Chapter 1
Basic Structure of Computers

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Contents

1.1 Computer Types

- Computer Types(size, cost, computational power, intended use)
  - Embedded computers
    - Integrated into a larger device or system
    - Automatically monitor and control a physical process or environment
    - For specific purpose

    - Typical Applications
      - Industrial and home automation
      - Appliances, telecommunication products
      - Vehicles

1.1   Computer Types

- Computer Types
  - Personal computers
    - Primarily for dedicated individual use
    - Support a variety of applications
      - General computation
      - Document preparation
      - Computer-aided design
      - Audiovisual entertainment, …
    - Desktop computers, workstation computers, portable and notebook computers
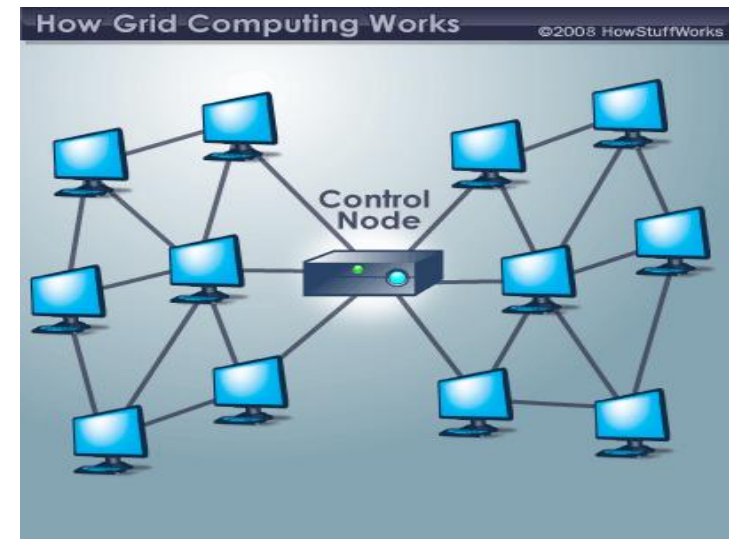
1.1 Computer Types

- Computer Types
  - Server & Enterprise systems
    - Large computers, be shared by a large number of users over a public or private network
    - Contain sizable database storage units
    - Capable of handling large volumes of requests to access the data
    - Business data processing in medium to large corporations, information processing for a government agency,…

1.1 Computer Types

How Grid Computing Works ©2008 HowStuffWorks
Control Node

- Computer Types
  - Supercomputers & Grid computers
    - Offer the highest performance
    - Supercomputers: used for the highly demanding computations, e.g., weather forecasting, engineering design, scientific work.
    - Grid computers: combine a large number of personal computers and disk storage units in a physically distributed high-speed network.

