Introduction : Computer Fundamental

Computer

Why do we use Computer?

How Computer Works?

-- Model of Computer

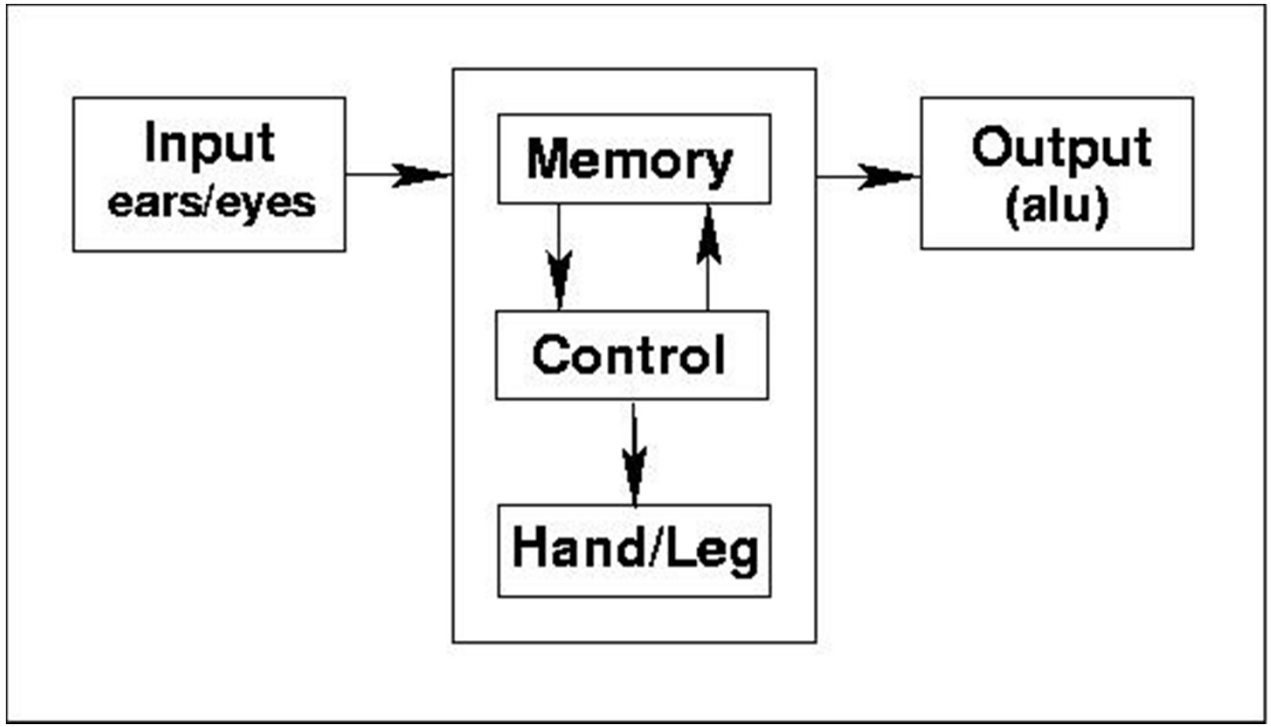
Work

Work: Buy 1kg Alu

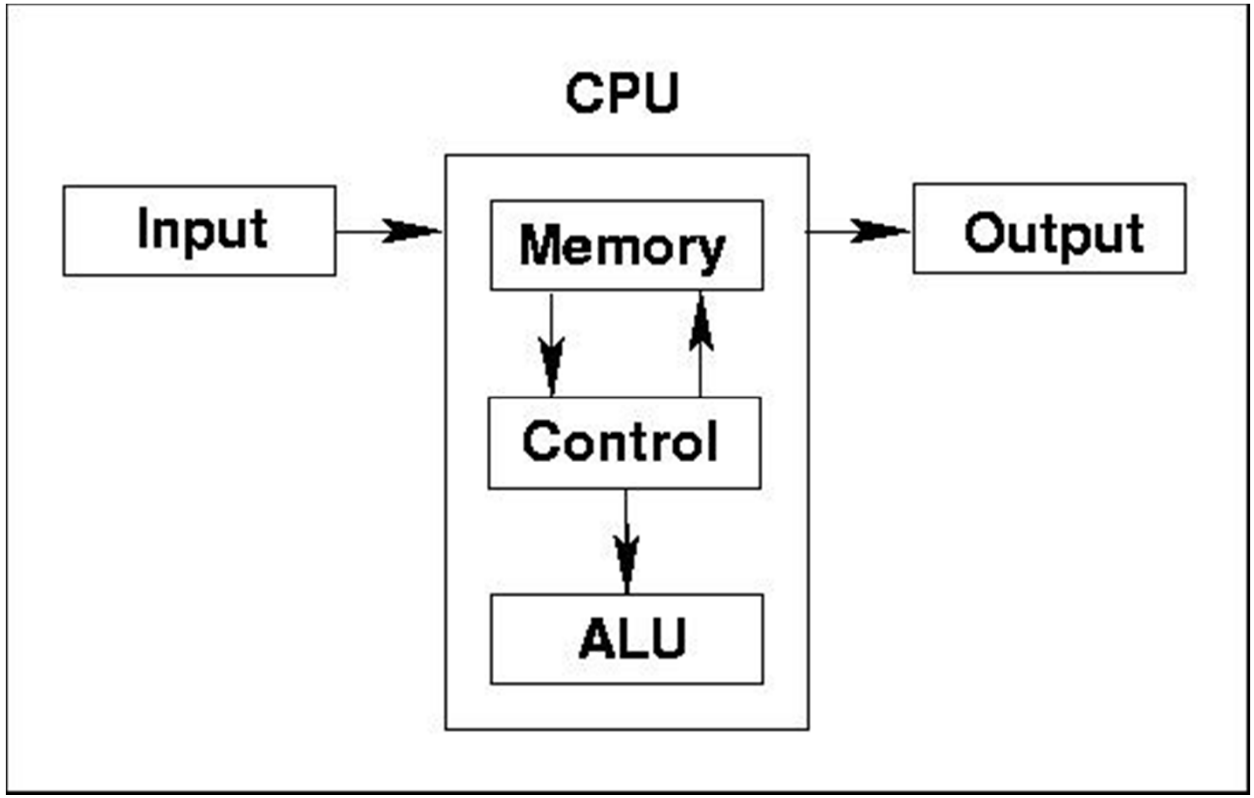
Action:

1. Take Bag, Money
2. Goto Market
3. Search for good Alu
4. Buy 1kg Alu
5. Go home

Model



Computer Model

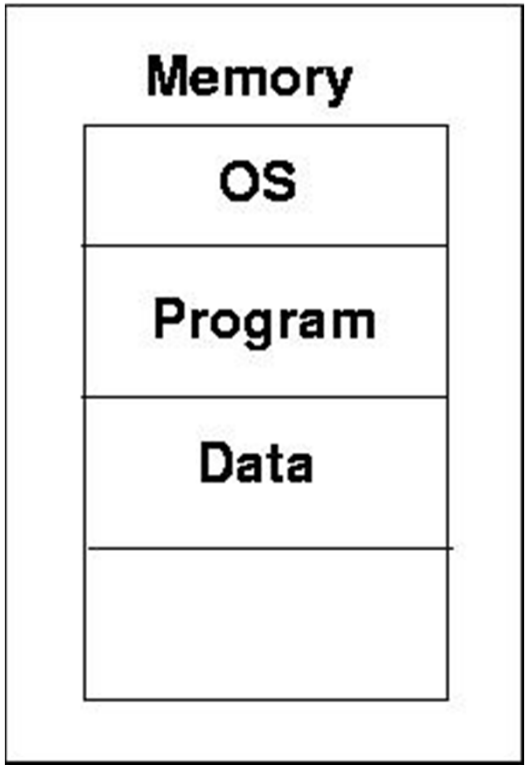


Algorithm: Procedure/Method to achieve desired result

Computer Program:

Set of Instructions

Executes in Sequence



Body --- Hardware

Life --- Software

- **Operating System, Compiler, editor, other tools**

Computer Programming Languages:

High Level Language: User Readable and understandable
(C, Pascal, Java, Cobol……)

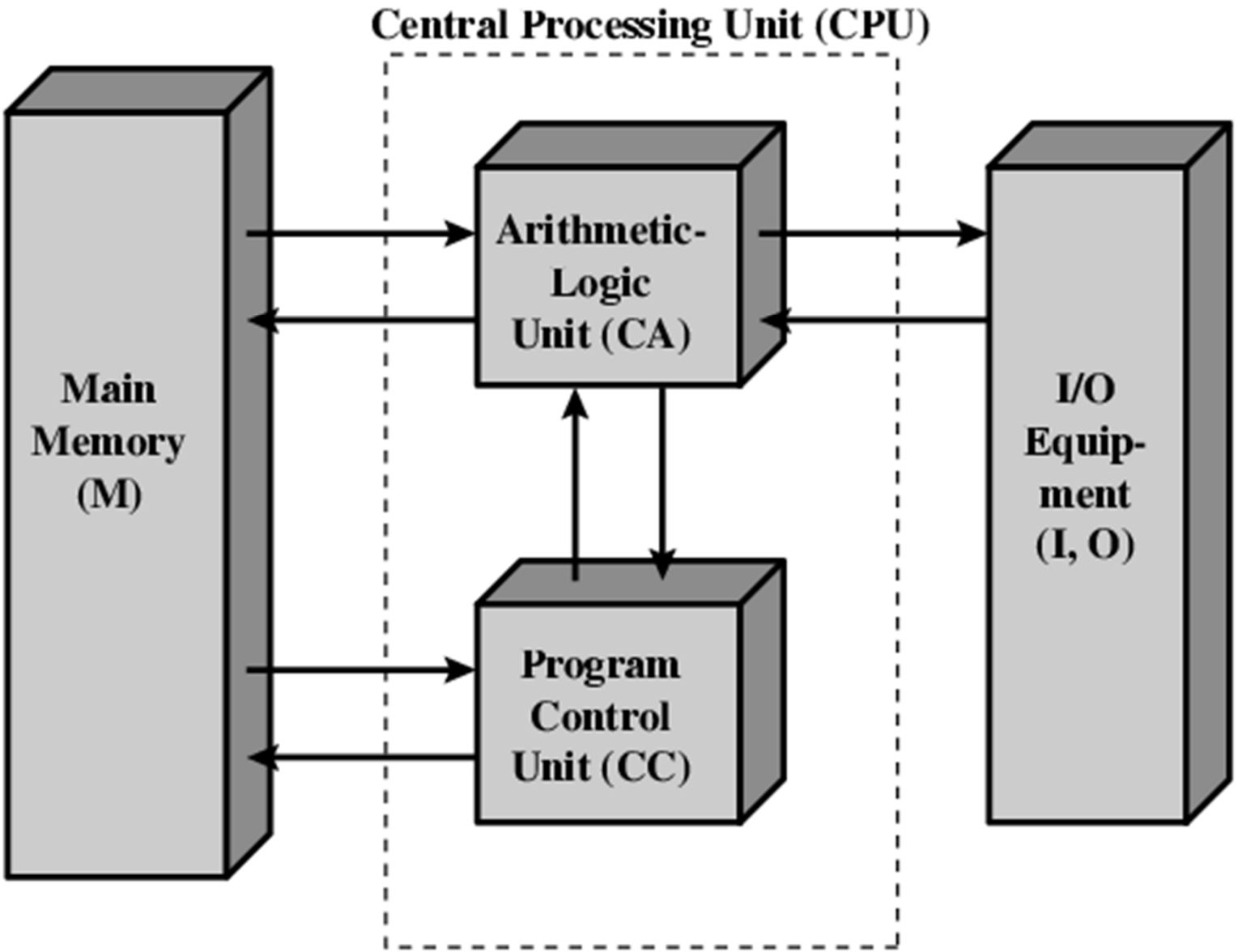
Assembly Language: (mnemonics: add, mov, mul, div, etc…)

Machine Language: sequence of 0s & 1s

Von Neumann

- Stored Program concept
- Main memory storing programs and data
- ALU operating on binary data
- Control unit interpreting instructions from memory and executing
- Input and output equipment operated by control unit
- Princeton Institute for Advanced Studies
  - IAS
- Completed 1952

