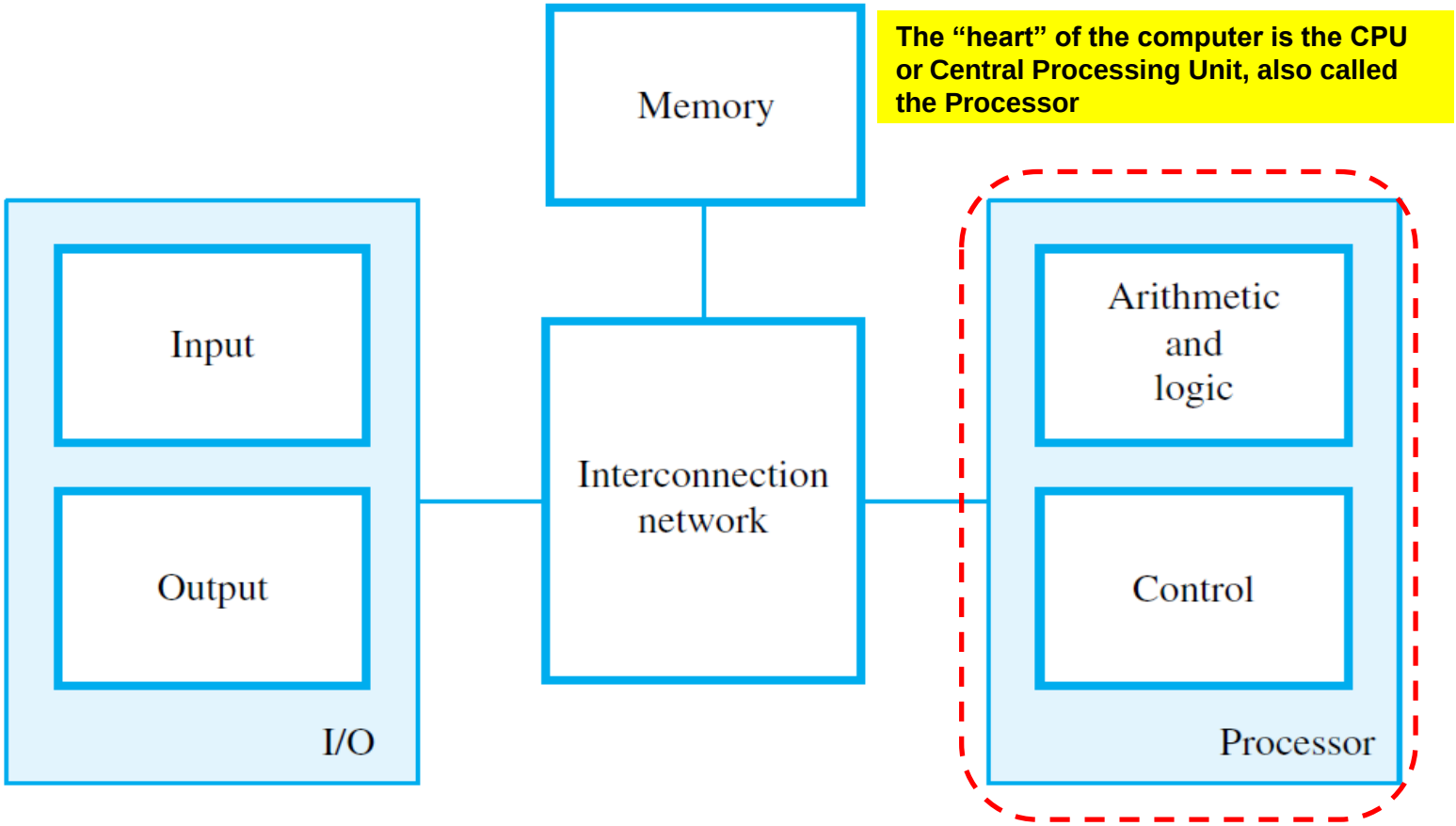
Topic 01B Fetch, Execution and IO

RECAP SUMMARY

ALU and Control



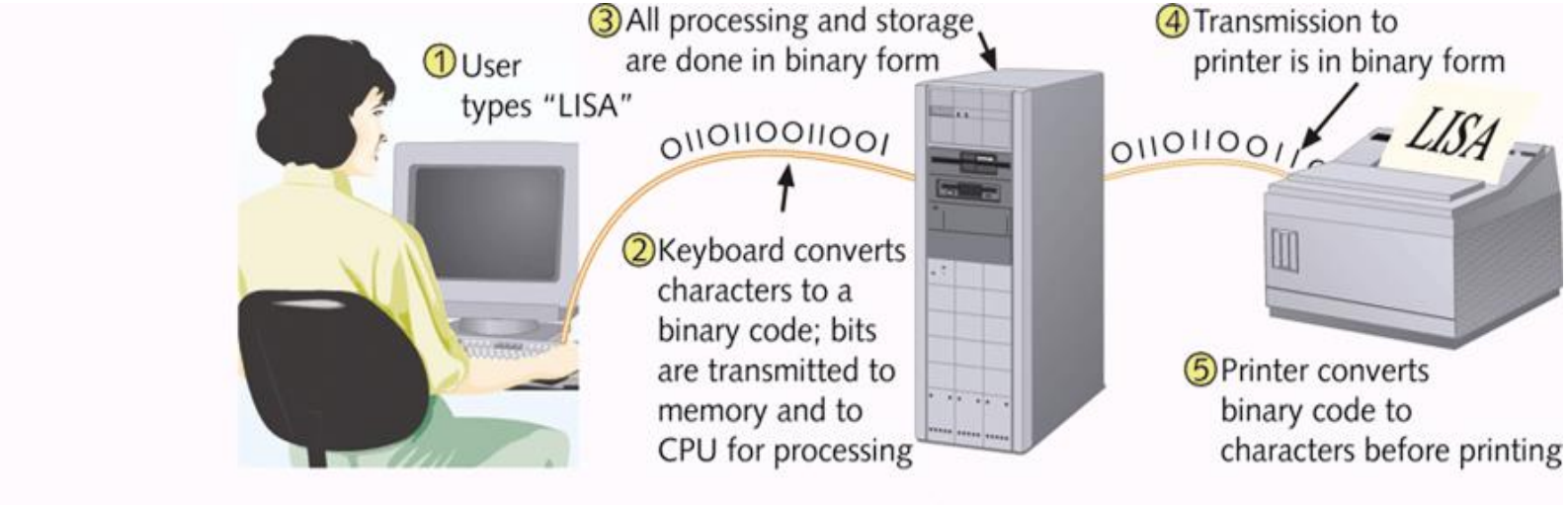
Data Is Stored in Bits

Data on a computer is stored as binary digits ("bits" for short)

- A bit holds a 1 or 0 value
  - A pulse of 5 volts of electricity can represent a 1 bit and a pulse of 0 volts (the absence of voltage) can represent a 0 bit
  - With fiber-optic cable, a 1 bit is represented by the presence of light and a 0 bit by the absence of light

A "byte" is a collection of 8 bits

Illustration of how information processes



Functional units

Primary memory (also called Main memory)

- Organized into **words (binary)** of typically 32 bits
  - A 32-bit word contains four 8-bit bytes
  - Example: 1010 0101 1111 0001 0101 1011 1001 0110

A personal computer memory might have 4 Gigabytes or more

- 4 Gbyte = $2^2 * 2^{30}$ bytes

Programs and their data must be in this memory to be executed

Functional units

Cache memory

- An adjunct to the main memory, fabricated on the processor chip
- Much smaller and faster than the main memory
- Holds sections of the program and data currently/frequently being executed

Processor

- **Logic circuits** – for performing arithmetic and logic operations on word-size data operands
- **Timing and control circuits** – for fetching program instructions and data from memory, one after another
- **Registers (typically 16 or 32)** – each of which hold one word of operand data