中国超级计算机的发展

- 银河一号(1983)
- 曙光一号(1992)
- 天河一号(2009)
- 天河二号(2014)
- 神威·太湖之光(20
- 天河三号(2018)
- 天河四号(2023)
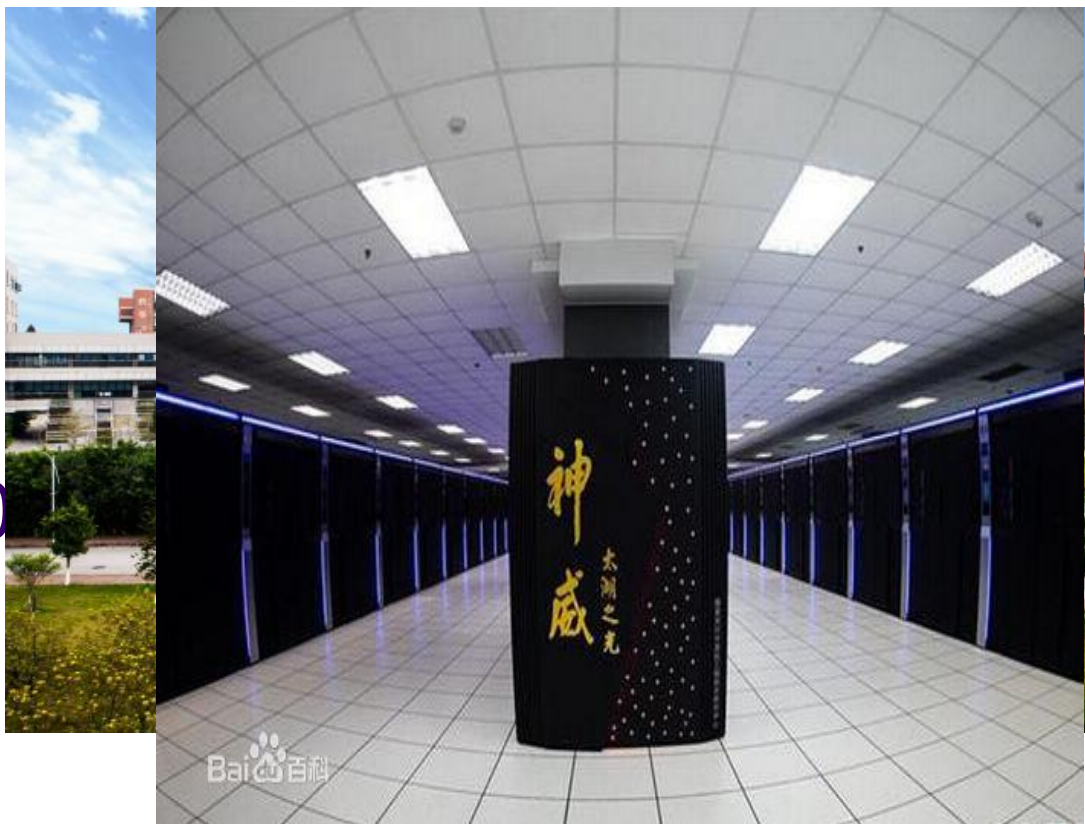
1.1 Computer Types