Structure of Von Neumann machine



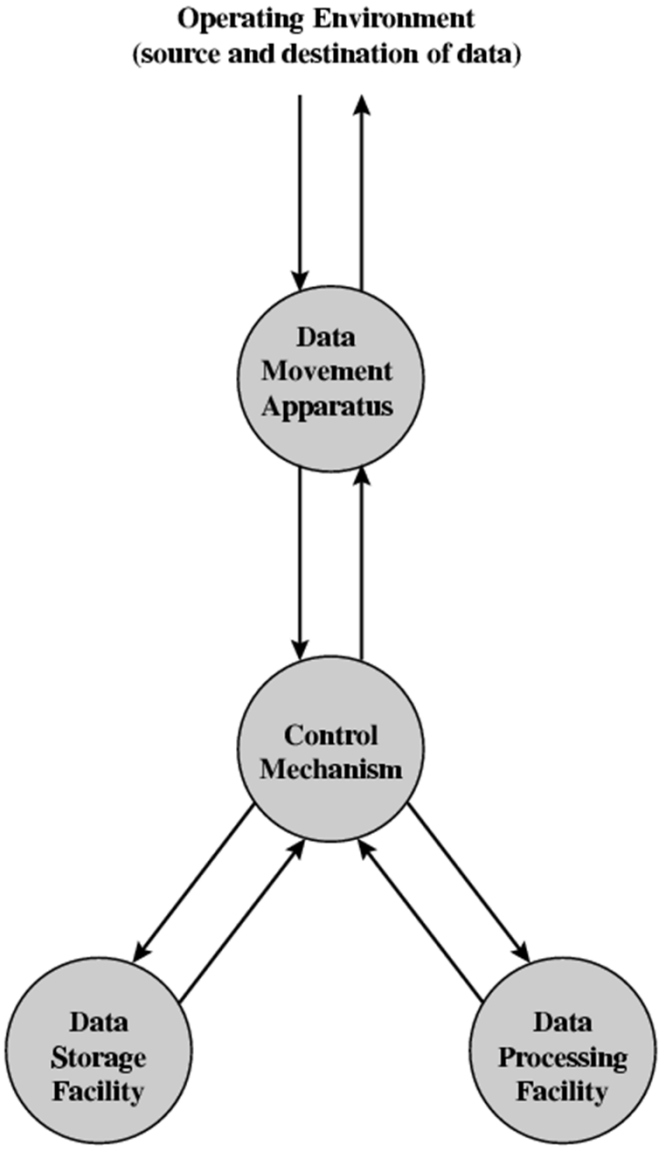
Computer : Structure & Function

- Structure is the way in which components relate to each other
- Function is the operation of individual components as part of the structure

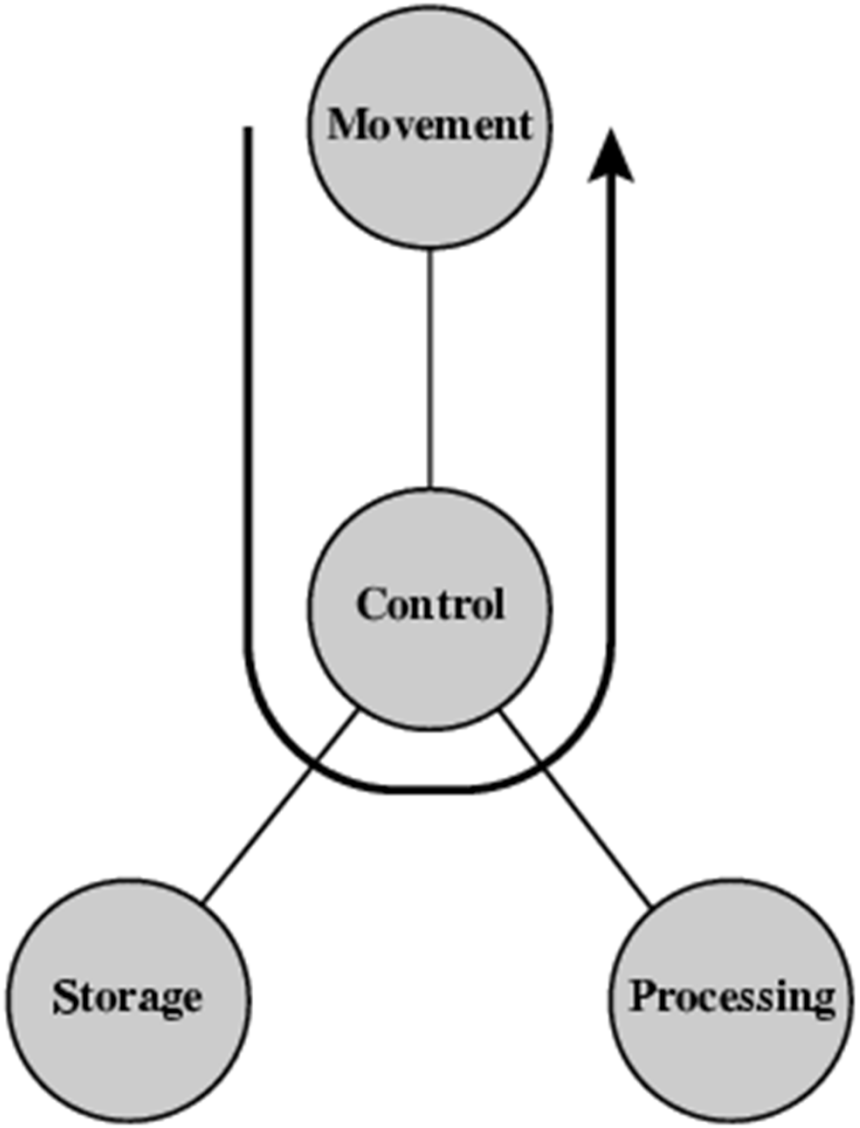
Function

- All computer functions are:
  - Data processing
  - Data storage
  - Data movement
  - Control

