CM12002
Computer Systems Architectures

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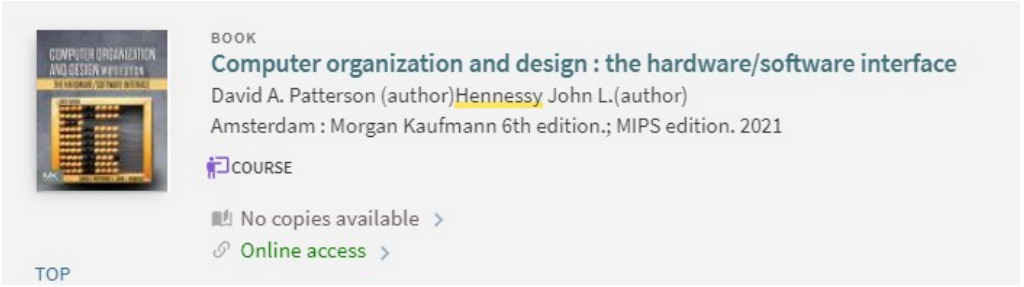
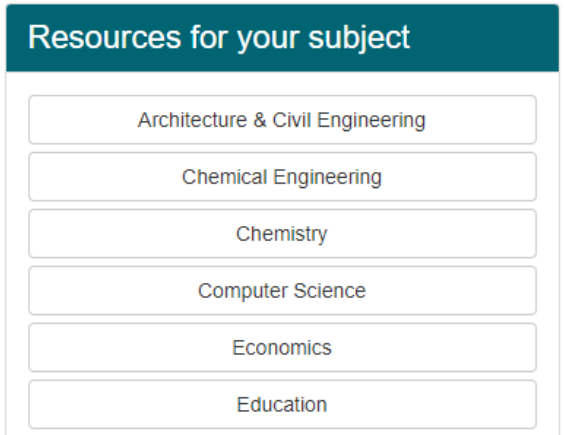
Library

I was asked if books were available online:





O'Reilly Learning

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[Library]

Uniprocessor Architectures

- The von Neumann Architecture

In this lecture:

- The von Neumann architecture: what is it, why is it useful?
- The main components of the architecture: their functions and how they are connected.
- Variants like the Harvard Architecture

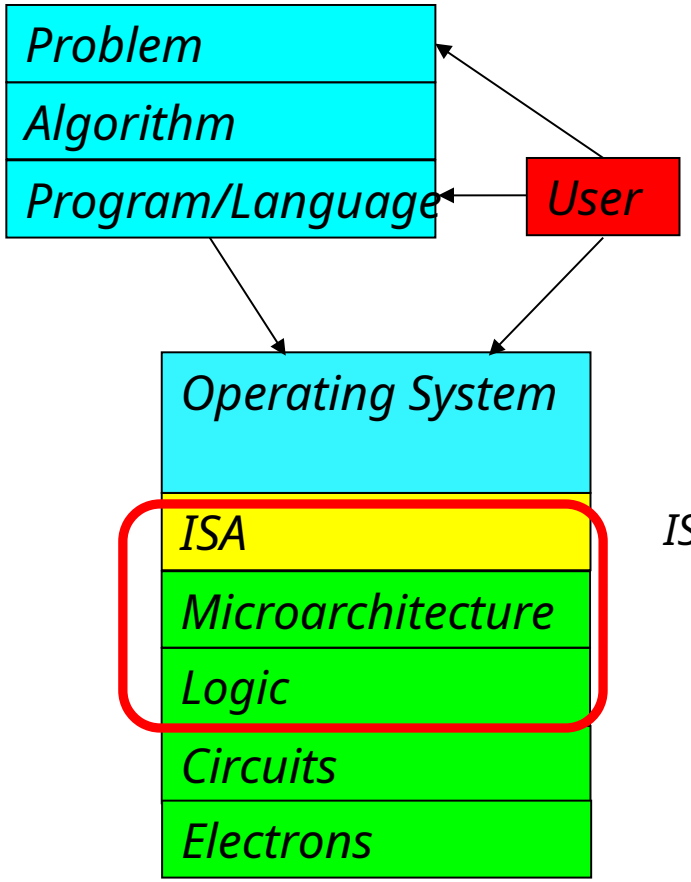
The von Neumann Architecture

Recall: we need to study architecture at the right *level of abstraction.*

A problem:

- Programmers and language designers need to know *in essence* how the computer will execute their program.
- But many of the details of execution are less important.
- …and we want to be able to run the same program on a variety of different machines anyway.