- Computer Types

  - Cloud Computing

    - Cloud computing is Internet-based computing, whereby shared resources, software and information are provided to computers and other devices on-demand.
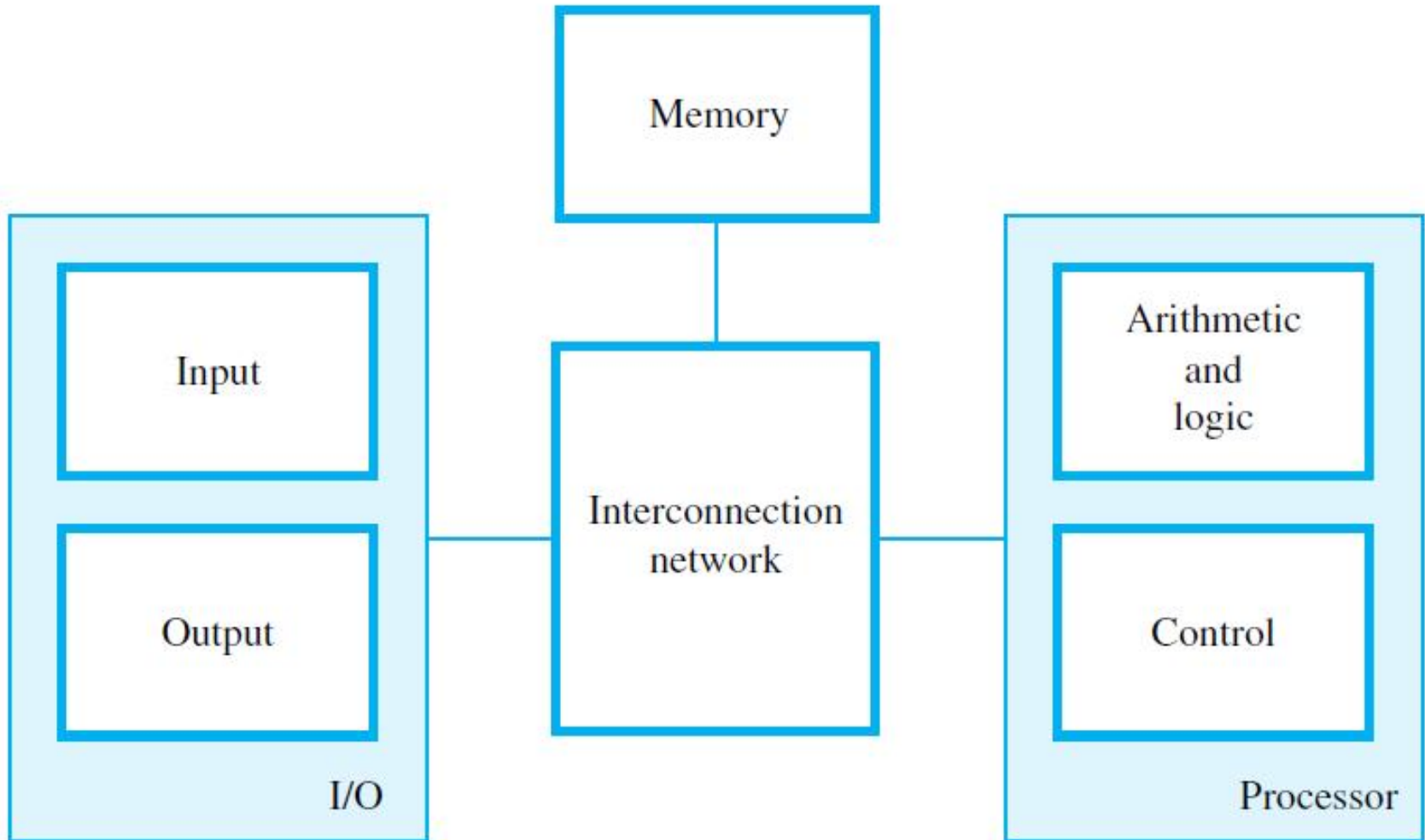
1.2 Functional Units

- Basic Functions of a Computer
  - Data Processing
    - Data means any digital information, includes
      - Machine Instructions
      - Numbers and Characters
  - Data Storage
  - Data Movement
  - Control

1.2   Functional Units

- Basic Functional Units of a Computer

  - Input Unit ⎫
  - Output Unit ⎭ I/O Unit

  - Memory

  - Arithmetic and Logic Unit (ALU) ⎫
  - Control Unit   ⎭ Processor

Basic Functional Units of a Computer

1.2   Functional Units

- Input Unit
  - Function
    - Make computer accept coded information
  - Input Devices
    - Keyboard
    - Graphic input devices: touchpad, mouse, joystick, and trackball
    - Digital Camera
    - Microphone
    - Digital communication facilities, such as the Internet
    - …

1.2   Functional Units

- Output Unit
  - Function
    - Send processed results to the outside world
  - Output Devices
    - Printer
    - Graphic display
    - …