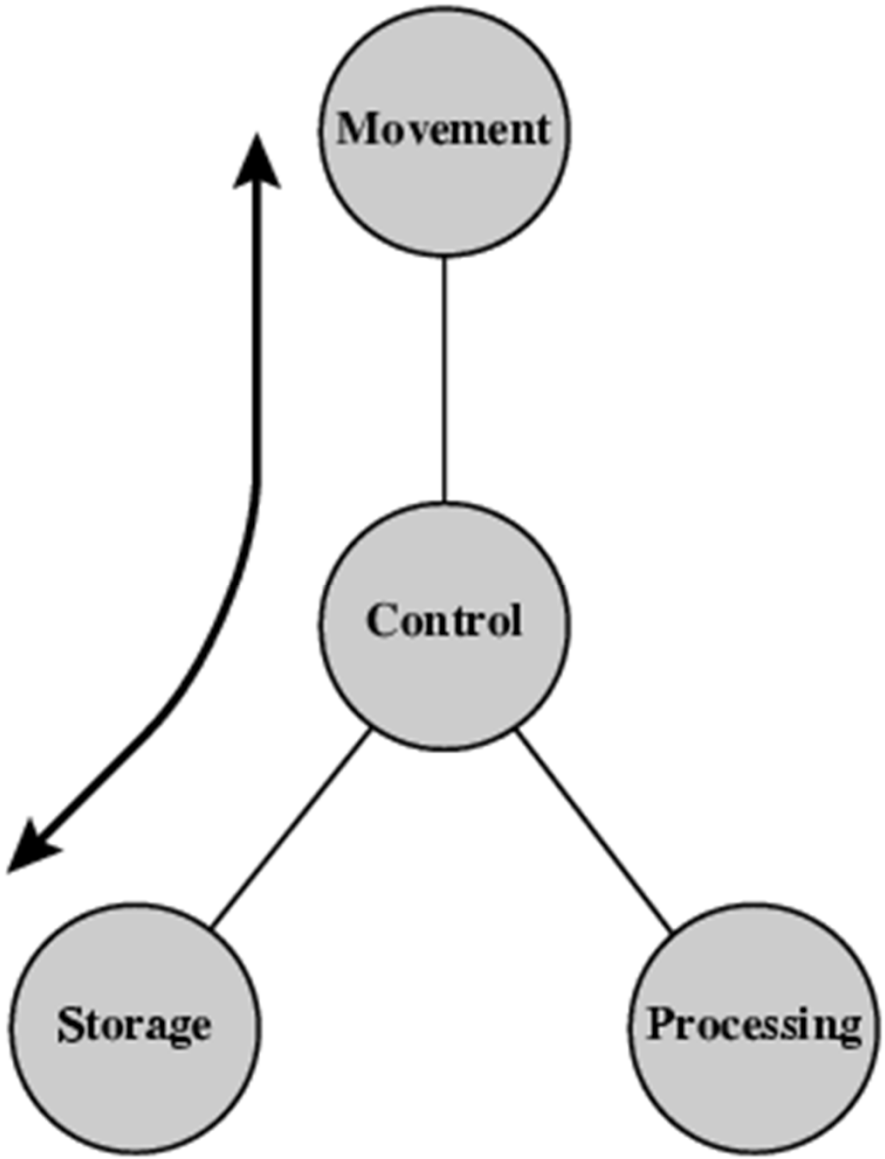
Functional View



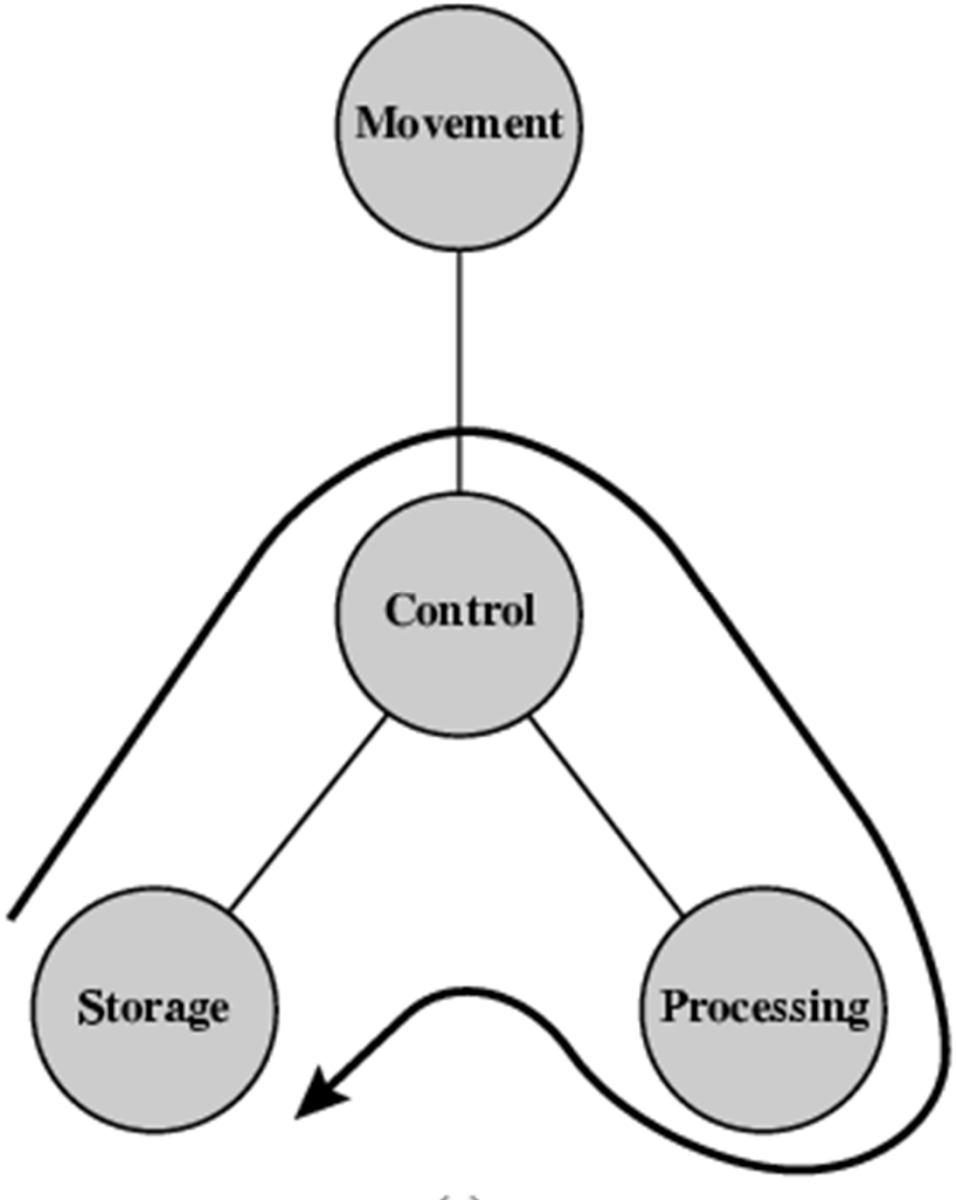
Operations (a) Data movement



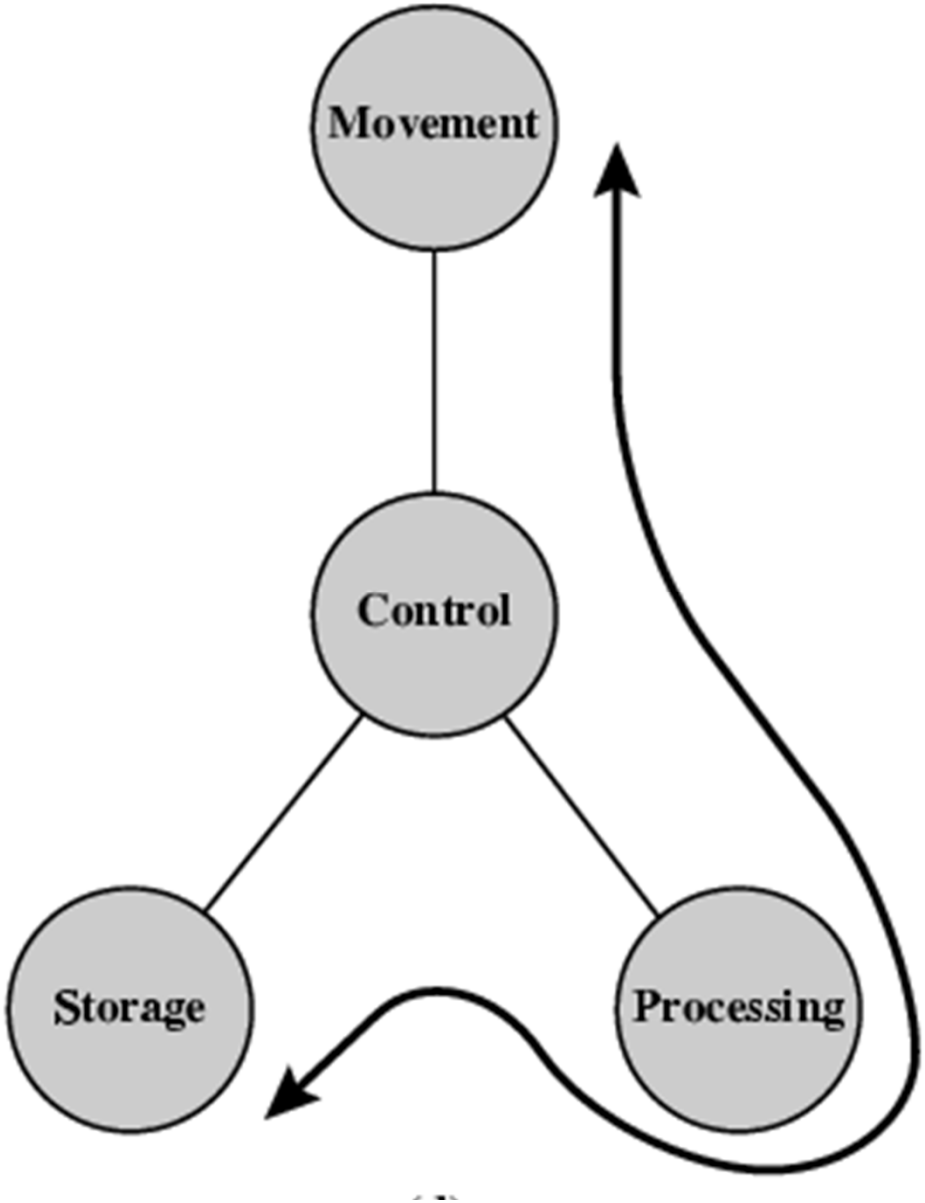
Operations (b) Storage



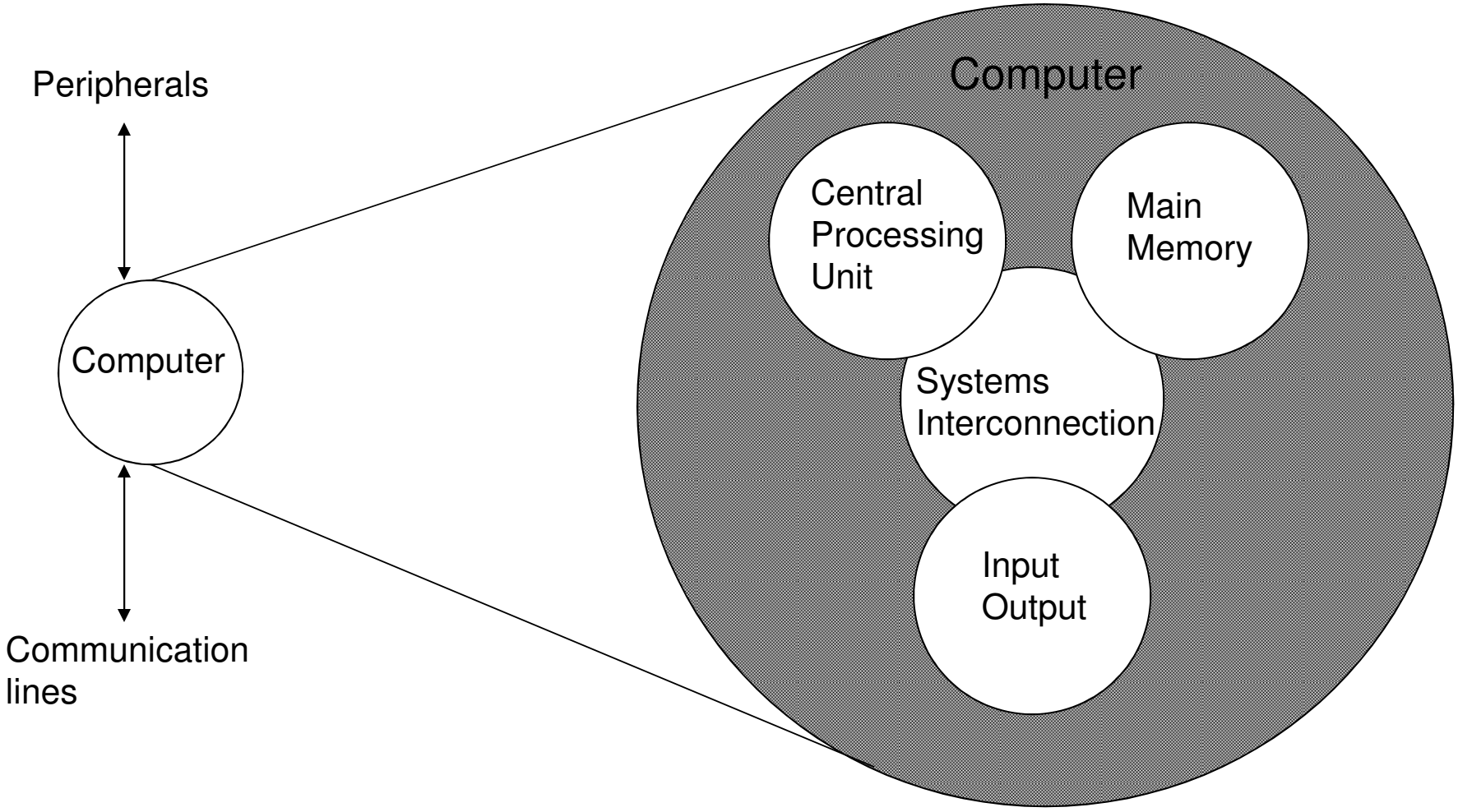
Operation (c) Processing from/to storage



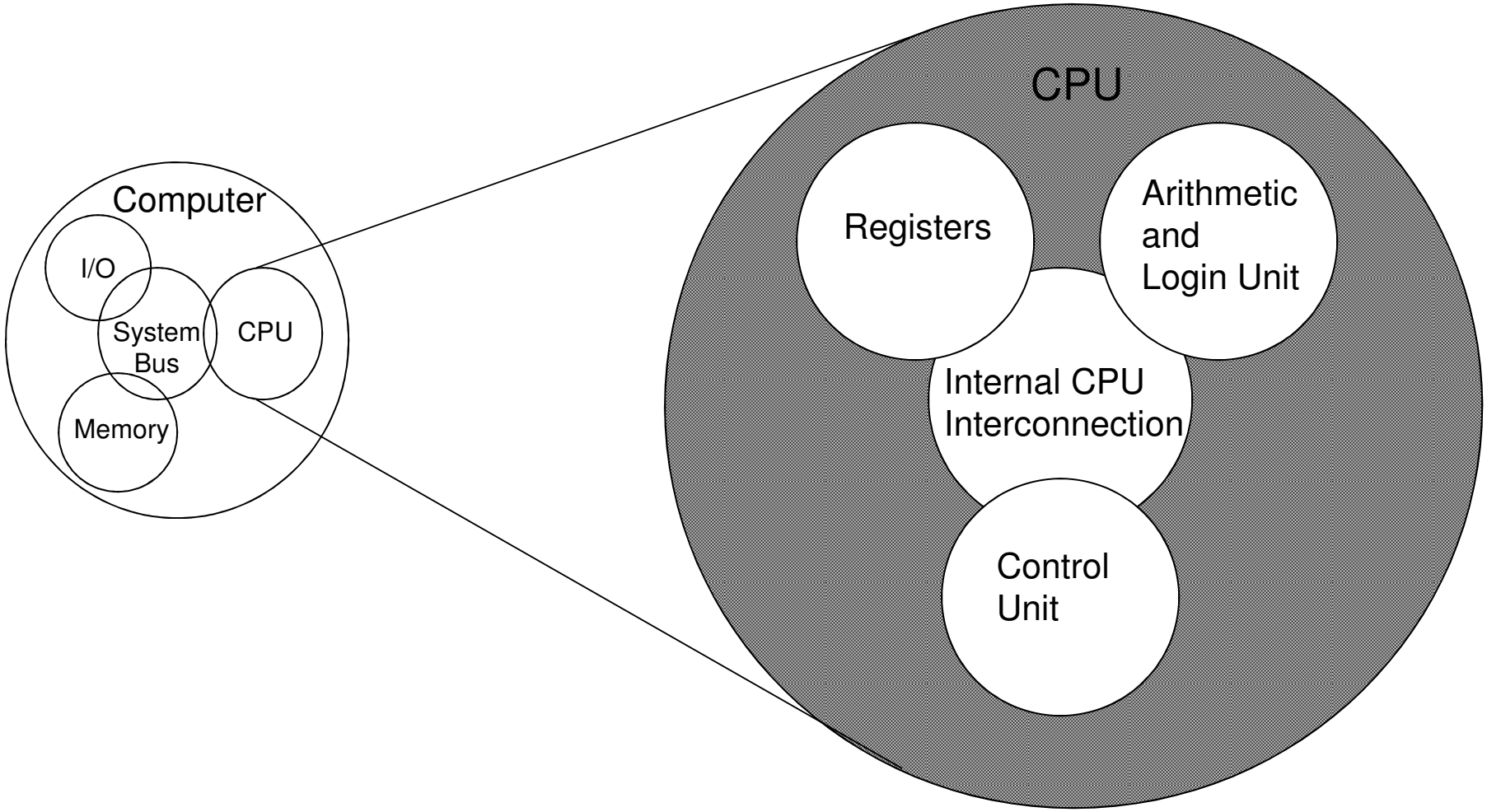
Operation (d)
Processing from storage to I/O



