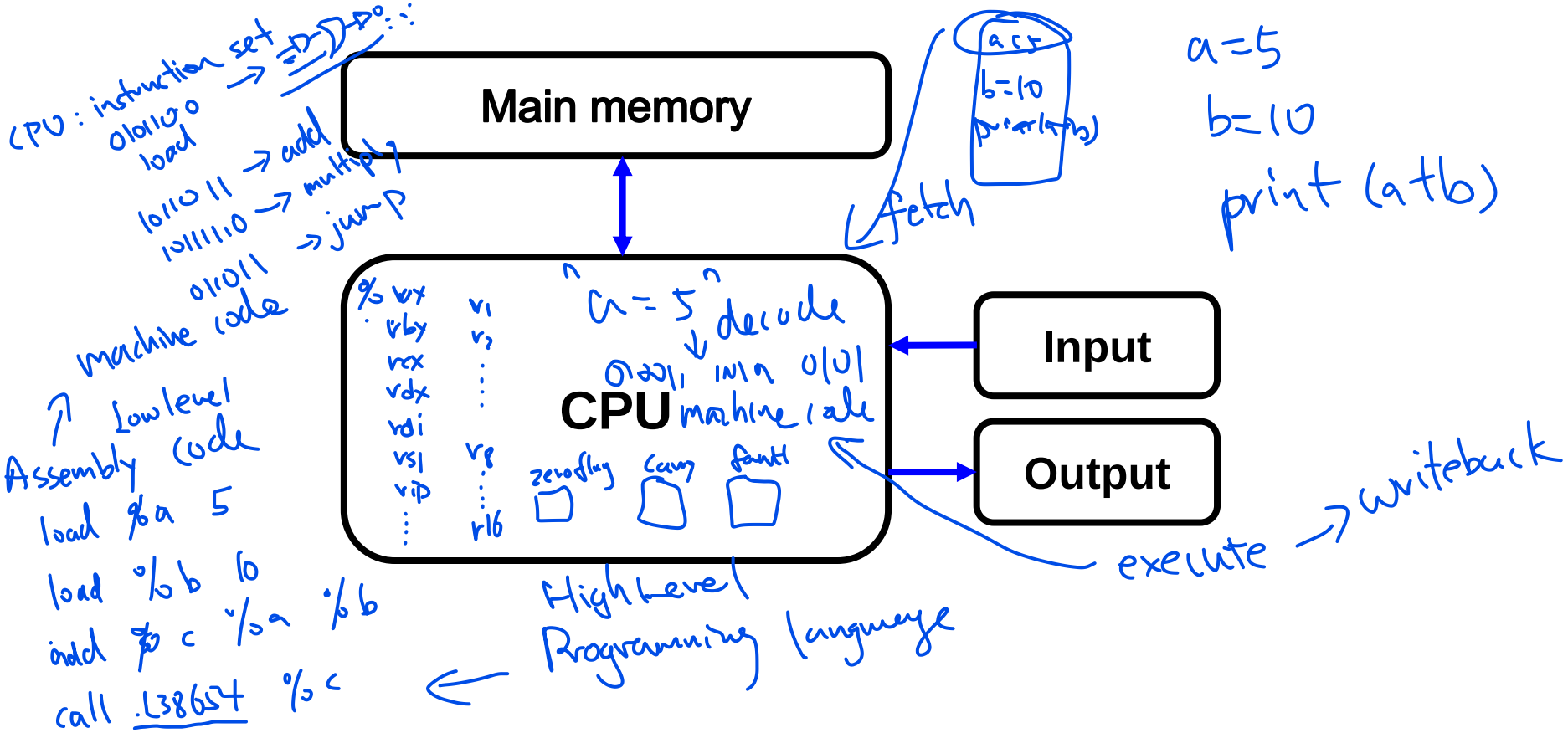
An architecture of computing devices developed by the EDVAC design team for the U.S. Army 1945-51.

Commonly attributed to John von Neumann due to the 1945 publication: First Draft of a Report on the EDVAC which you can download it from DUO (of historical only interest).