1.2 Functional Units

Word

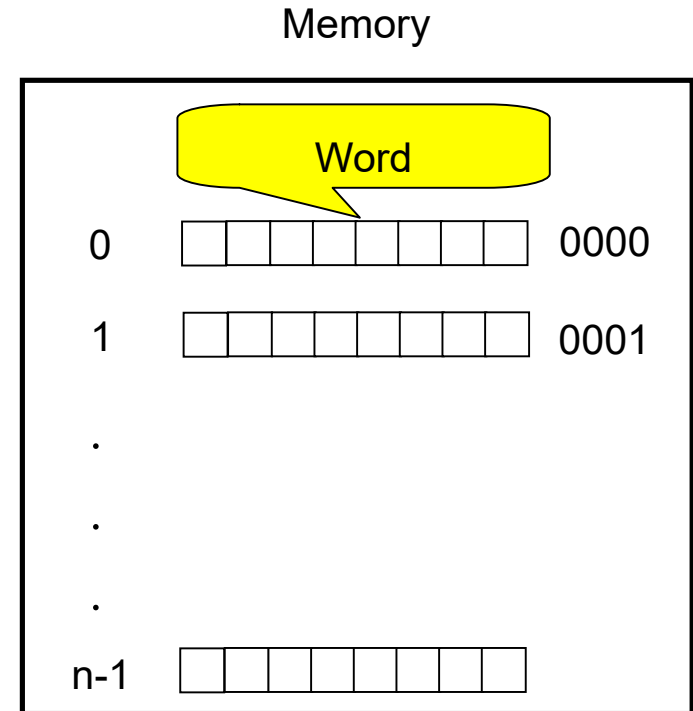| 0 | | 0000 |
| 1 | | 0001 |

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n-1

- Memory
  - Function
    - Store programs and data
  - Classification of Storage
    - Primary Storage (main memory)
      - Store programs when they are being executed
      - Related Terms
        - Word
        - Word Length (typically 16, 32, or 64 bits)
        - Address
        - Random Access Memory (RAM)
        - Memory Access Time
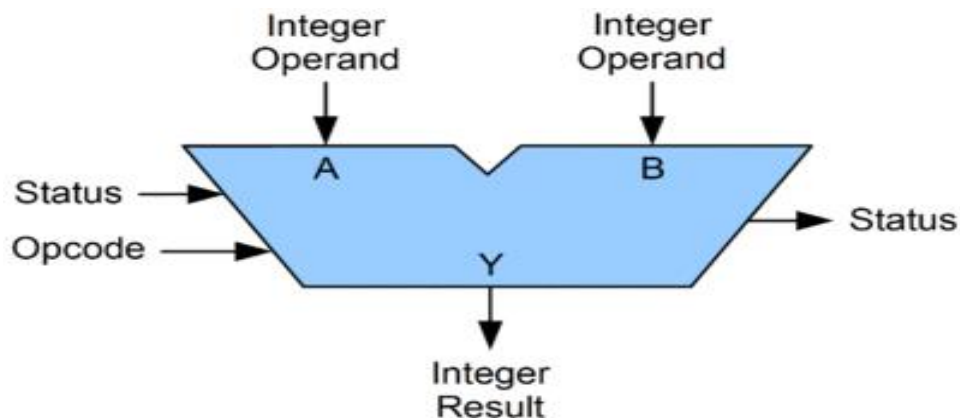
1.2 Functional Units

- Memory
  - Classification of Storage
    - Cache Memory
      - A smaller, faster RAM unit.
      - Hold sections of a program that are currently being executed.
      - Initially, the cache is empty. As execution proceeds, instructions and the required data are copied to the cache.

1.2 Functional Units

- Memory
  - Classification of Storage
    - Secondary Storage
      - Store many programs and large amounts of data, particularly for information that is accessed infrequently.
      - Secondary storage devices
        - Magnetic disks and tapes
        - Optical Disks (DVD and CD)
        - Flash memory devices

1.2 Functional Units

- Arithmetic and Logic Unit (ALU)
  - Function
    - Execute arithmetic or logic operations
  - Most computer operations are executed in ALU of the processor.
  - Load the operands into memory – bring them to the processor – perform operation in ALU – store the result back to memory or retain in the processor.