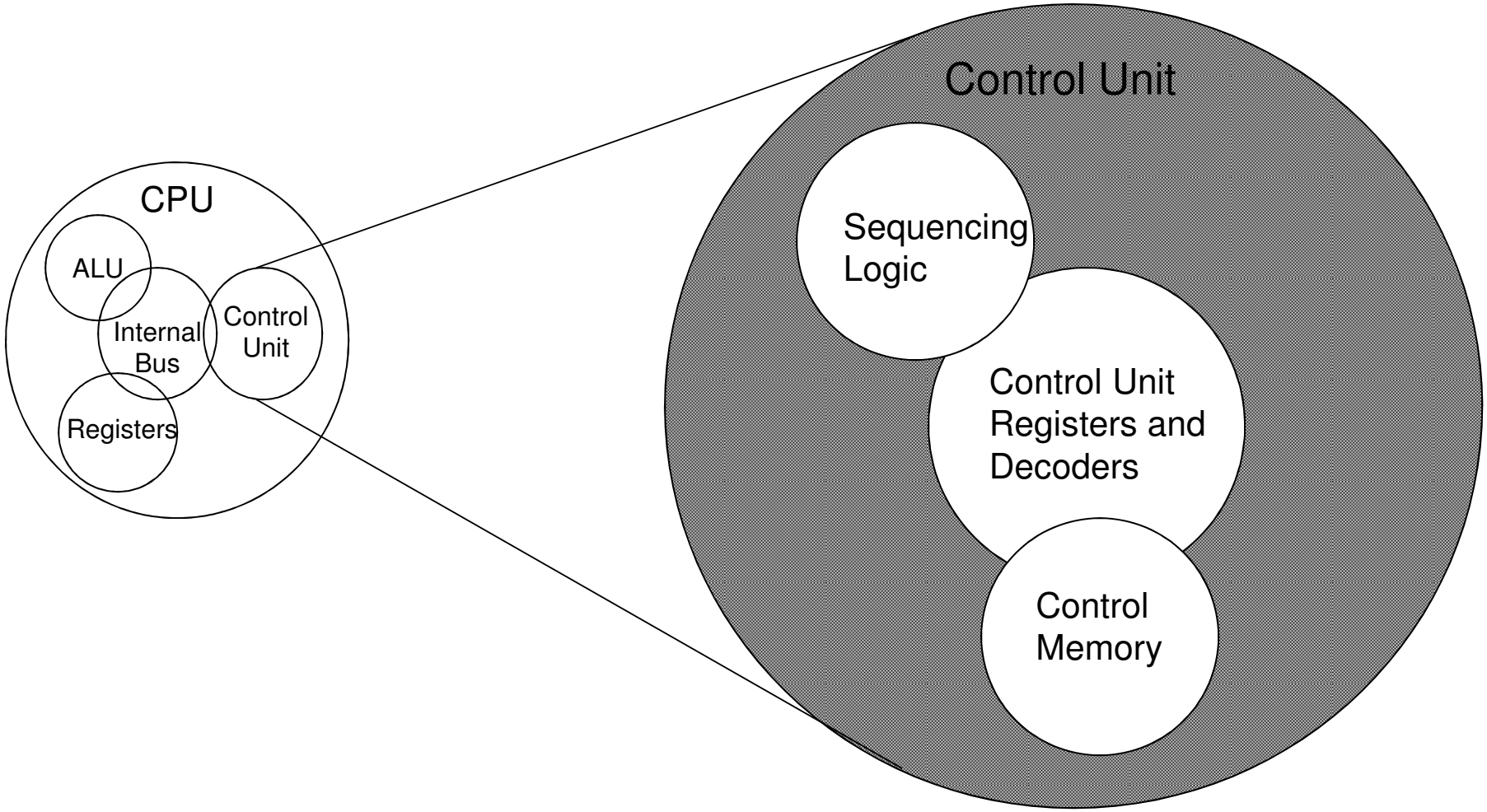
Structure - Top Level



Structure - The CPU



Structure - The Control Unit



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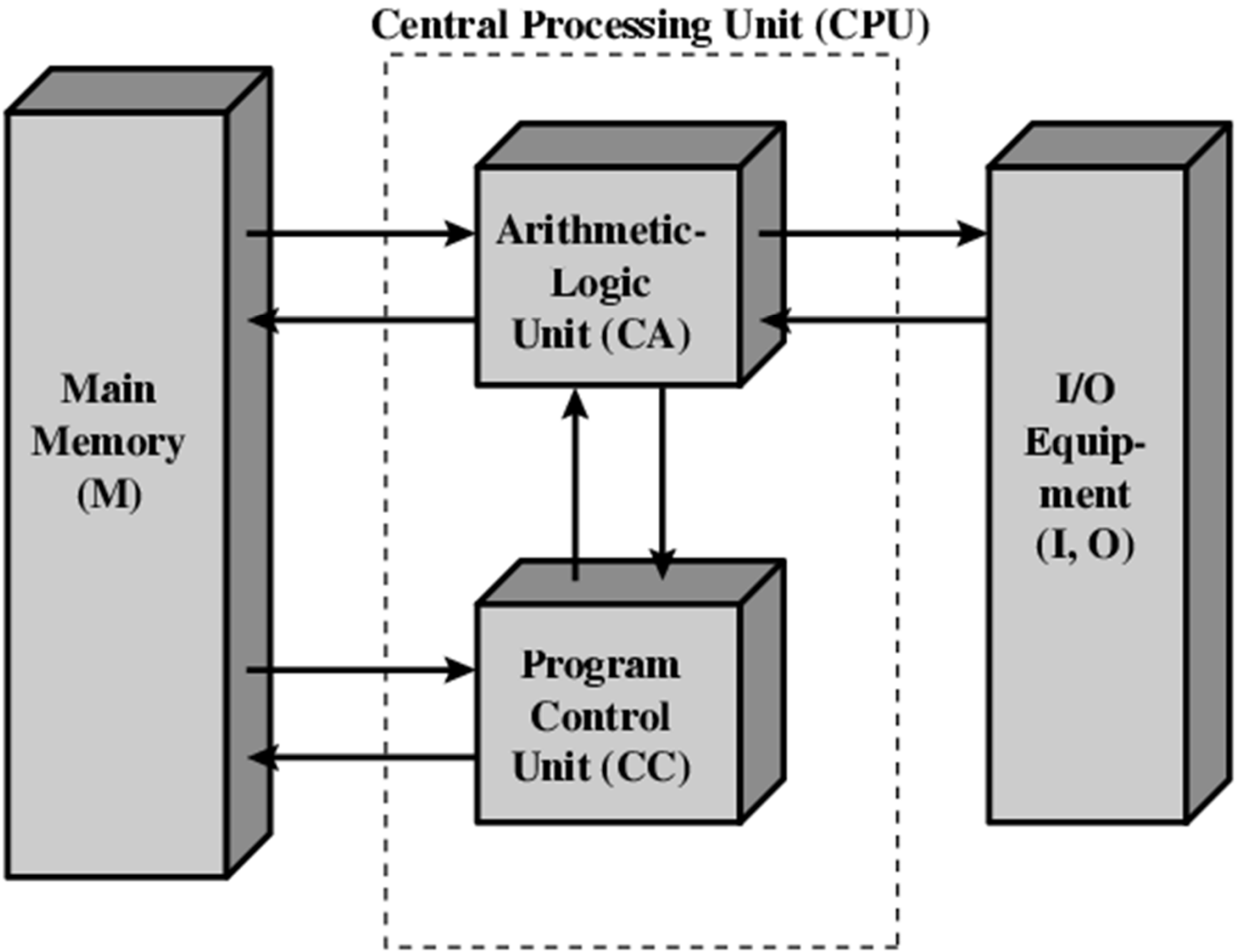
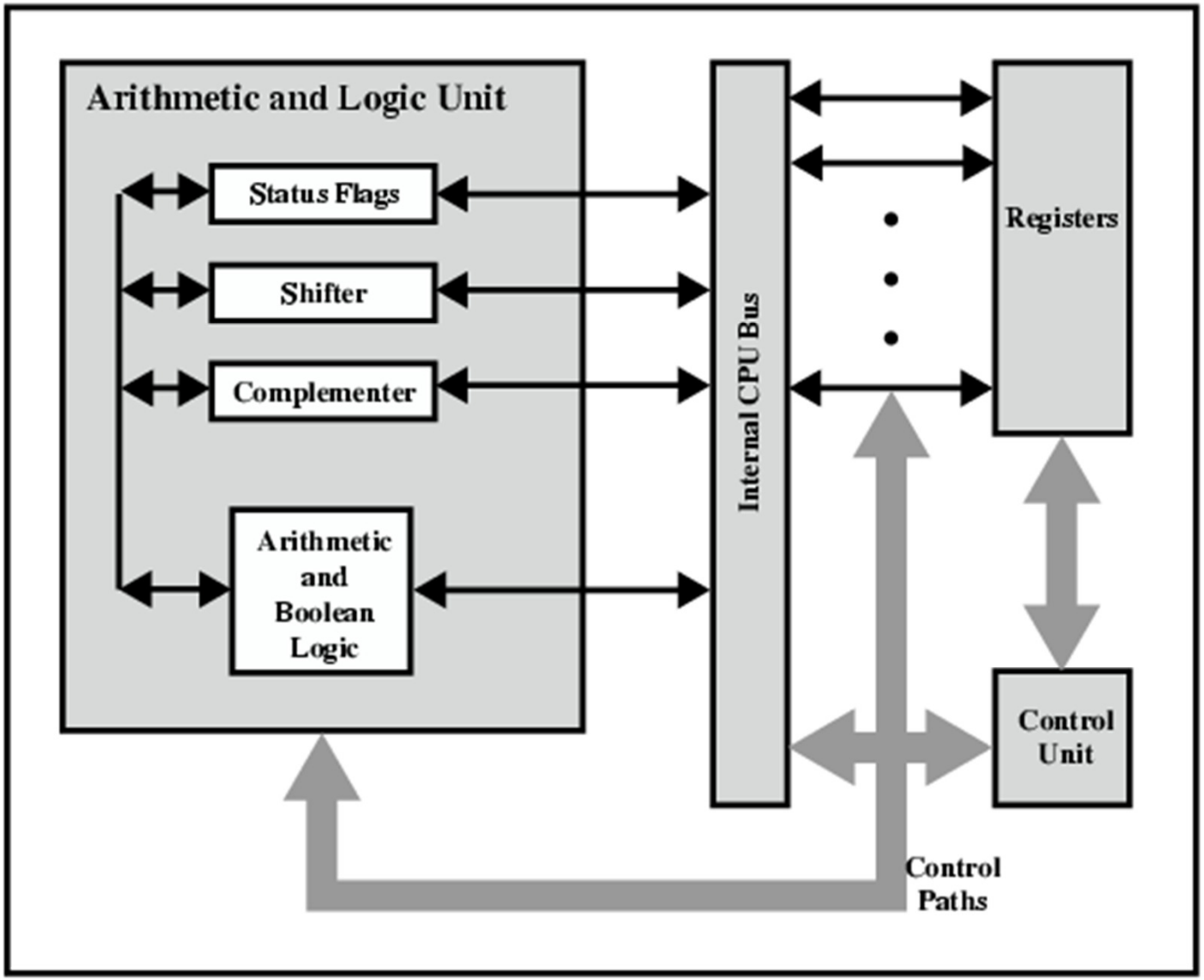


CPU Internal Structure

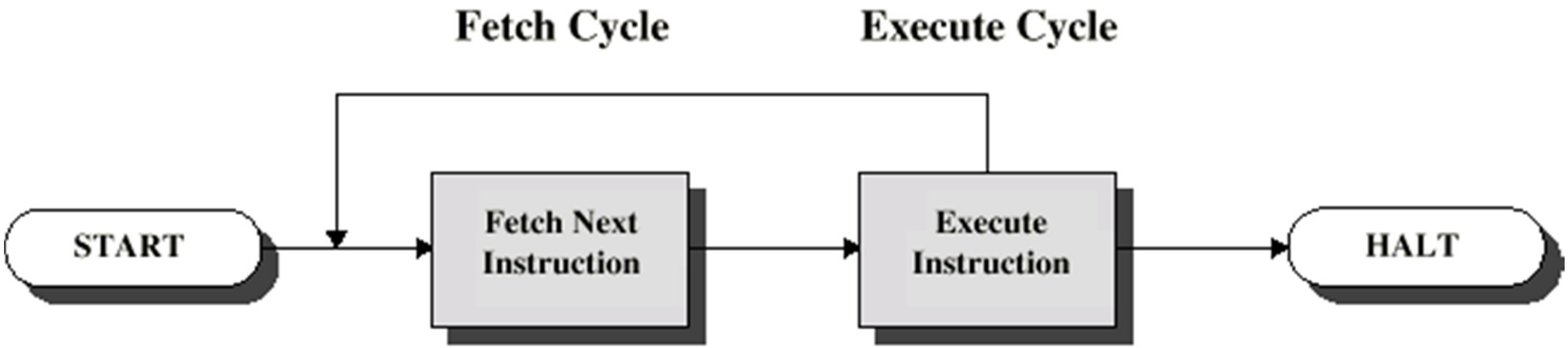


What is a program?