Abstractions



ISA: Instruction Set Architecture

**Diagram credit: Prof. Onur Mutlu*

Abstractions

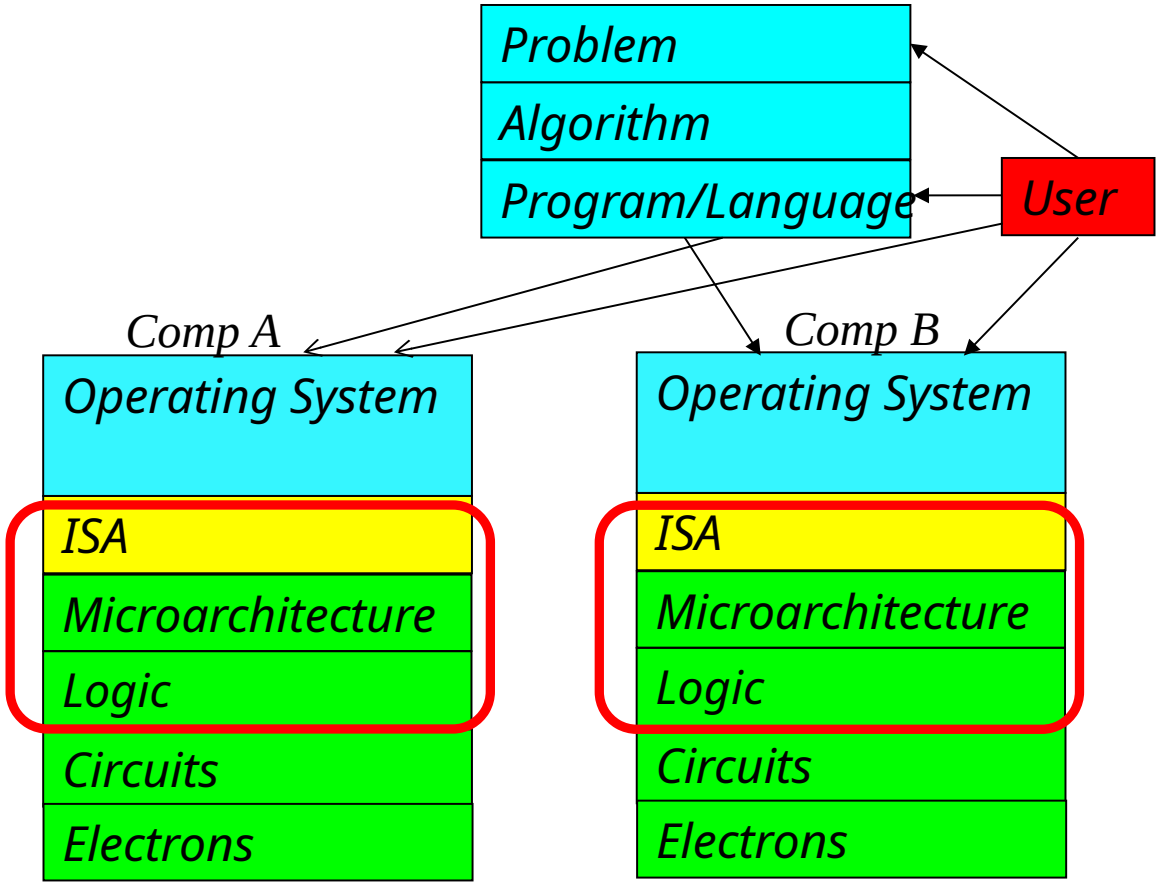


*Diagram credit: Prof. Onur Mutlu

The von Neumann Architecture

Solution:

Virtually all single processor machines correspond to a single *architecture* or *idealization* of a computer, proposed by John von Neumann:

The **von Neumann Architecture**.