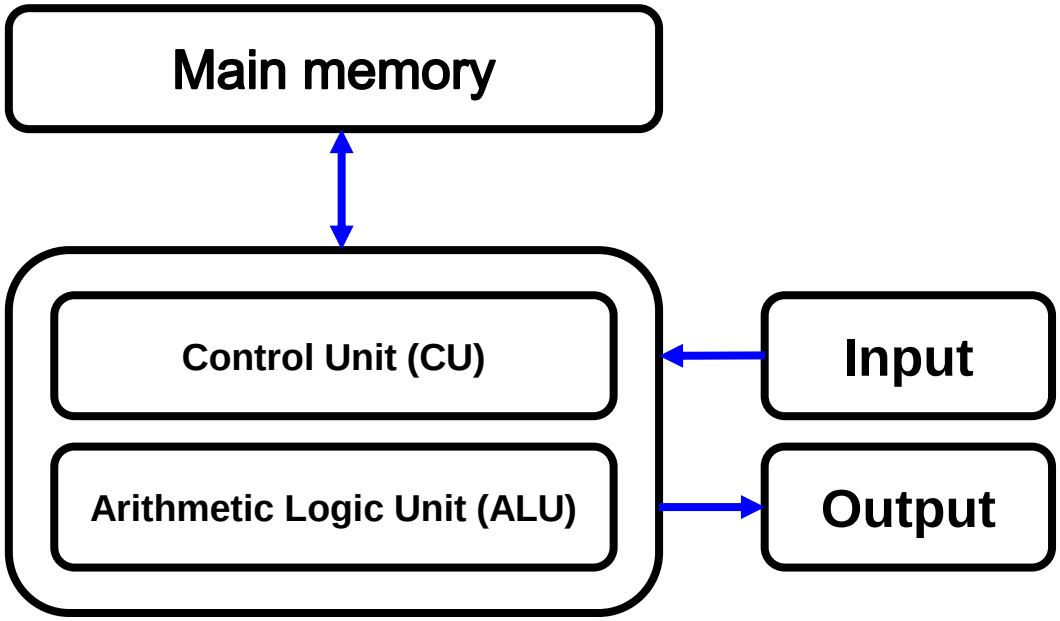
The main elements of computers are still virtually unchanged.

von Neumann architecture

A (very) high-level description of the von Neumann architecture:



von Neumann architecture



By zooming in on each of these components we can produce more and more detailed, but less and less general, architectures.

von Neumann architecture

Central Processing Unit (CPU):

- Control Unit (CU): responsible for directing the flow of instructions and data.
- Arithmetic Logic Unit (ALU) : responsible for performing operations on the data.

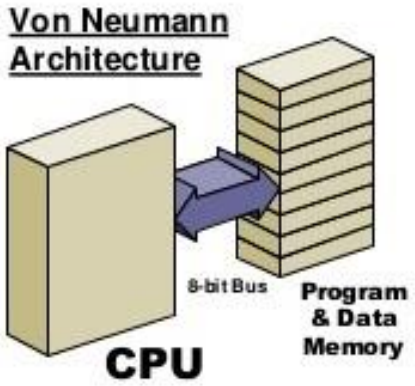
Main memory.

Input / Output devices.

Communication between components through buses.

Harvard architecture

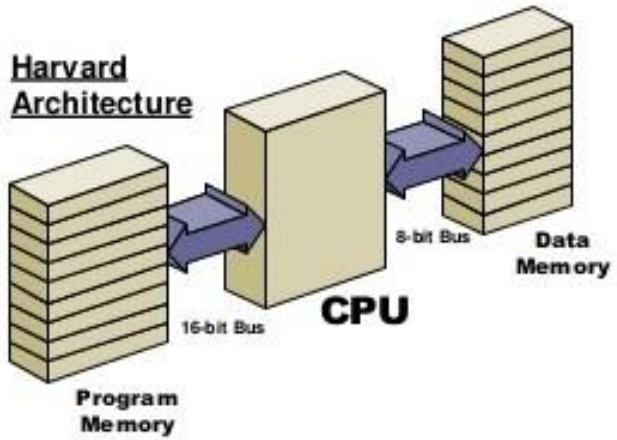
Are there any architecture that are not of the von-Neumann type?



Yes, the Harvard architecture.

Two separate memory spaces for program instructions and data.

Two separate buses.