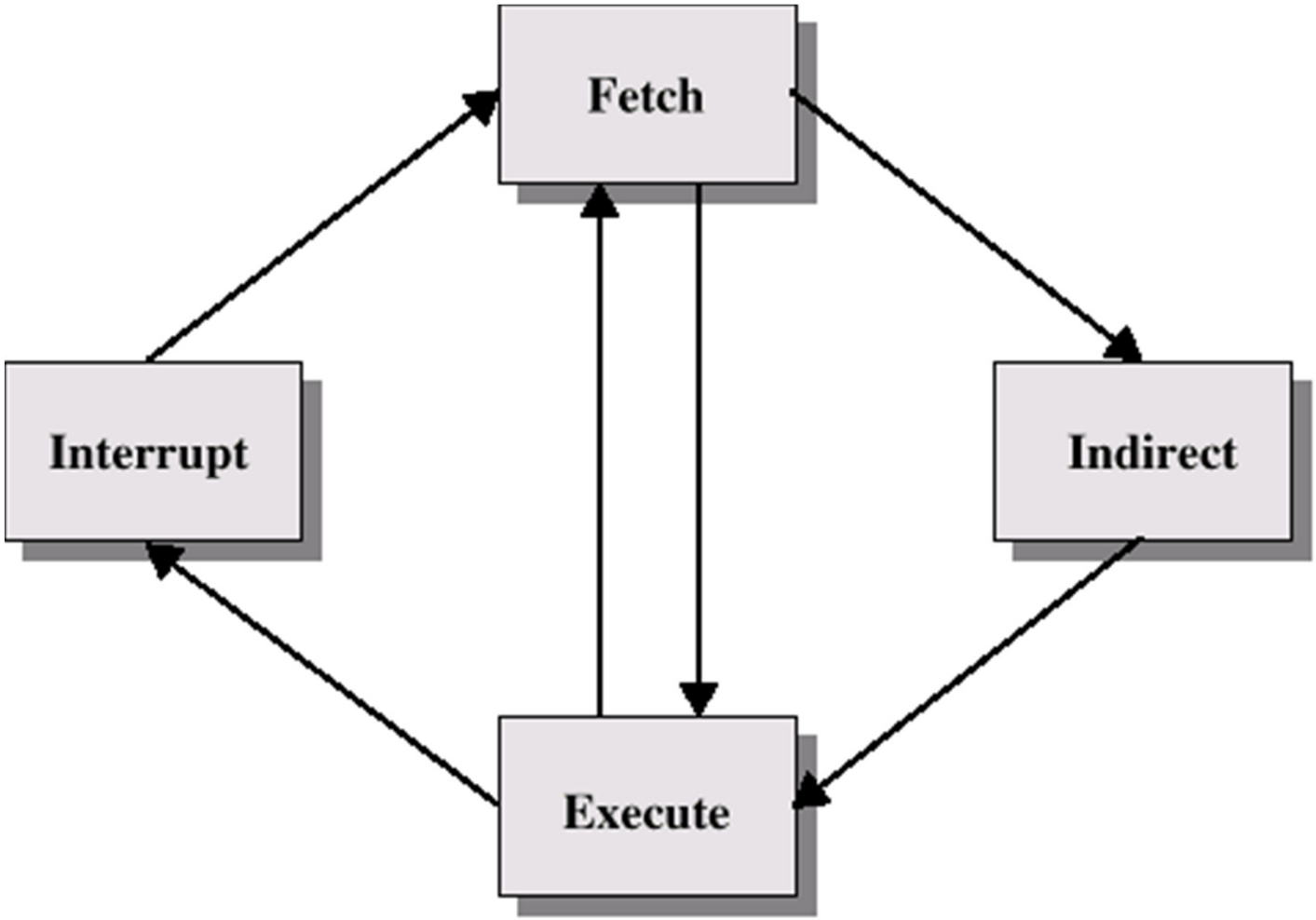
- A sequence of steps
- For each step, an arithmetic or logic operation is done
- For each operation, a different set of control signals is needed