This *abstracts from* (hides) the details of particular machines, and reveals their common structure.

It is also the basis of other, more particular abstractions, allowing execution of the same program on different platforms

John von Neumann (1903 Hungary - 1957 USA)

Mathematician, physicist, computer scientist, and polymath

Found time between seminal contributions to:

- Set theory
- Game theory
- Quantum Mechanics
- The “Manhattan” project
- ….

to describe the fundamental computer architecture still the basis of most modern processors.

He proposed this architecture for the EDVAC computer though it was based on work by Turing, Eckert and Mauchly

The Manchester Baby

- first computer with von Neumann architecture
- ran its first stored-program on 21 June 1948

Photo by user:geni

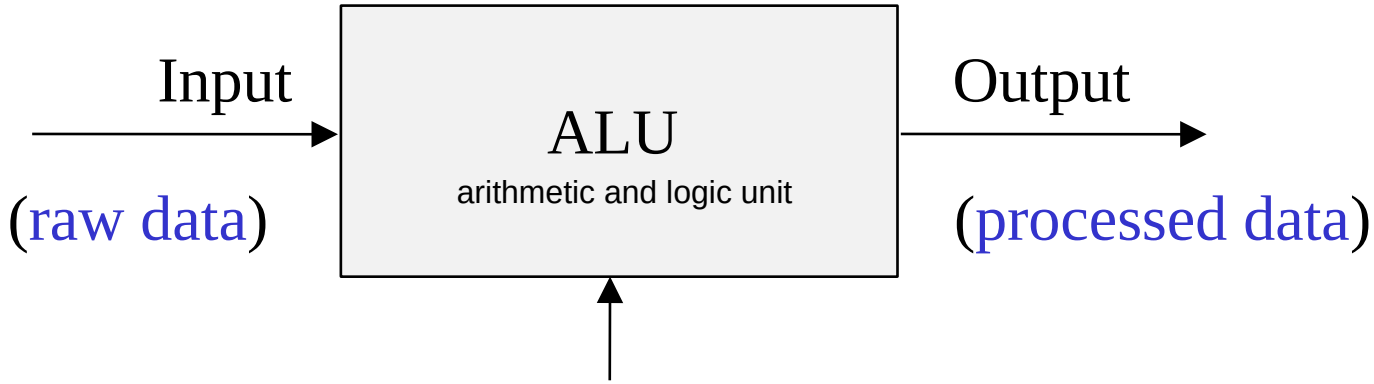
The von Neumann Architecture: Data Processing

The *arithmetic and logic unit* (ALU) is where computational operations are carried out.

To carry out an operation we need:

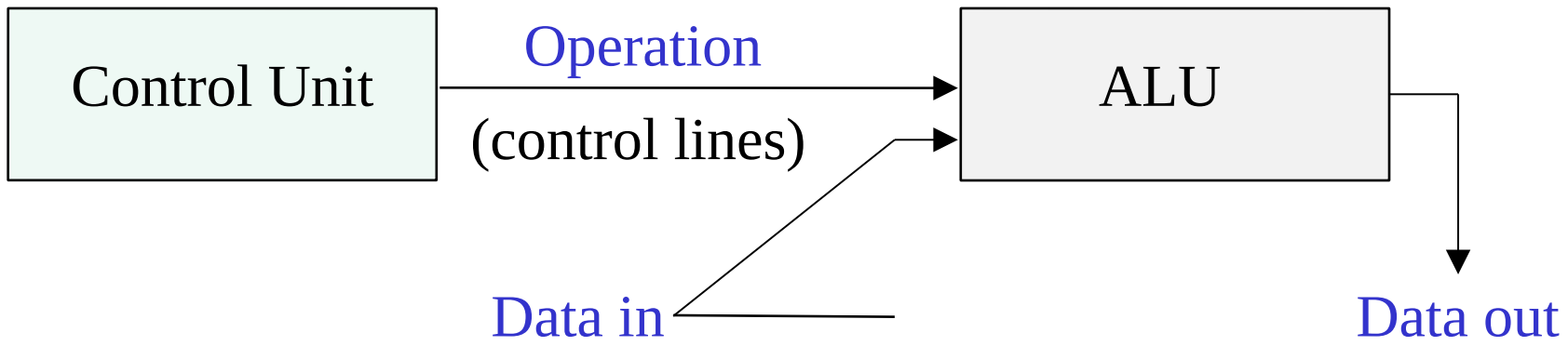
a) An *operation* specification (e.g. add)

