The Stored Program Computer

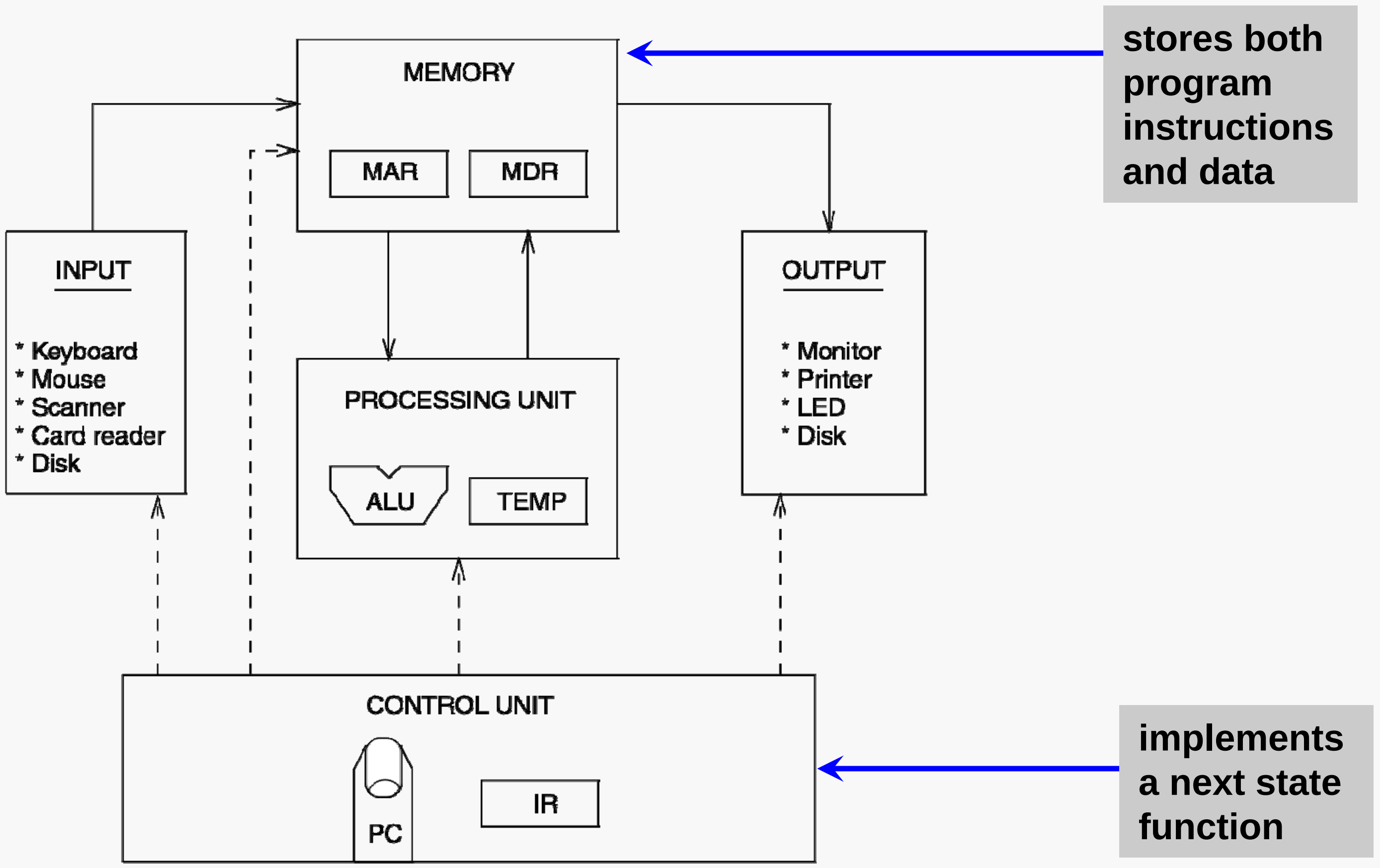
1945: John von Neumann

- Wrote a report on the stored program concept, known as the First Draft of a Report on EDVAC
- also Alan Turing… Konrad Zuse… Eckert & Mauchly…

The basic structure proposed in the draft became known as the “von Neumann machine” (or model).