Instruction Cycle

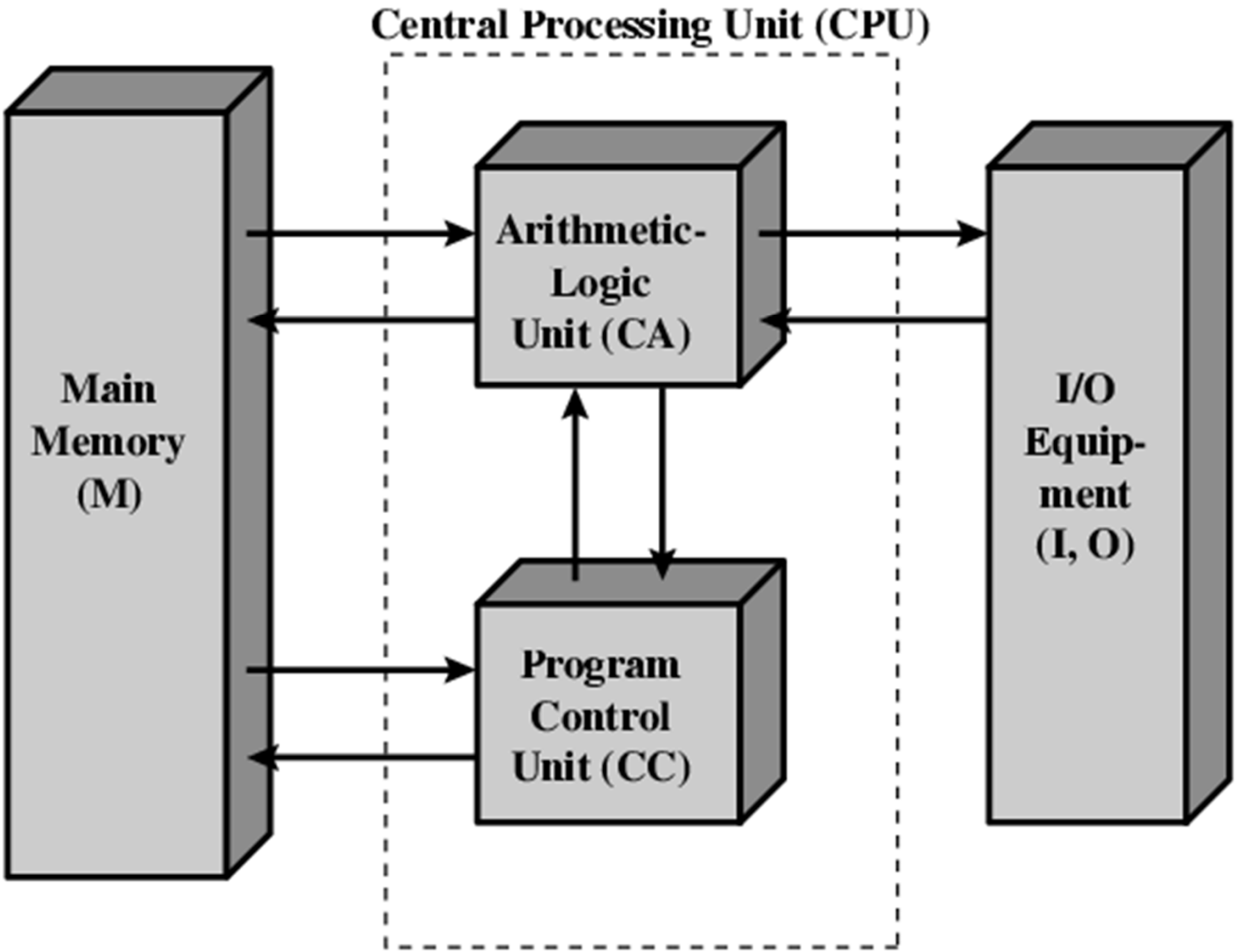
- Two steps:
  - Fetch
  - Execute



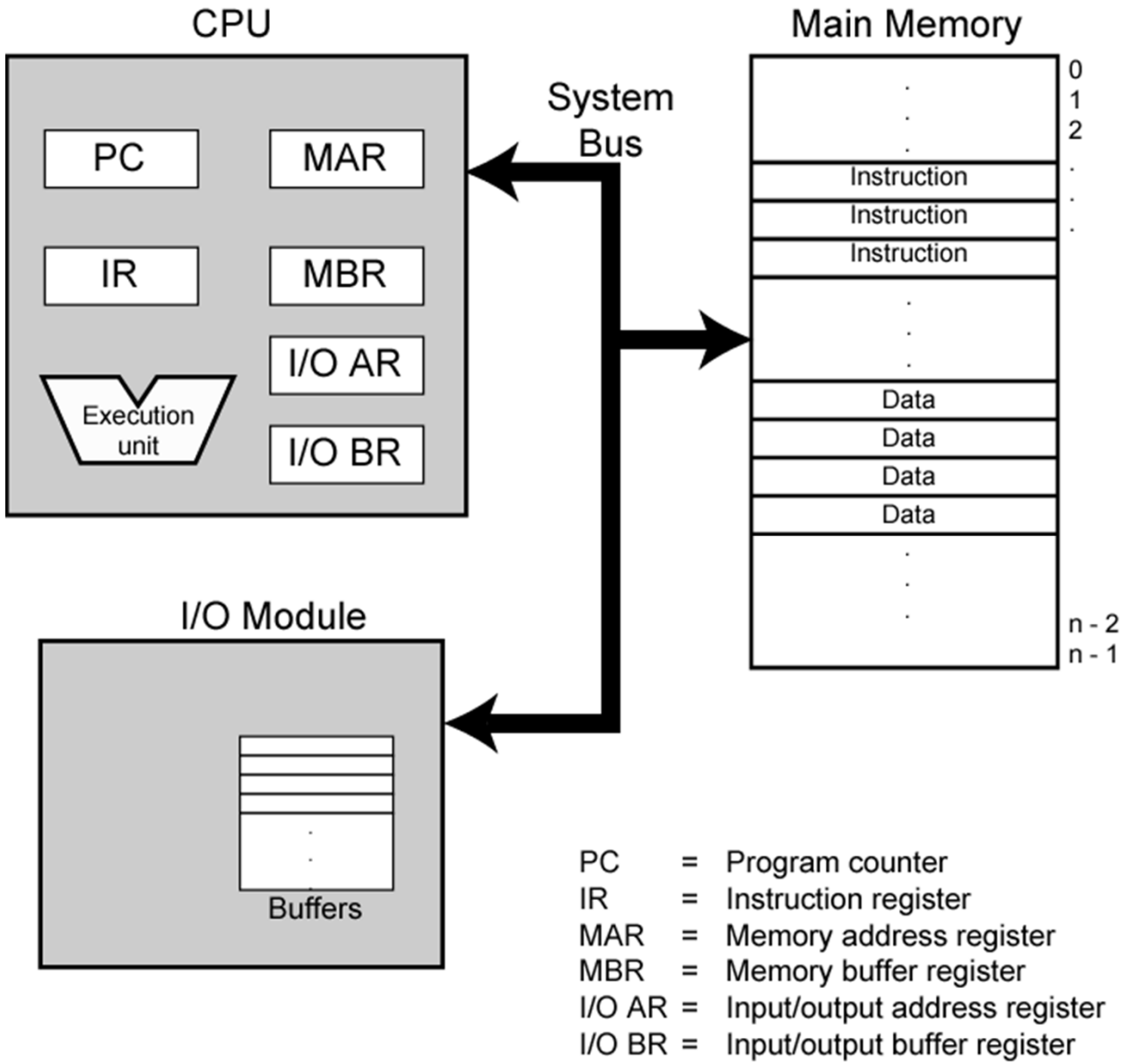
Instruction Cycle with Indirect



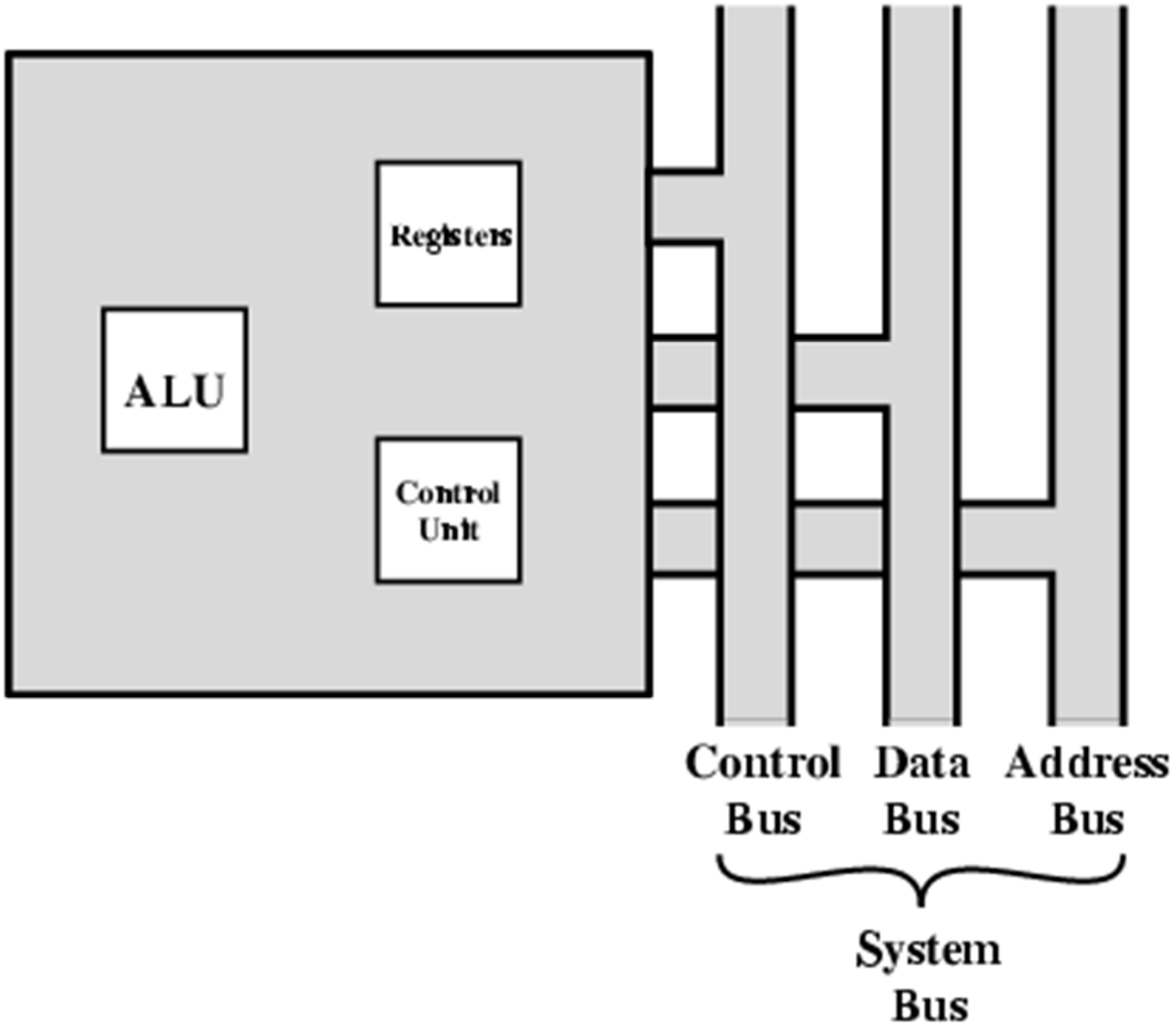
Structure of Von Neumann machine



Computer Components: Top Level View



CPU With Systems Bus



Data Bus and Address Bus

- Size of Address Bus:

SIZE	BINARY	DEC	HEXA	
8	0000 0000	0	00	
8	1111 1111	255	FF	
8	0101 0111	87	57	
8	0000 0110	6	06	
10	11 1111 1111	1023	3FF	
12	1111 1111 1111	4095	FFF	
16	1111 1111 1111 1111	2^{16} -1	FFFF	
20	1111 1111 1111 1111 1111	2^{20} -1	FFFFF	
30	11 1111	2^{30} -1	3FFFFFFF	
32	1111 1111	2^{32} -1	FFFFFFFF	

Data Bus and Address Bus

- Size of Address Bus and Memory Capacity:

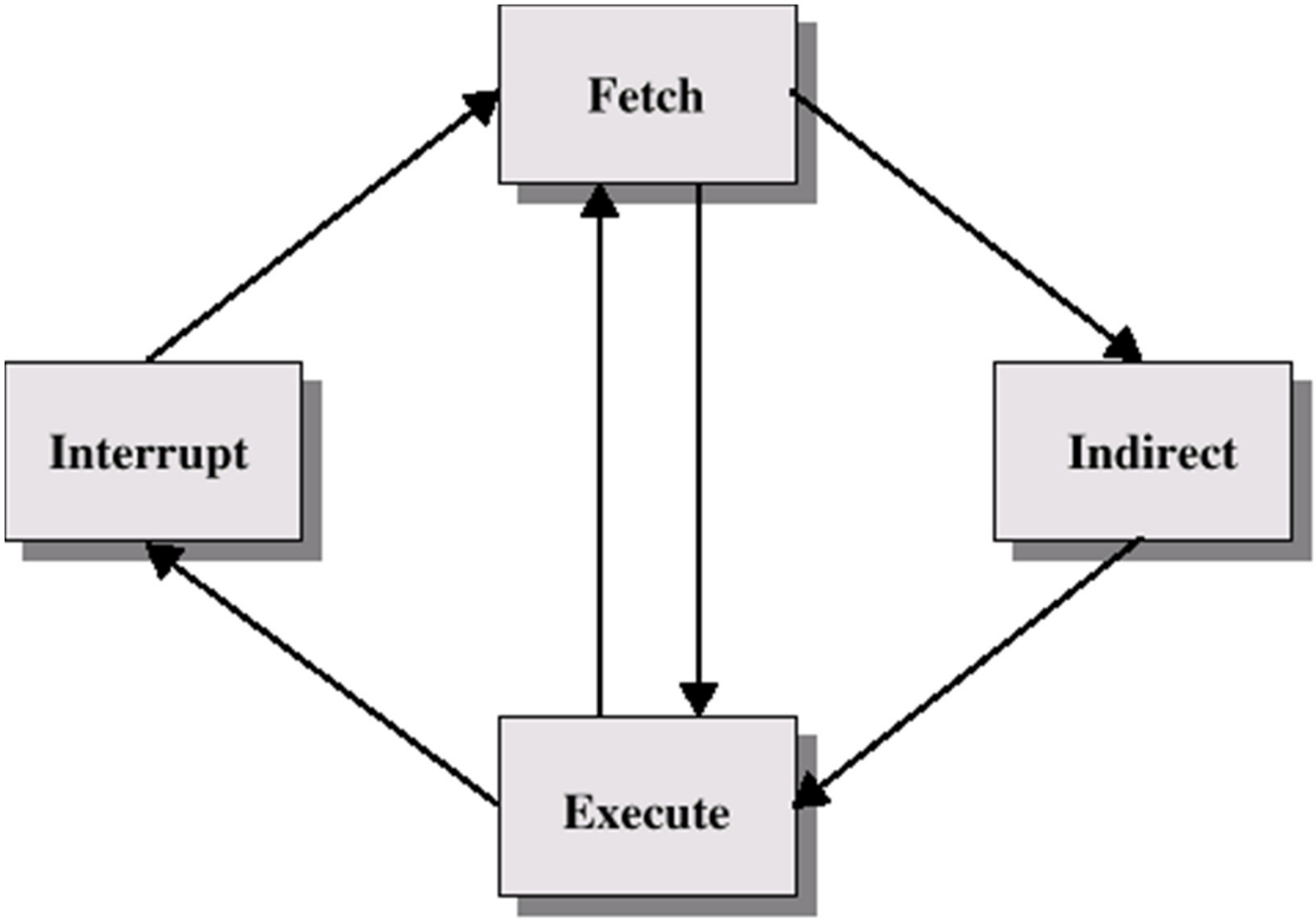
SIZE	BINARY	DEC	HEXA	
8	0000 0000	0	00	
8	1111 1111	255	FF	256
10	11 1111 1111	1023	3FF	1K
12	1111 1111 1111	4095	FFF	4K
16	1111 1111 1111 1111	2^{16} -1	FFFF	64K
20	1111 1111 1111 1111 1111	2^{20} -1	FFFFF	1M
30	11 1111	2^{30} -1	3FFFFFFF	1G
32	1111 1111	2^{32} -1	FFFFFFFF	4G

Data Bus and Address Bus

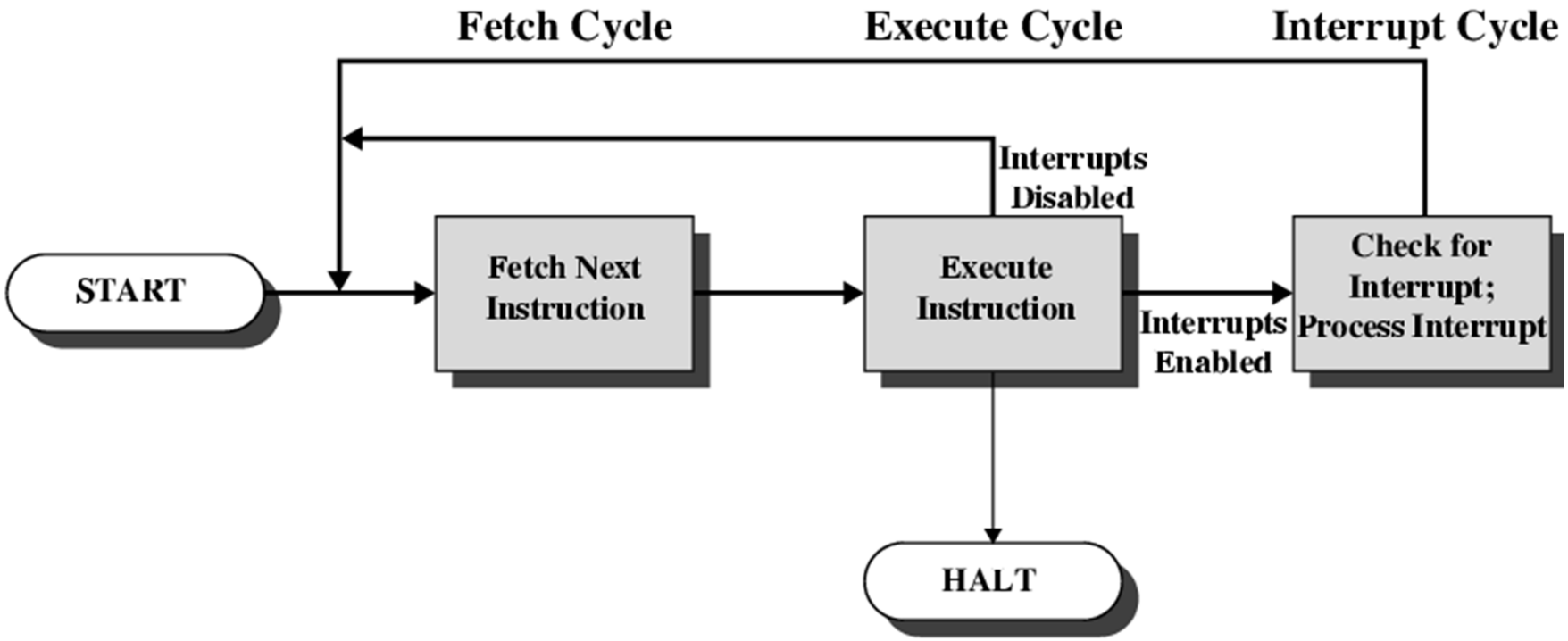
- Size of Data Bus/Memory Location:

SIZE	BINARY	DEC	HEXA
8	1111 1111 0111 1111	-127 +127	00 - FF
12	1111 1111 1111 0111 1111 1111	-2047 +2047	000 - FFF
16	1111 1111 1111 1111 0111 1111 1111 1111	$-(2^{15} - 1)$ $+(2^{15} - 1)$	0000- FFFF
20	1111 1111 1111 1111 1111 0111 1111 1111 1111 1111	$-(2^{19} -1)$ $+(2^{19} -1)$	00000 - FFFFF
32	1111 .....1111 0111 1111	$-(2^{31} -1)$ $+(2^{31} -1)$	00000000 – FFFFFFFF

Instruction Cycle with Indirect



Instruction Cycle with Interrupts



Indirect Cycle

- May require memory access to fetch operands
- Indirect addressing requires more memory accesses
- Can be thought of as additional instruction subcycle