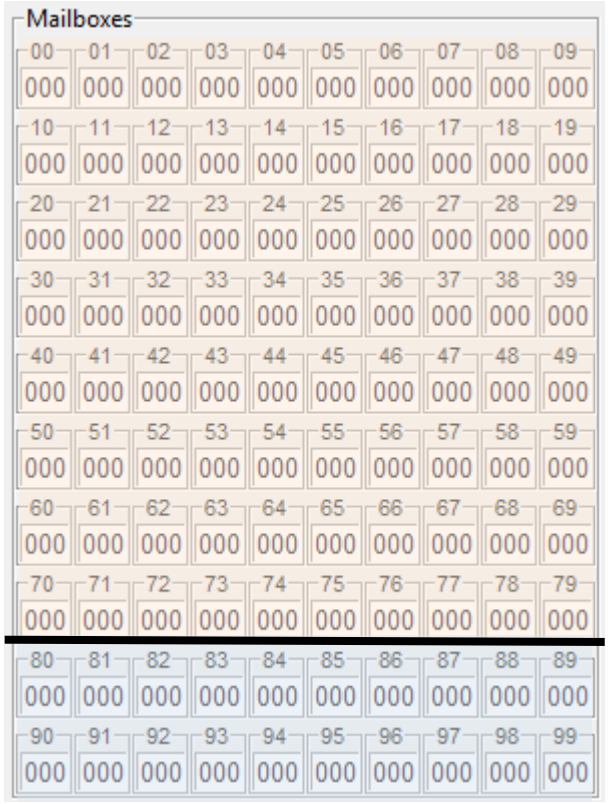
Harvard architecture

Imagine I use mailboxes 00-79 of the LMC for storing op codes only, and mailboxes 80-99 for storing data only.

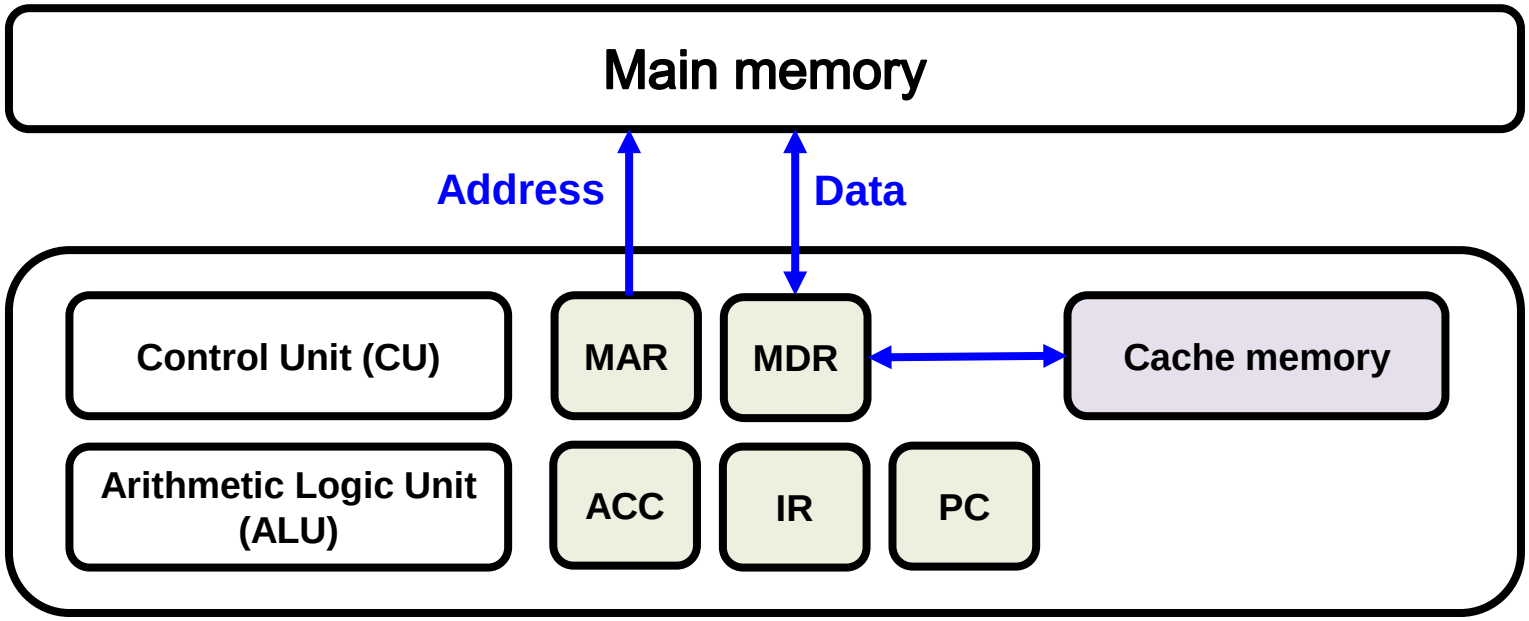
Does it make the architecture Harvard?

No, as long as we have one only Minion.

A single bus for both instructions and data is considered the litmus test of von Neumann architecture.



von Neumann architecture



By zooming in on each component (including the bus) we can produce more and more detailed, but less and less general, architectures.

Components of the CPU

Registers: special memory locations that can be accessed very fast.

Five registers were shown:

- Accumulator (ACC)
- Program Counter (PC)
- Instruction Register (IR)
- Memory Address Register (MAR)
- Memory Data Register (MDR)

Buses: bundles of tiny wires that carry data between components.