b) Data or *operands* to operate upon



The von Neumann Architecture:
Control

The ALU alone is not automatic. Operations and operands must be supplied in the correct sequence and at the appropriate times. A *control* unit is added to do this:



The von Neumann Architecture

The main activities of the control unit are as follows:

- To determine the operation to be performed;
- To select the correct operands and make them available at the right time;
- To perform the operation on the operands by supplying the correct control data to the ALU; and
- To determine the next operation to be performed!

It is thus the control unit that renders the digital data-processor automatic.

The von Neumann Architecture:
Data

- What form is this data and where does it come from?

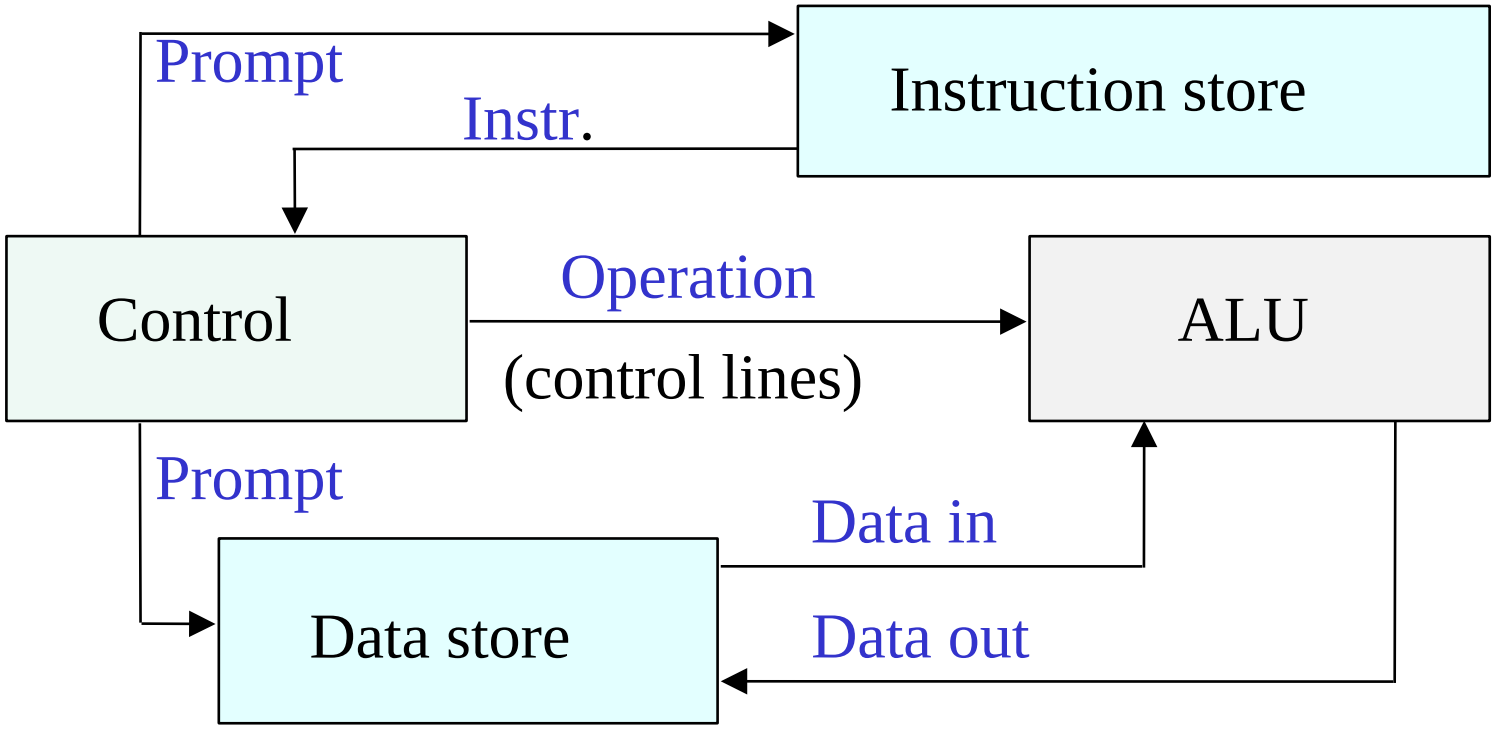
- We assume it is *digital (exact)* in form, and can be stored and retrieved in a *data store* unit in response to a stimulus from the control unit.