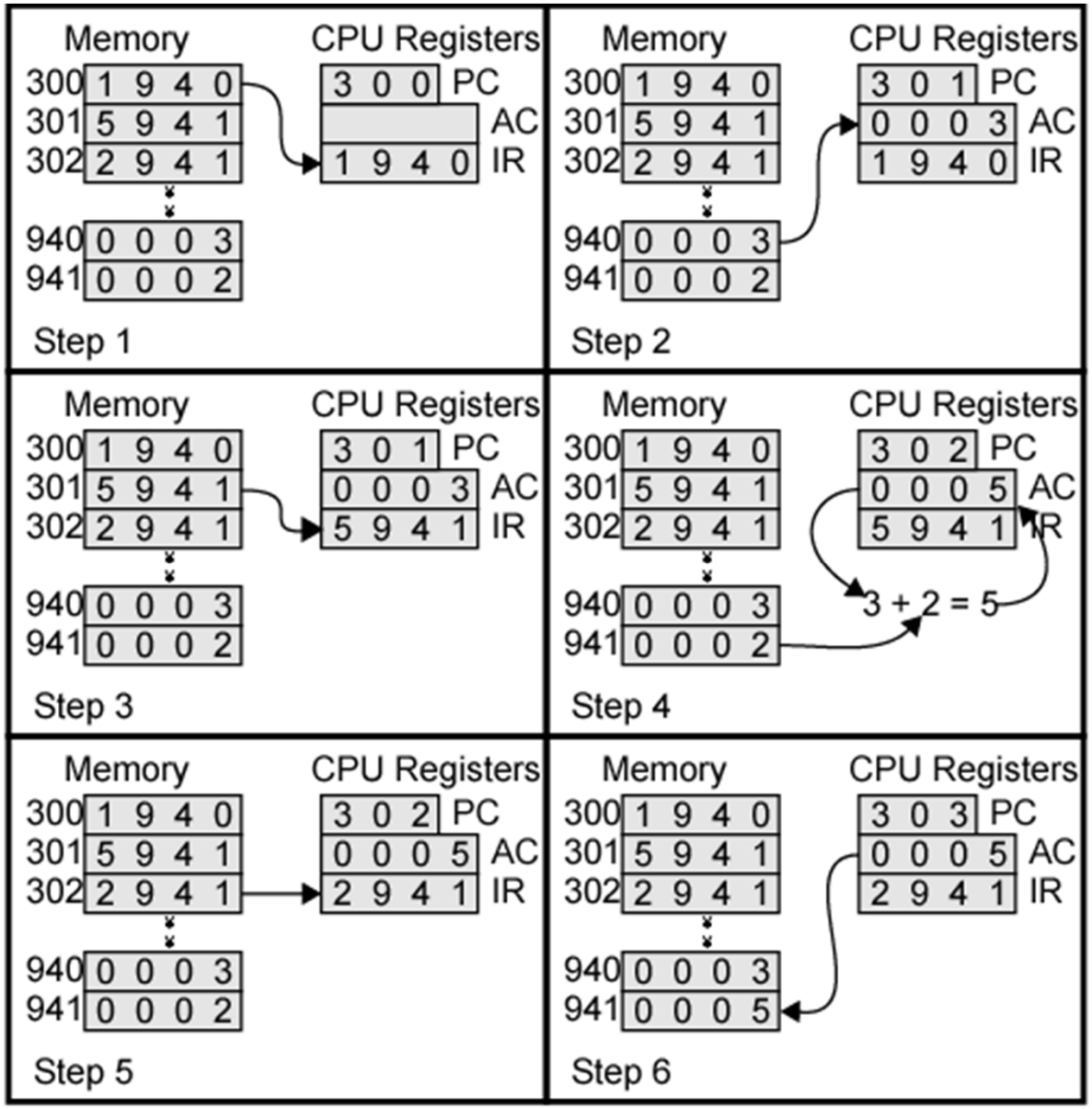
Fetch Cycle

- Program Counter (PC) holds address of next instruction to fetch
- Processor fetches instruction from memory location pointed to by PC
- Increment PC
  - Unless told otherwise
- Instruction loaded into Instruction Register (IR)
- Processor interprets instruction and performs required actions

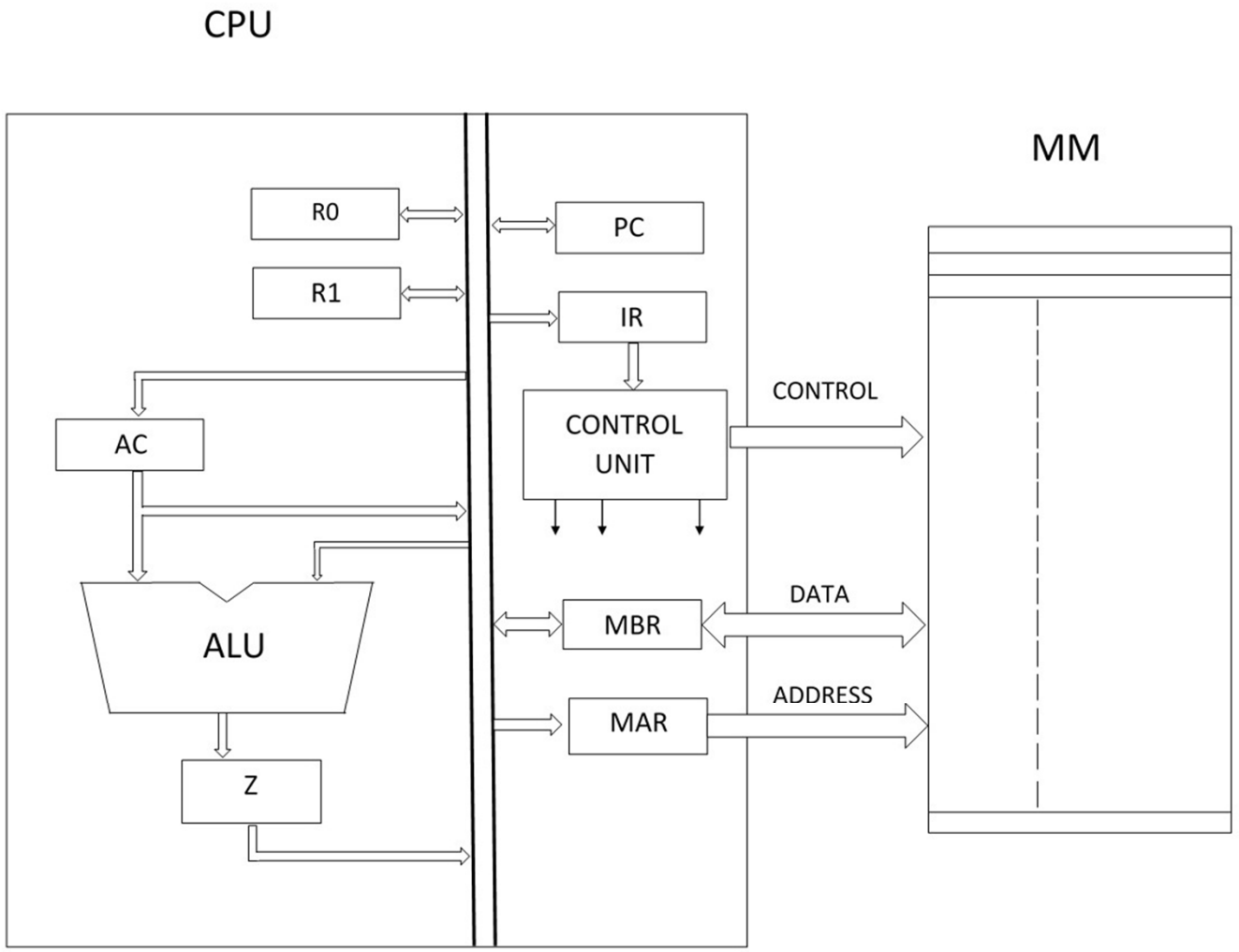
Execute Cycle

- Processor-memory
  - —data transfer between CPU and main memory
- Processor I/O
  - —Data transfer between CPU and I/O module
- Data processing
  - —Some arithmetic or logical operation on data
- Control
  - —Alteration of sequence of operations
  - —e.g. jump
- Combination of above

Example of Program Execution



CPU Organization



Machine Instruction

Machine	Instruction Format				Assembly
Instruction	Operation	Address			Code
1940	0001	1001	0100	0000	LDA M
5941	0101	1001	0100	0001	ADD M
2941	0010	1001	0100	0001	STA M

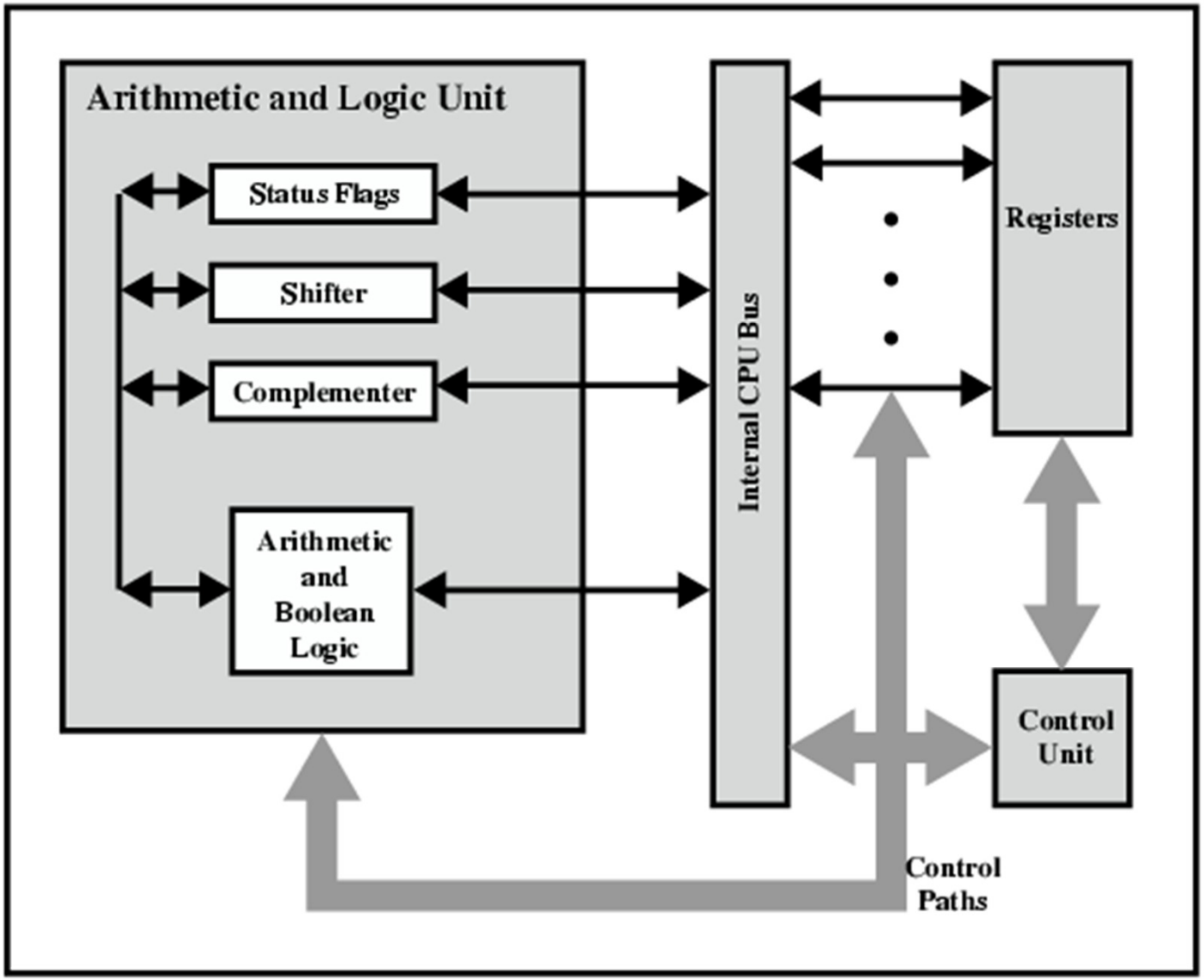
(LDA M) LOAD AC: Load the accumulator by the contents of memory location specified in the instruction

(ADD M) ADD AC: Add the contents of memory location specified in the instruction to accumulator and store the result in accumulator

(STA M) STORE AC: Store the contents of accumulator the memory location specified in the instruction

High Level Code	Assembly Code	Machine Code (HEX)
Y = X + Y	LDA X ADD Y STA Y	1940 5941 2941

CPU Internal Structure



Registers

- CPU must have some working space (temporary storage)
- Called registers
- Number and function vary between processor designs
- One of the major design decisions
- Top level of memory hierarchy