- a <u>memory</u>, containing instructions and data
- a <u>processing unit</u>, for performing arithmetic and logical operations
- a <u>control unit</u>, for interpreting instructions

von Neumann Model



Abstraction of von Neumann

Memory

2^k x *m* array of stored bits

Address

– unique (*k*-bit) identifier of location

Contents

– *m*-bit value stored in location

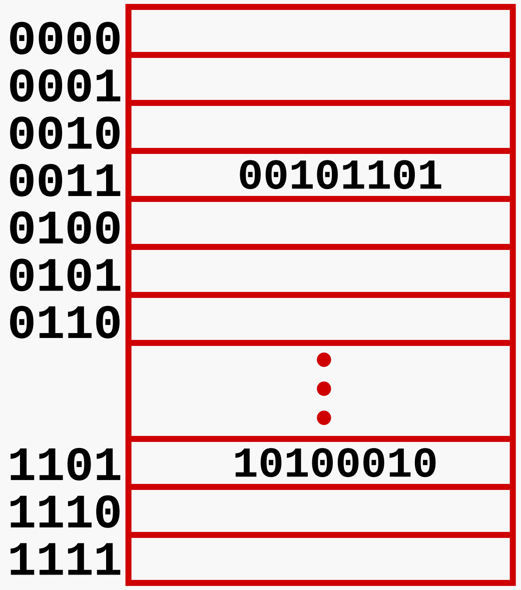
Basic Operations

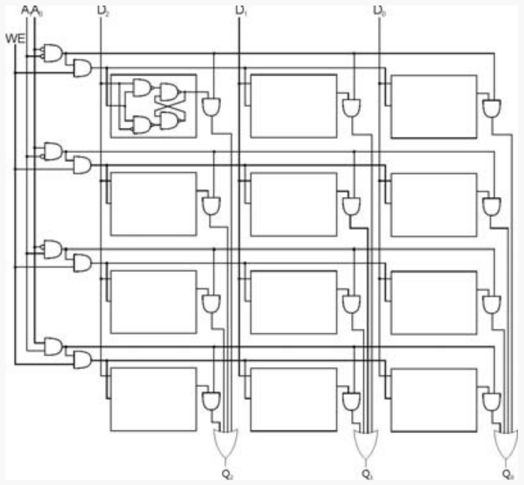
LOAD

– read a value from a memory location

STORE

– write a value to a memory location



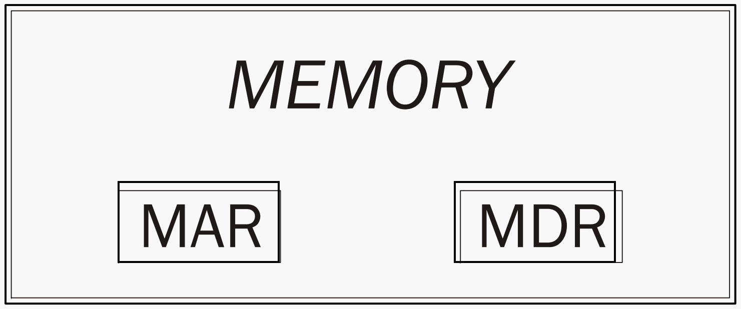


Interface to Memory

How does processing unit get data to/from memory?

MAR: Memory Address Register

MDR: Memory Data Register



To LOAD a location (A):

- Write the address (A) into the MAR.
- Send a "read" signal to the memory.
- Read the data from MDR.

To STORE a value (X) to a location (A):