- If data store and the control unit work fast enough the ALU can be kept in continuous operation.

The von Neumann Architecture

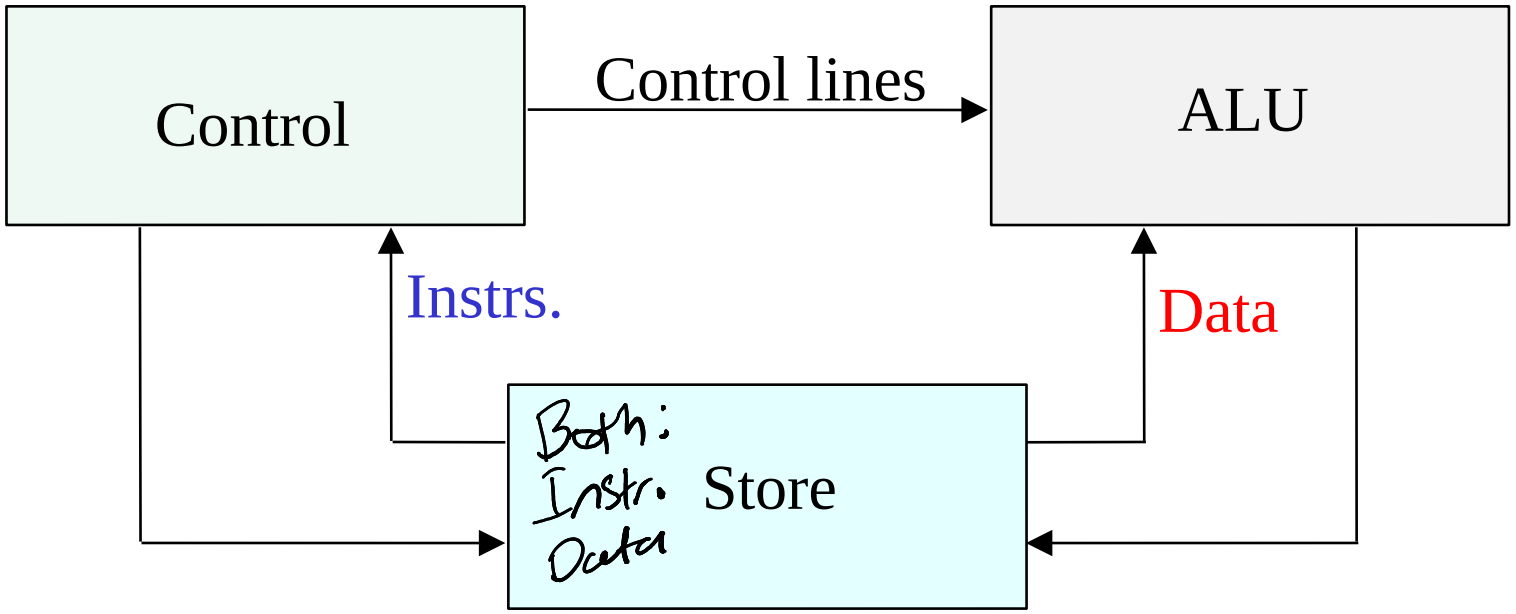
Q: Where does the operation information come from?