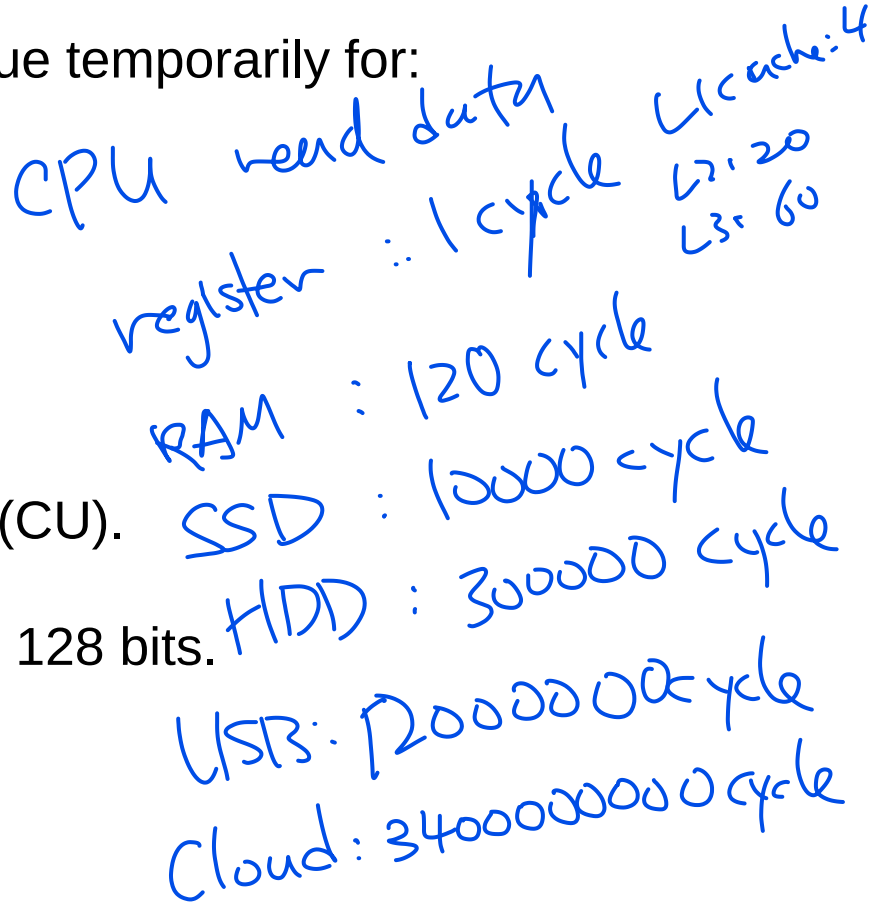
Registers

The ‘work space’ of the CPU. Hold a value temporarily for:

- storage
- manipulation
- calculation

Manipulated directly by the Control Unit (CU).

Their size of registers can vary from 1 to 128 bits.



Registers

Accumulators are often seen as part of the ALU.

General purpose registers used for:

- Holding data.
- Holding interim and final results of arithmetic operations.
- Holding data waiting to be transferred between different memory locations.
- Holding data waiting to be transferred between I/O and main memory.

Registers

The Program Counter (PC), Instruction Register (IR) and the Flags are often seen as part of the Control Unit.

The Program Counter holds the address of the next instruction to be executed.

The Instruction Register holds the actual instruction being executed.

Flags are 1 bit registers used to keep track of special conditions, such as: arithmetic carry, overflow, power failure, internal computer error

Flags are grouped together in one or more Status Registers (SR).

Registers

The Memory Address Register (MAR) and the Memory Data Register (MDR) are used for memory management.

The Memory Address Register holds the address of a memory location to be accessed.

Connects to the memory with a one-way bus.

The Memory Data Register holds the value that is being stored to or retrieved from the memory location currently addressed by the MAR.

Connects to the memory with a two-way bus. Also known as the Memory Buffer Register (MBR).

Buses

The physical connection that makes it possible to transfer data from one location in the system to another is called a bus.

A bus is a group of electrical conductors (lines) used to carry signals.

Four general categories of lines: Data, Address, Control, and Power.

Buses are used to:

- Transfer data between different points on the CPU.
- Transfer data between the CPU and main memory.
- Transfer data between computer peripherals and the CPU.

Bus types

Point-to-point buses carries the signal from a specific source to a specific destination.

Broadcast buses carry signals to many different destinations.

Bus Interface Bridges allow communications between the different buses:

External bus

PCI: Peripheral Control Interface bus

USB: Universal Serial Bus