User Visible Registers

- General Purpose
- Data
- Address
- Condition Codes

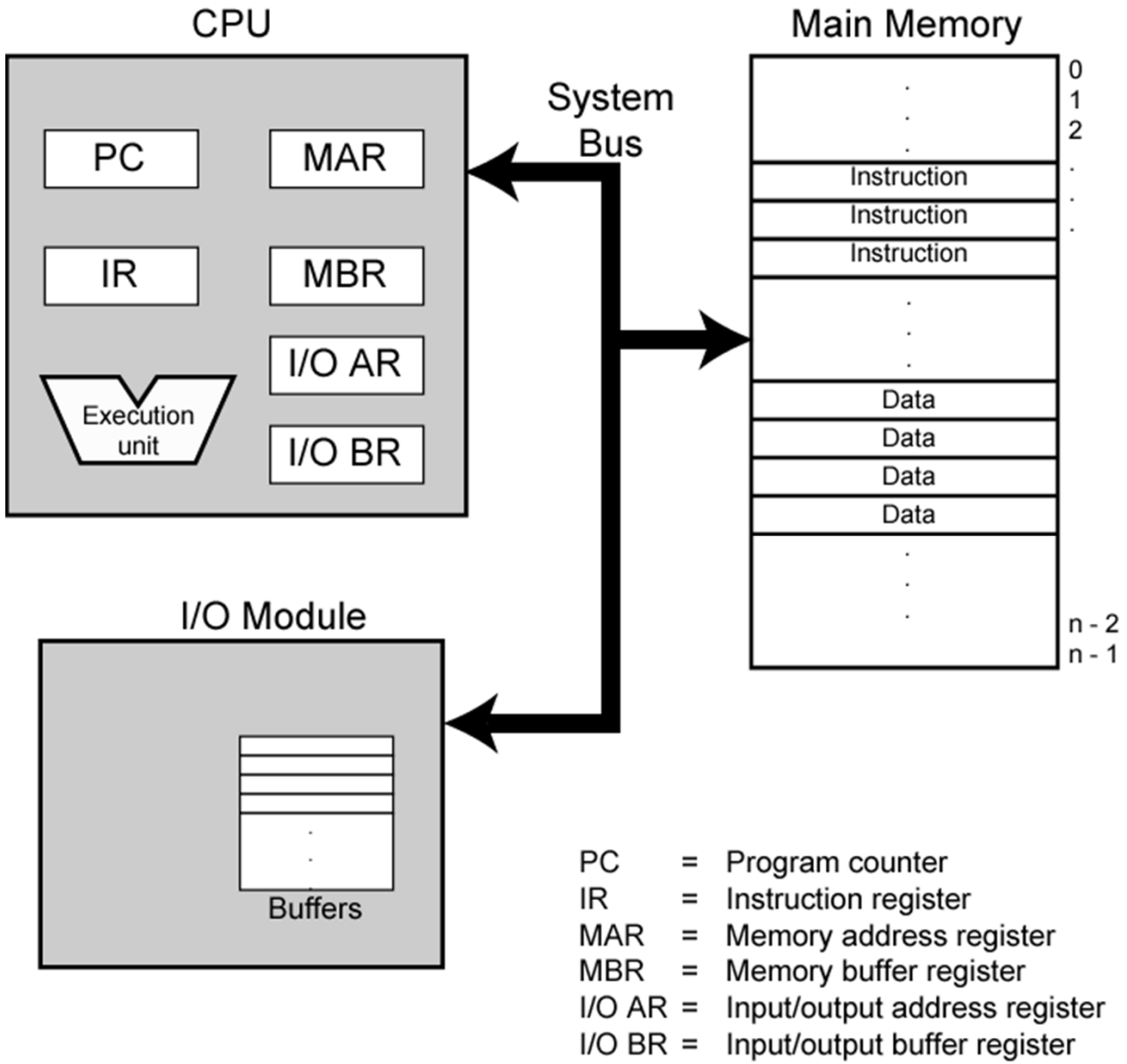
How Many GP Registers?

- Between 8 - 32
- Fewer = more memory references
- More does not reduce memory references and takes up processor space
- Large enough to hold full address
- Large enough to hold full word
- Often possible to combine two data registers
  - C programming
  - double int a;
  - long int a;

Control & Status Registers

- Program Counter
- Instruction Decoding Register
- Memory Address Register
- Memory Buffer Register

Computer Components: Top Level View



Condition Code Registers

- Sets of individual bits
  - —e.g. result of last operation was zero
- Can be read (implicitly) by programs
  - —e.g. Jump if zero
- Can not (usually) be set by programs
- Needs for conditional instructions

Program Status Word

- A set of bits
- Includes Condition Codes
- Sign of last result
- Zero
- Carry
- Equal
- Overflow
- Interrupt enable/disable
- Supervisor

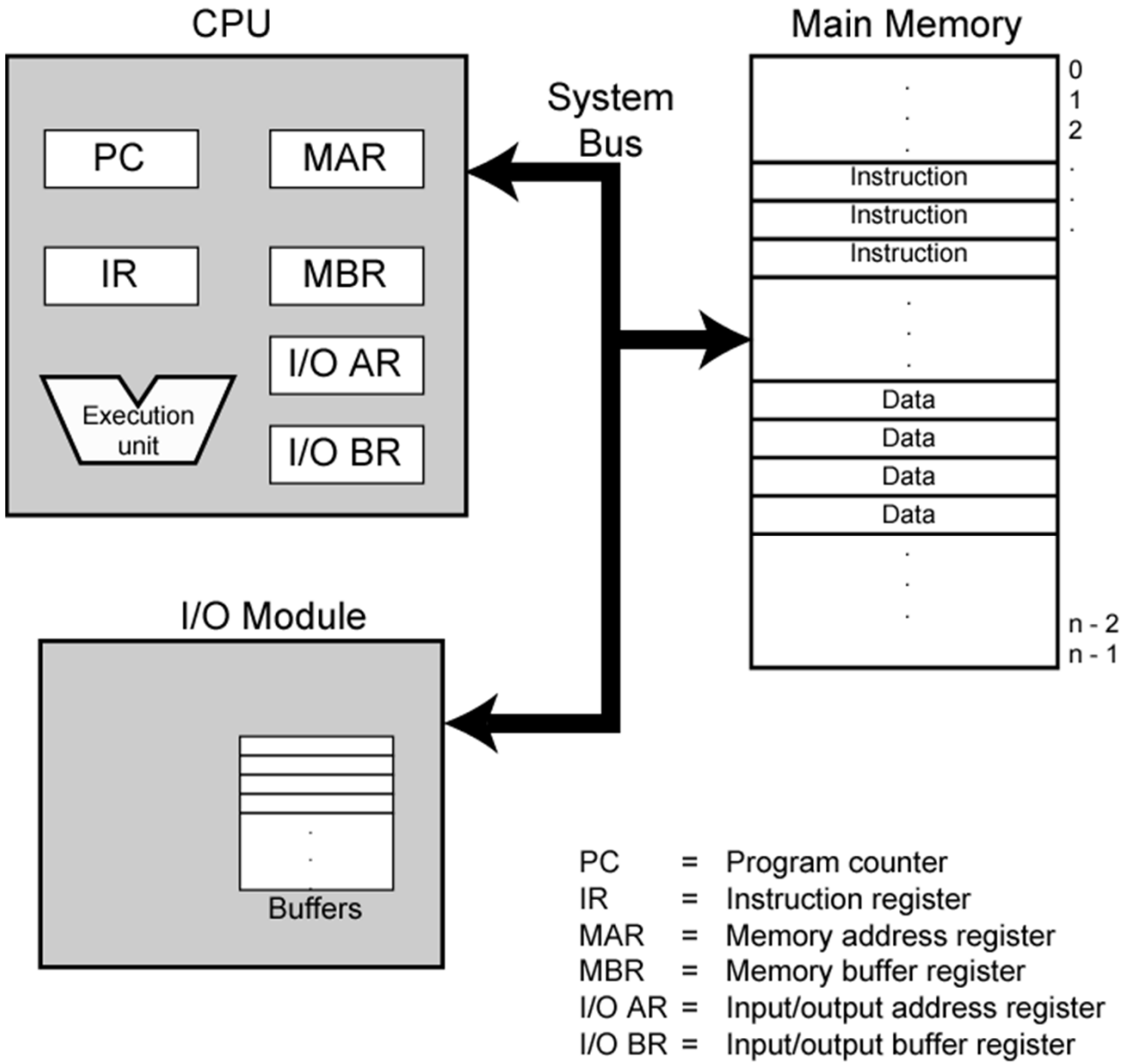
Function of Control Unit

- For each operation a unique code is provided
  - —e.g. ADD, MOVE
- A hardware segment accepts the code and issues the control signals

Components

- The Control Unit and the Arithmetic and Logic Unit constitute the Central Processing Unit
- Data and instructions need to get into the system and results out
  - Input/output
- Temporary storage of code and results is needed
  - Main memory

Computer Components: Top Level View



Connecting

- All the units must be connected
- Different type of connection for different type of unit
  - Memory
  - Input/Output
  - CPU

Memory Connection

- Receives and sends data
- Receives addresses (of locations)
- Receives control signals
  - Read
  - Write
  - Timing

Input/Output Connection(1)

- Similar to memory from computer's viewpoint
- Output
  - —Receive data from computer
  - —Send data to peripheral
- Input
  - —Receive data from peripheral
  - —Send data to computer

What is a Bus?

- A communication pathway connecting two or more devices
- Usually broadcast
- Often grouped
  - —A number of channels in one bus
  - —e.g. 32 bit data bus is 32 separate single bit channels

Data Bus

- Carries data
  - Remember that there is no difference between "data" and "instruction" at this level
- Width is a key determinant of performance
  - 8, 16, 32, 64 bit

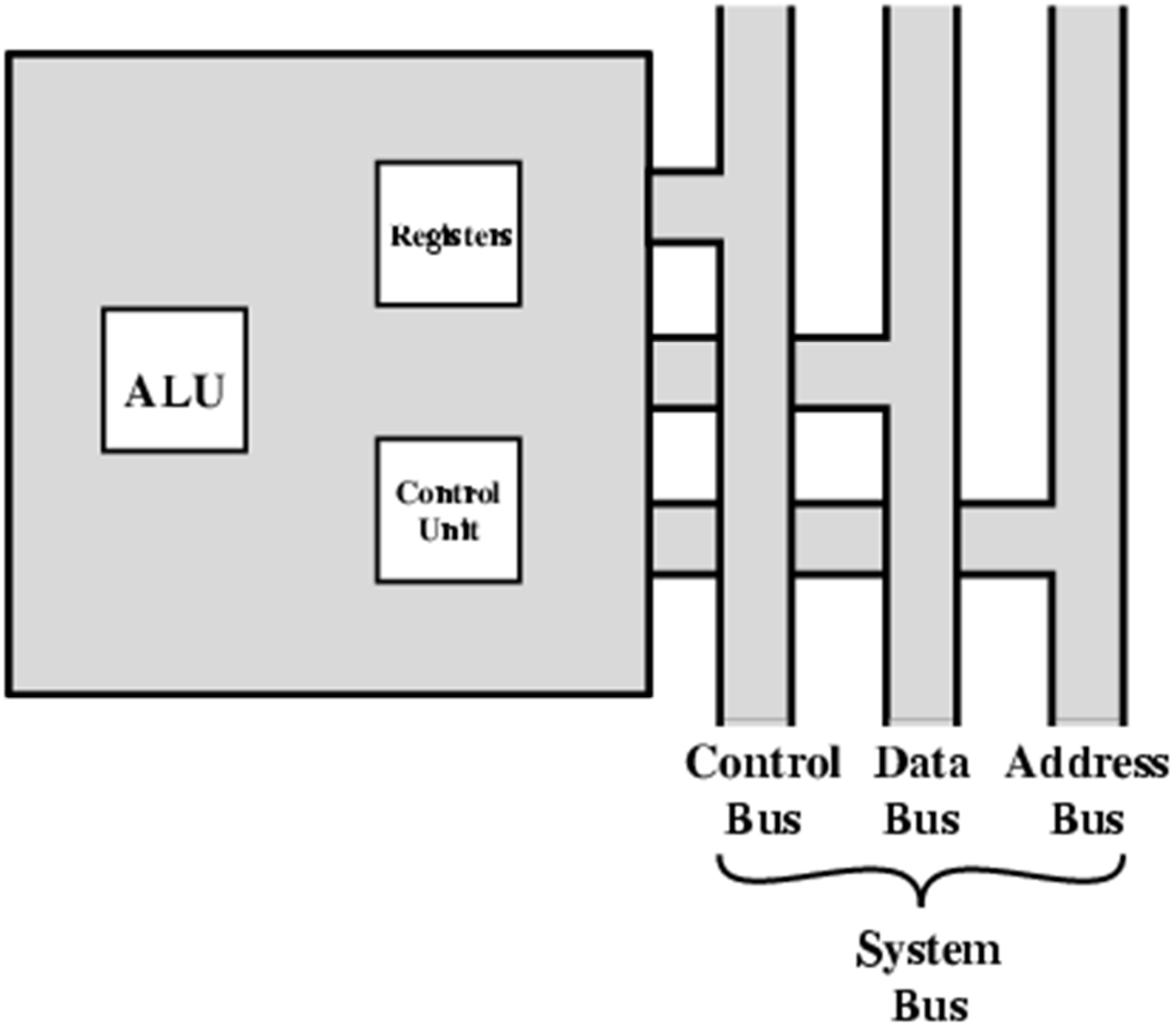
Address bus

- Identify the source or destination of data
- e.g. CPU needs to read an instruction (data) from a given location in memory
- Bus width determines maximum memory capacity of system
  - e.g. 8080 has 16 bit address bus giving 64k address space

Control Bus

- Control and timing information
  - Memory read/write signal
  - Interrupt request
  - Clock signals

CPU With Systems Bus



Program Concept

- Hardwired systems are inflexible
- General purpose hardware can do different tasks, given correct control signals

Program Concept

- Operating Systems
  - Viewed as an Extended Machine

What is a program?

- A sequence of steps
- For each step, an arithmetic or logic operation is done
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