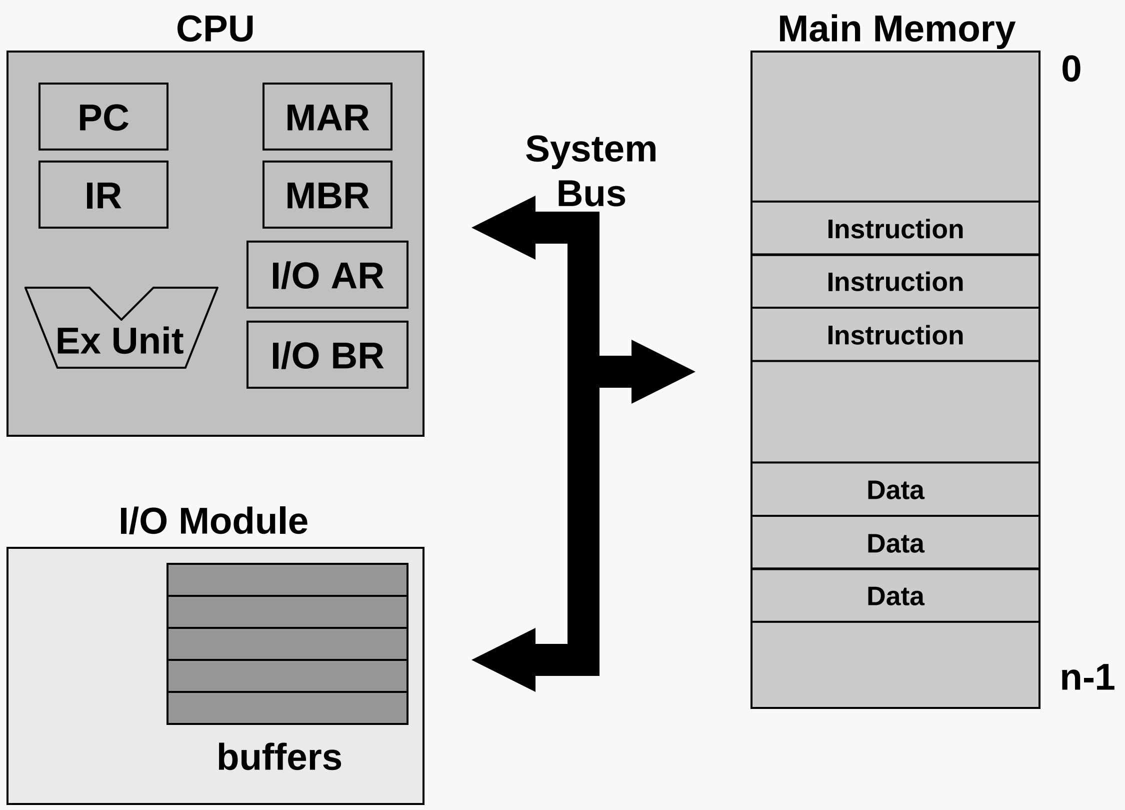
- Write the data (X) to the MDR.
- Write the address (A) into the MAR.
- Send a "write" signal to the memory.

Hardware Level Organization

Major components:

- memory
- central processing unit
- registers
- the fetch/execute cycle

  (the *hardware process*)



PC	=	program counter
IR	=	instruction register
MAR	=	memory address register
MBR	=	memory buffer register
I/O AR	=	I/O address register
I/O BR	=	I/O buffer register

Central Processing Unit

Control

- decodes instructions and manages CPU's internal resources

Registers

- general-purpose registers available to user processes
- special-purpose registers directly managed in fetch/execute cycle
- other registers may be reserved for use of operating system
- very fast and expensive (relative to memory)
- hold all operands and results of arithmetic instructions (on RISC systems)
- save bits in instruction representation

Data path or arithmetic/logic unit (ALU)