Processor

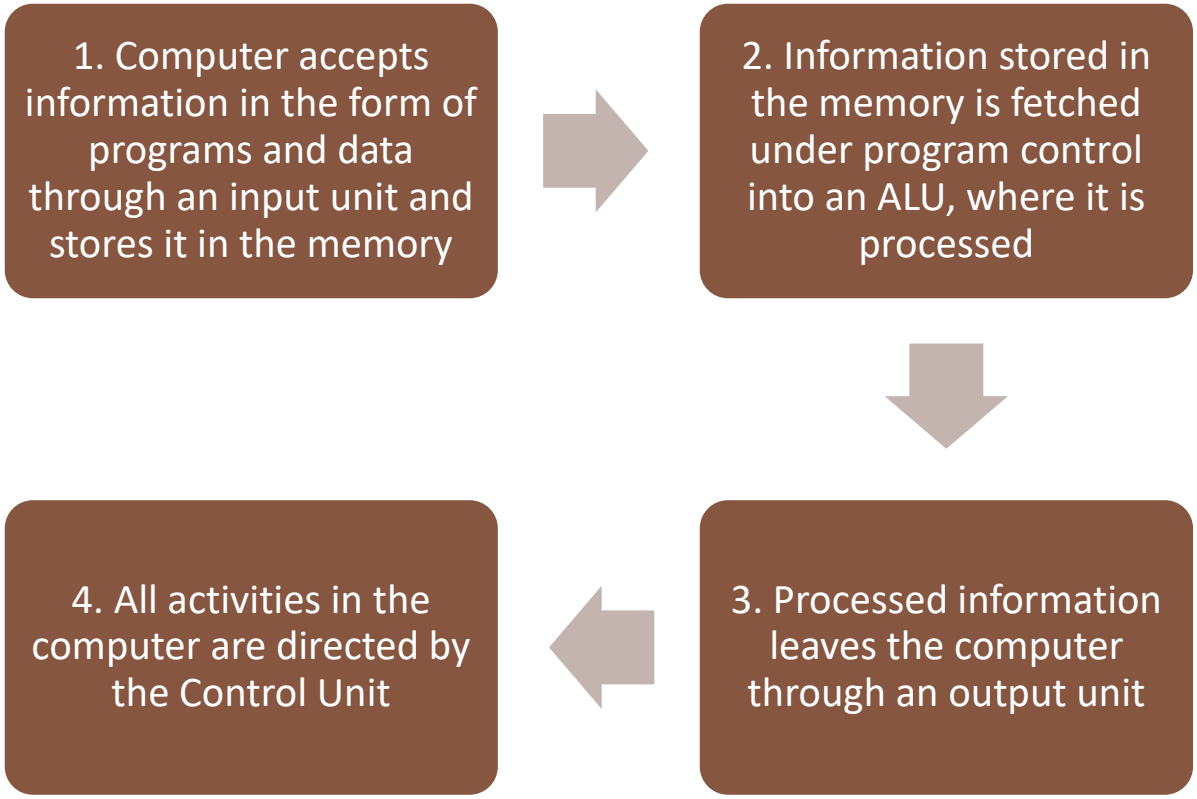
Arithmetic and Logic Unit

- Most computer operations are executed in the ALU of the processor
- Performs arithmetic or logic operation

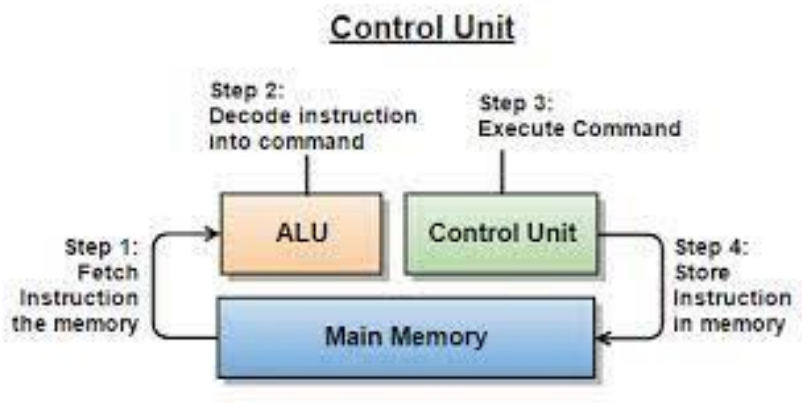
Control Unit

- Memory, ALU and I/O units store and process information and perform input and output operations
- The operation of these units must be coordinated (this is the responsibility of the control unit)

Operation of a computer



Step	Action
1	Fetch an instruction and increment the program counter.
2	Decode the instruction and read registers from the register file.
3	Perform an ALU operation.
4	Store instruction to memory
5	Write the result into the destination register. If needed.