A: An *instruction store*!



The von Neumann Architecture: Store

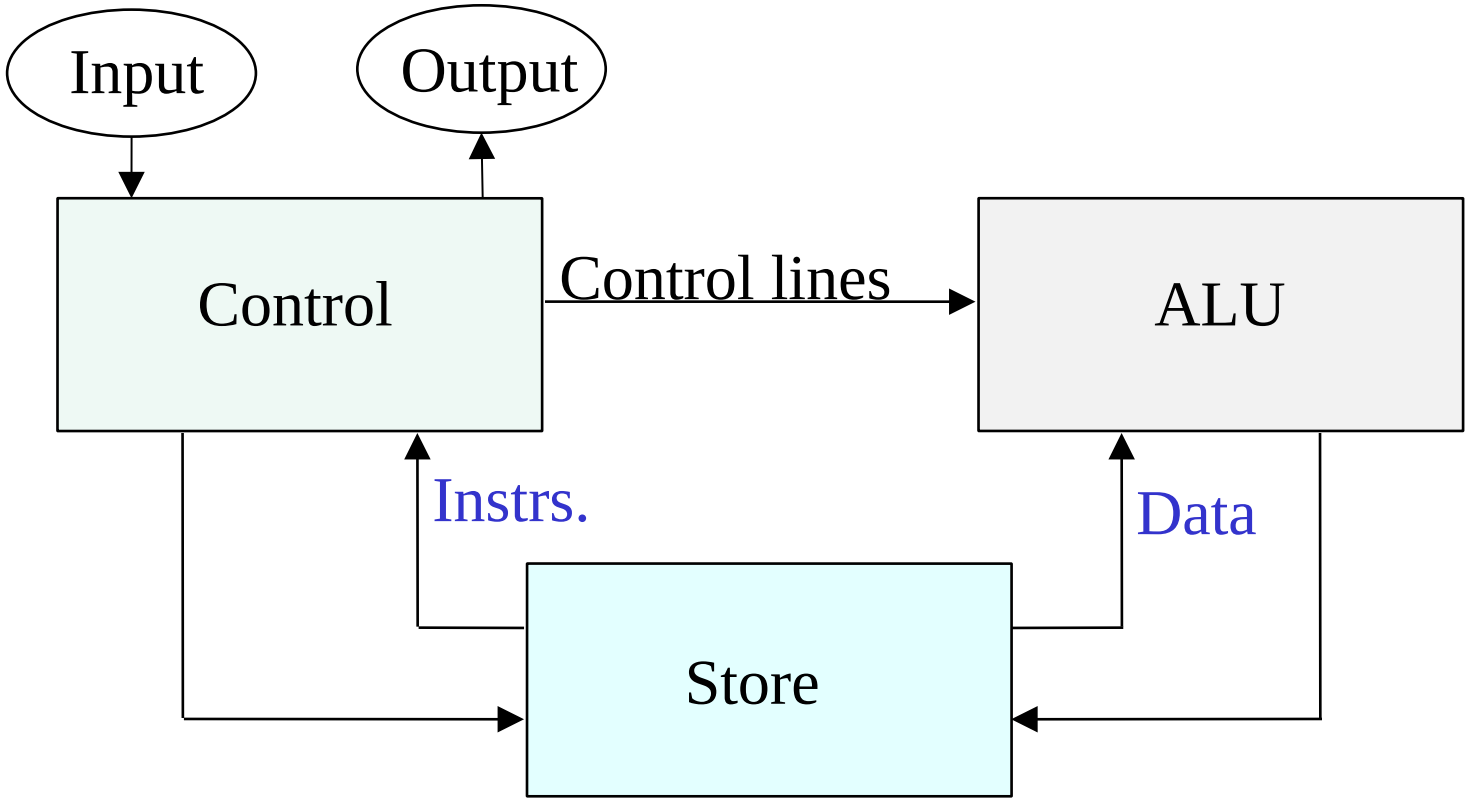
Manipulating code as data is a powerful programming technique - the two stores are combined into a single unit:



John von Neumann defined an architecture which uses the same memory both to store programs and data: virtually all contemporary computers use this architecture (or some variant)

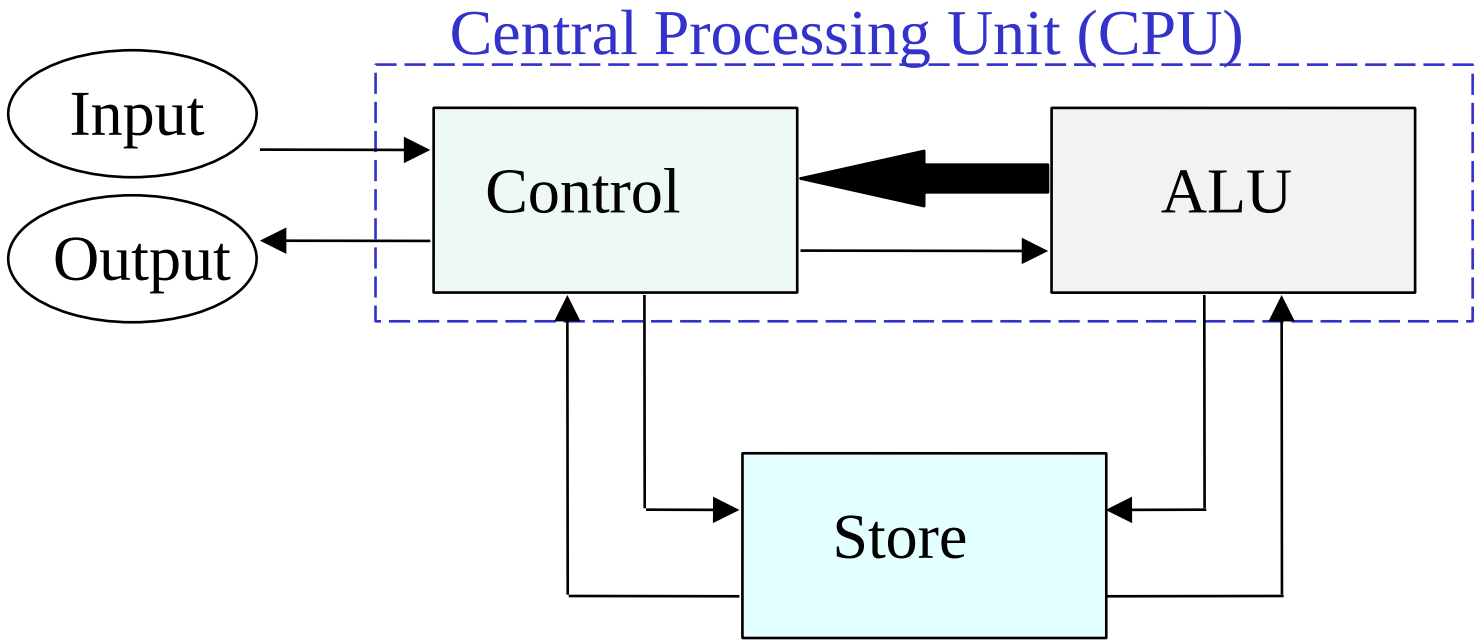
The von Neumann Architecture:
I/O

We still need communication between the machine and the outside world, using *input* and *output* devices