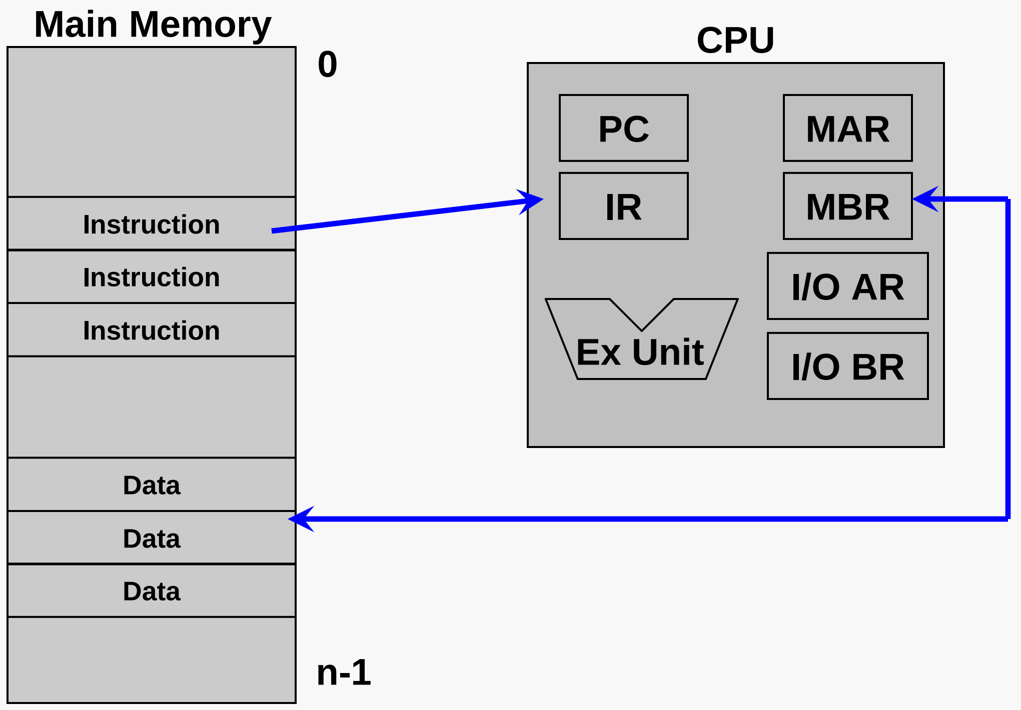
- operates on data

Stored Program Concept

Instructions are collections of bits

Programs are stored in memory, to be read or written just like data

memory for data, programs, compilers, editors, etc.



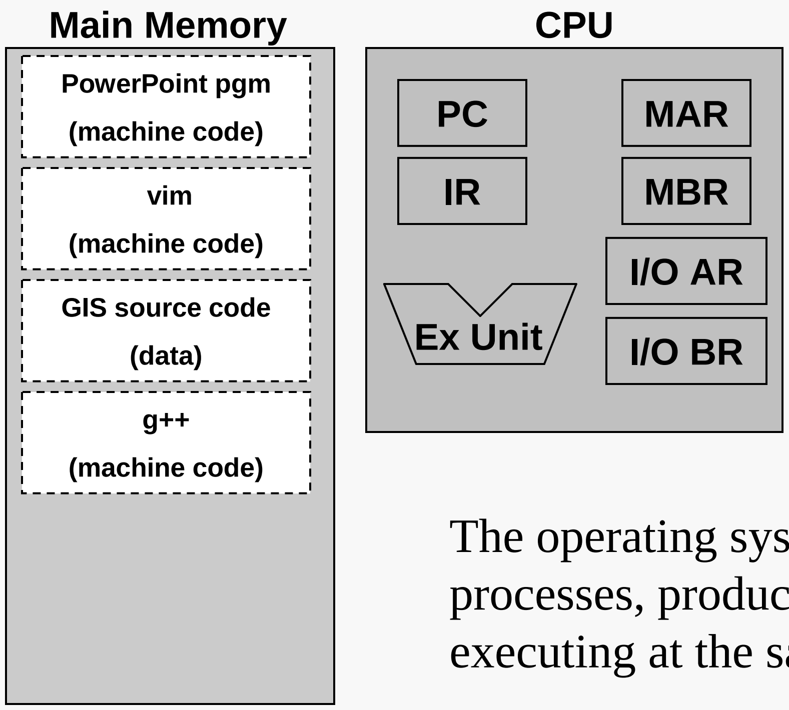
Fetch & Execute Cycle

- Instructions are fetched and put into a special register
- Bits in the register "control" the subsequent actions
- Fetch the “next” instruction and continue

Stored Program Concept

Of course, on most systems several programs will be stored in memory at any given time.

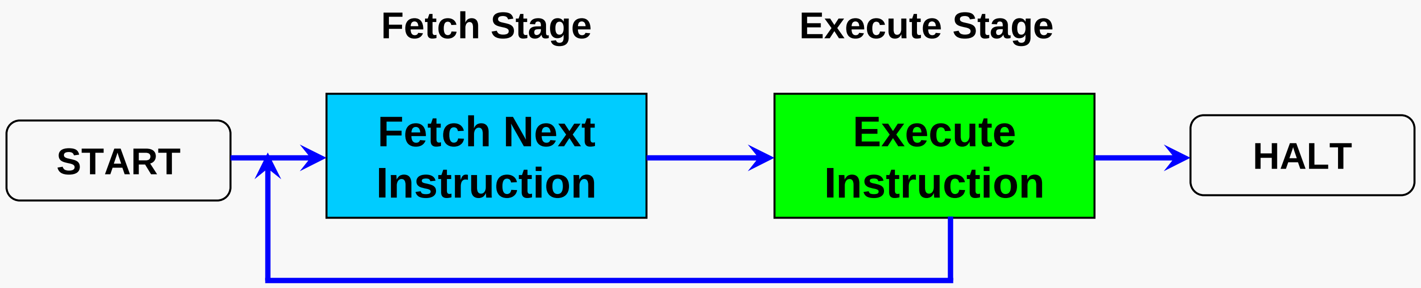
On most contemporary systems instructions of only one of those will be executed at any given instant.



The operating system will rapidly switch among the eligible processes, producing the illusion that several programs are executing at the same time.