https://freepikpsd.com/control-unit-png-transparent-images/209290/

Instruction cycle operations

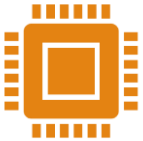
Instructions and Programs

1. An **instruction** specifies an operation and the locations of its data operands
2. A 32-bit word typically holds one encoded instruction
3. A sequence of instructions, executed one after another, constitutes a **program**
4. Both a program and its **data** are stored in the main memory

Instruction types

Load

Read a data operand from memory or an input device into the processor



Store

Write a data operand from a processor register to memory or an output device

Operate

Perform an arithmetic or logic operation on data operands in processor registers

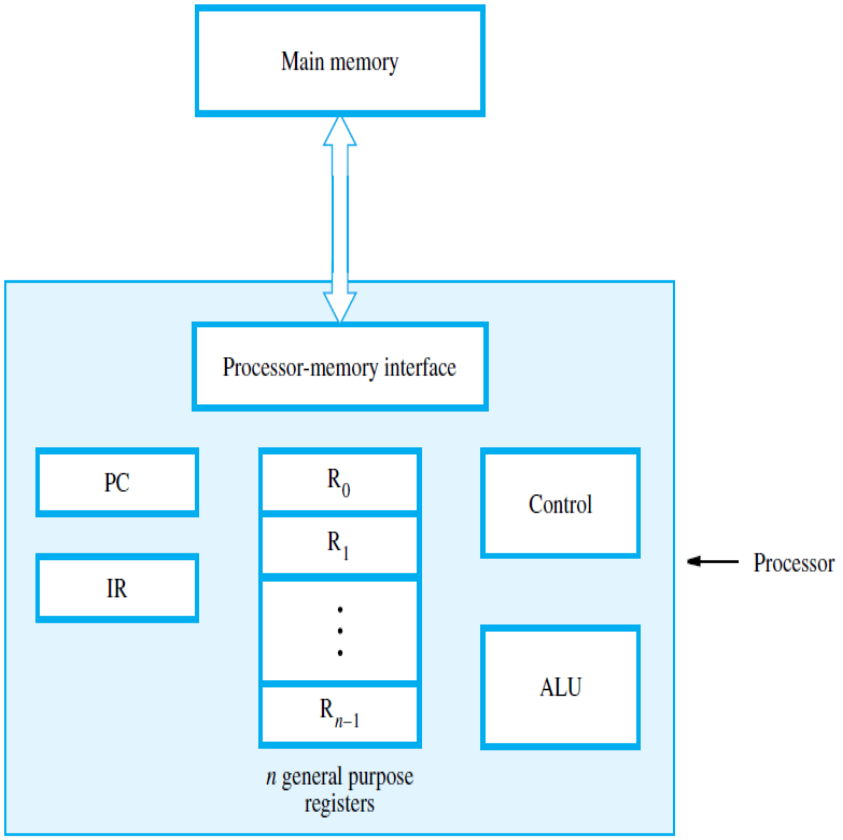
Functional units

The **program counter (PC)** register holds the memory address of the current instruction

The **instruction register (IR)** holds the current instruction

General-purpose registers hold data and addresses

Control circuits and the **arithmetic and logic unit (ALU)** fetch and execute instructions



PC: Program Counter

A program counter is a register in a computer processor that contains the address (location) of the instruction being executed at the current time.

As each instruction gets fetched, the program counter increases its stored value by 1. After each instruction is fetched, the program counter points to the next instruction in the sequence.

When the computer restarts or is reset, the program counter normally reverts to 0.

Handling I/O devices

Read	Write	Sense
Read data (such as a keyboard character) from an input device	Write data (such as letter character) to an output display screen	Sense the readiness of an input or output (I/O) device to perform a transfer

Performance (How quickly can a program be executed ?)

Speed	Access	Design	Number
Speed of electronic circuits in the processor	**Access times** to the cache and main **memory**	Design of the **instruction set**	Number of operations that can be done at the same time (**parallelism**)

Performance - Parallelism

Multicore processors (across multiple cores)

- Multiple processing units can be fabricated on a single chip.
- **core** is used for each of these processors
- the term processor is then used for the complete chip
- **dual-core, quad-core and octo-core** processors for chips