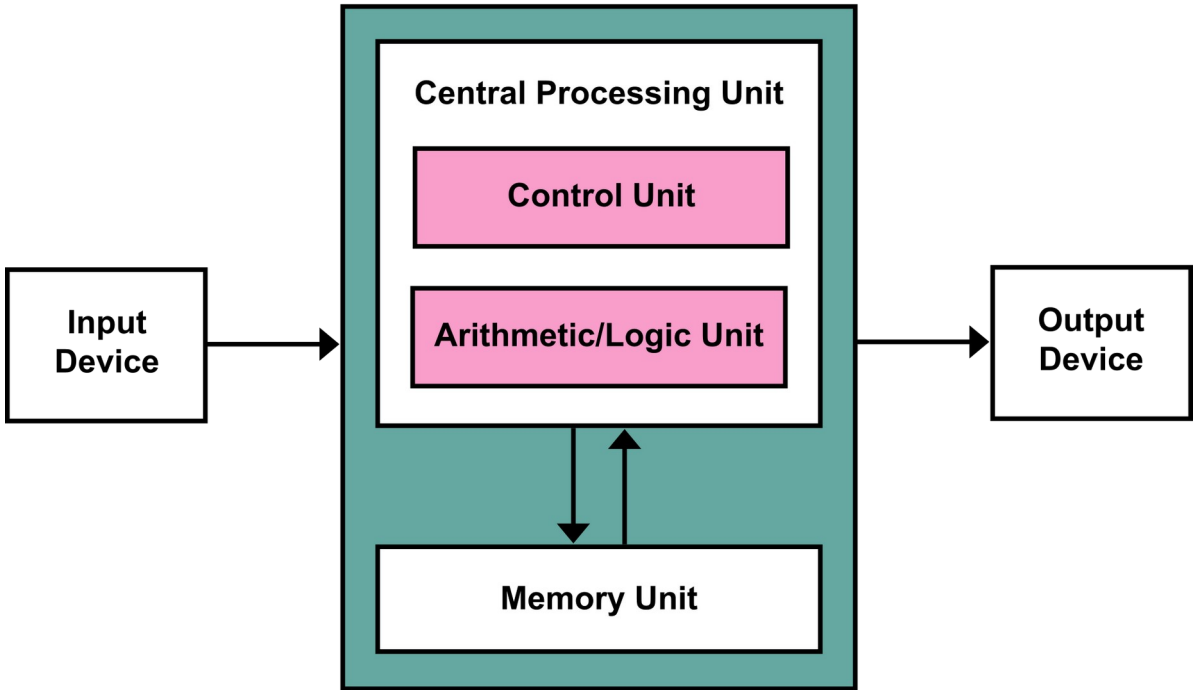


The complete computer system

Operation sequencing can be controlled directly by the state of the ALU (which is fed back to the control unit) - in particular *prompts* when an operation is finished:



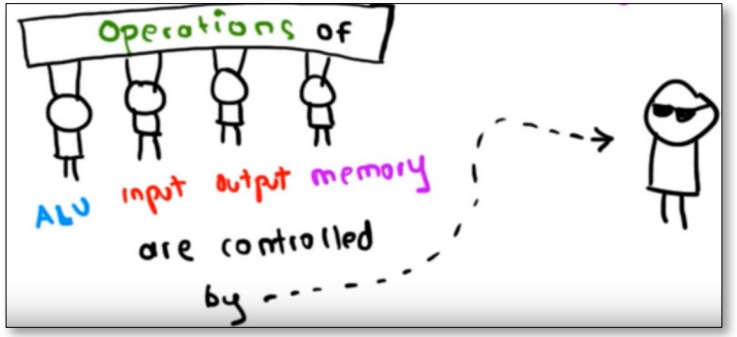
Once more with feeling



From: *https://en.wikipedia.org/wiki/Von_Neumann_architecture*

- Should we review the Von Neumann Architecture in less than 3 minutes?

- The video includes topics from future lectures:
  - Registers
  - Execution of instructions



- Video: http://www.youtube.com/watch?v=5BpgAHBZgec

Next time:

Harvard Architecture and more