Fetch/Execute Cycle

Sometimes called the hardware process… executes continuously.

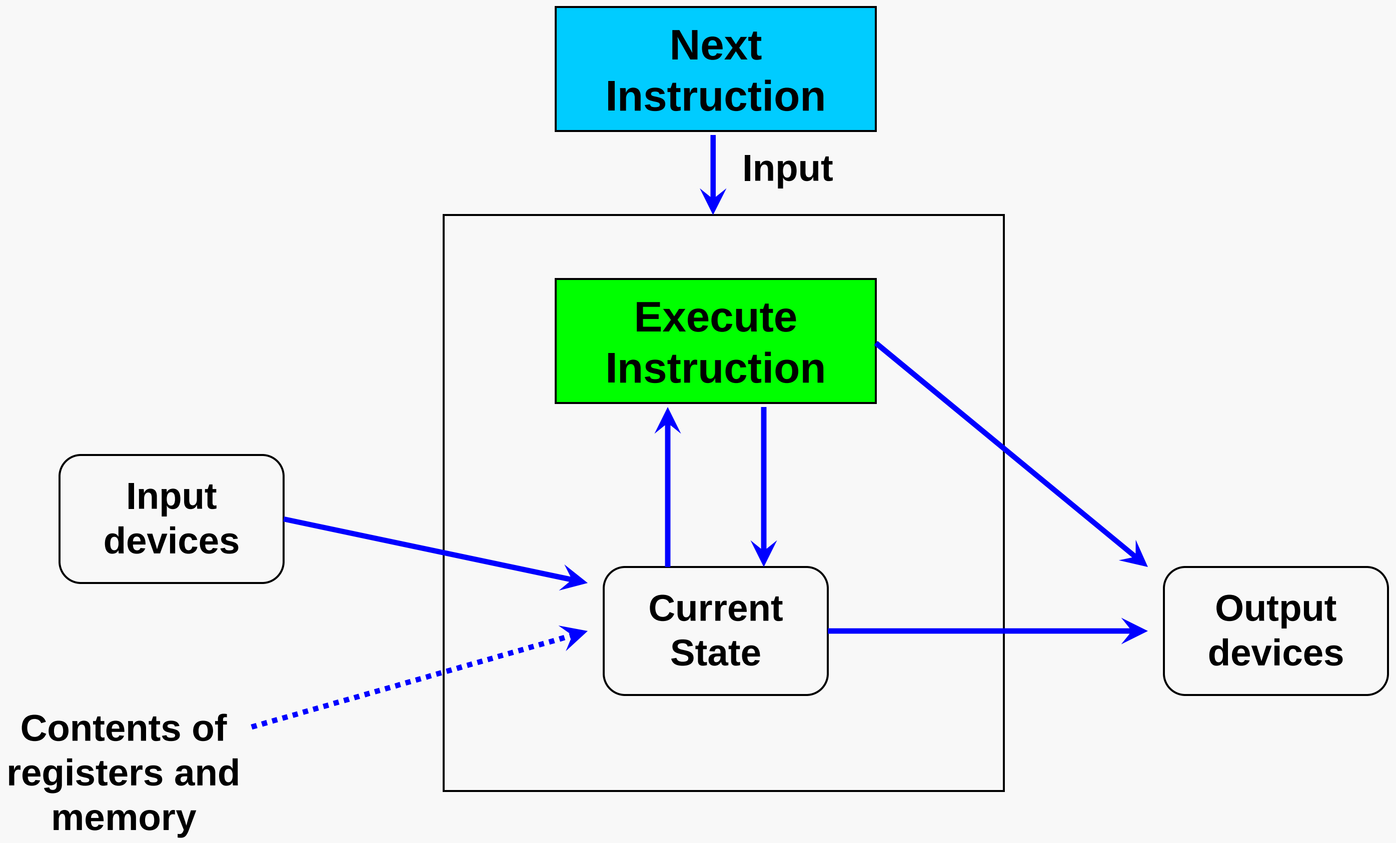


Steps:

- fetch an instruction from memory to the *instruction register*
- increment the *program counter* register (by the instruction length)
- decode the instruction (in the control unit)
- fetch operands, if any, usually from registers
- perform the operation (in the data path); this may modify the PC register
- store the results, usually to registers

Finite State Machine

So, where's the FSM?


Next Instruction
Input
Execute Instruction
Input devices
Current State
Output devices
Contents of registers and memory