1.2   Functional Units

- Control Unit
  - Function
    - Coordinate operations of the other units
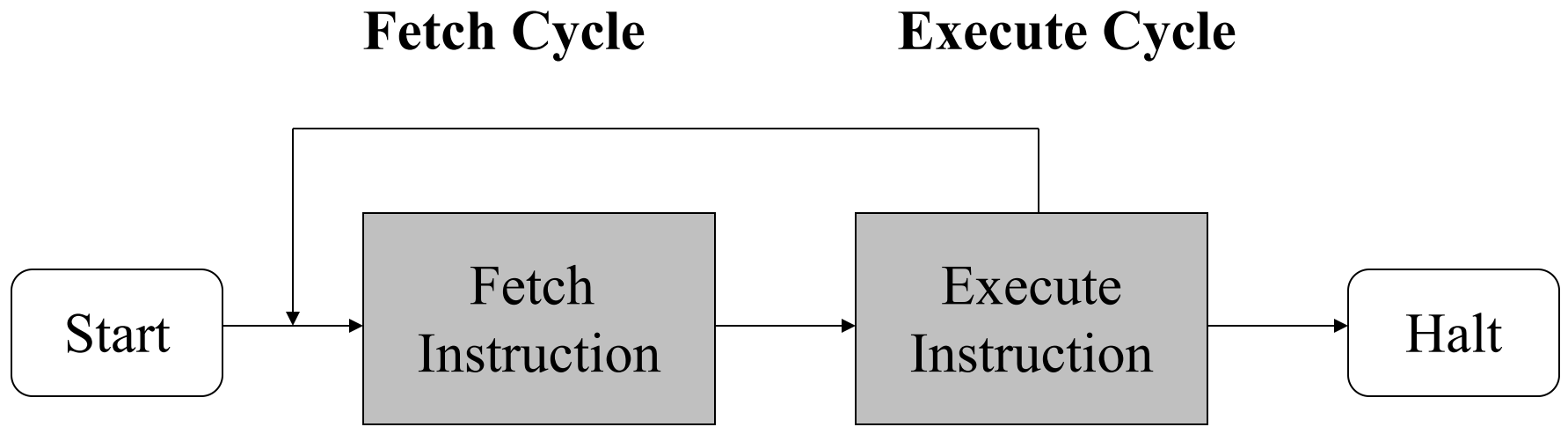   - Send control signals to other units and sense their states

1.2   Functional Units

- Operations of a Computer

  - The computer accepts information in the form of programs and data through an input unit and stores it in the memory.

  - Information stored in the memory is fetched, under program control, into an arithmetic and logic unit where it is processed.

  - Processed information leaves the computer through an output unit.

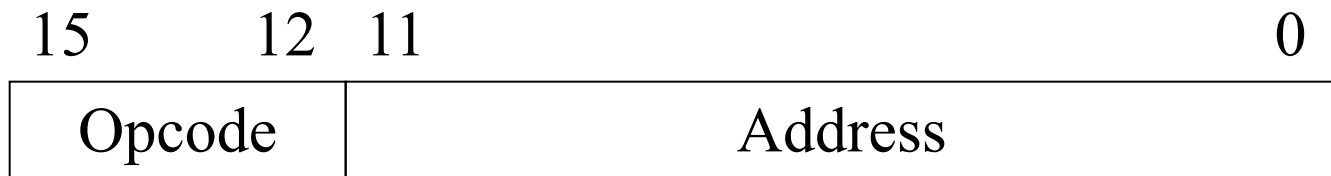 - All activities in the computer are directed by the control unit.

1.3 Basic Operational Concepts

- Program Execution

  - Execute instructions specified in the program

    - 1. The processor reads (fetch) instructions from memory one at a time, and executes each instruction.

    - 2. Program execution consists of repeating the process of instruction fetch and instruction execution.

Fetch Cycle   **Execute Cycle**

```
                    ┌──────────────────────────────────┐
                    │                                  │
                    ▼                                  │
┌─────────┐    ┌─────────────┐    ┌──────────────┐    ┌────────┐
│  Start  │───▶│    Fetch    │───▶│   Execute    │───▶│  Halt  │
│         │    │ Instruction │    │ Instruction  │    │        │
└─────────┘    └─────────────┘    └──────────────┘    └────────┘
```

Instruction Cycle

15 12	11 0
Opcode	Address

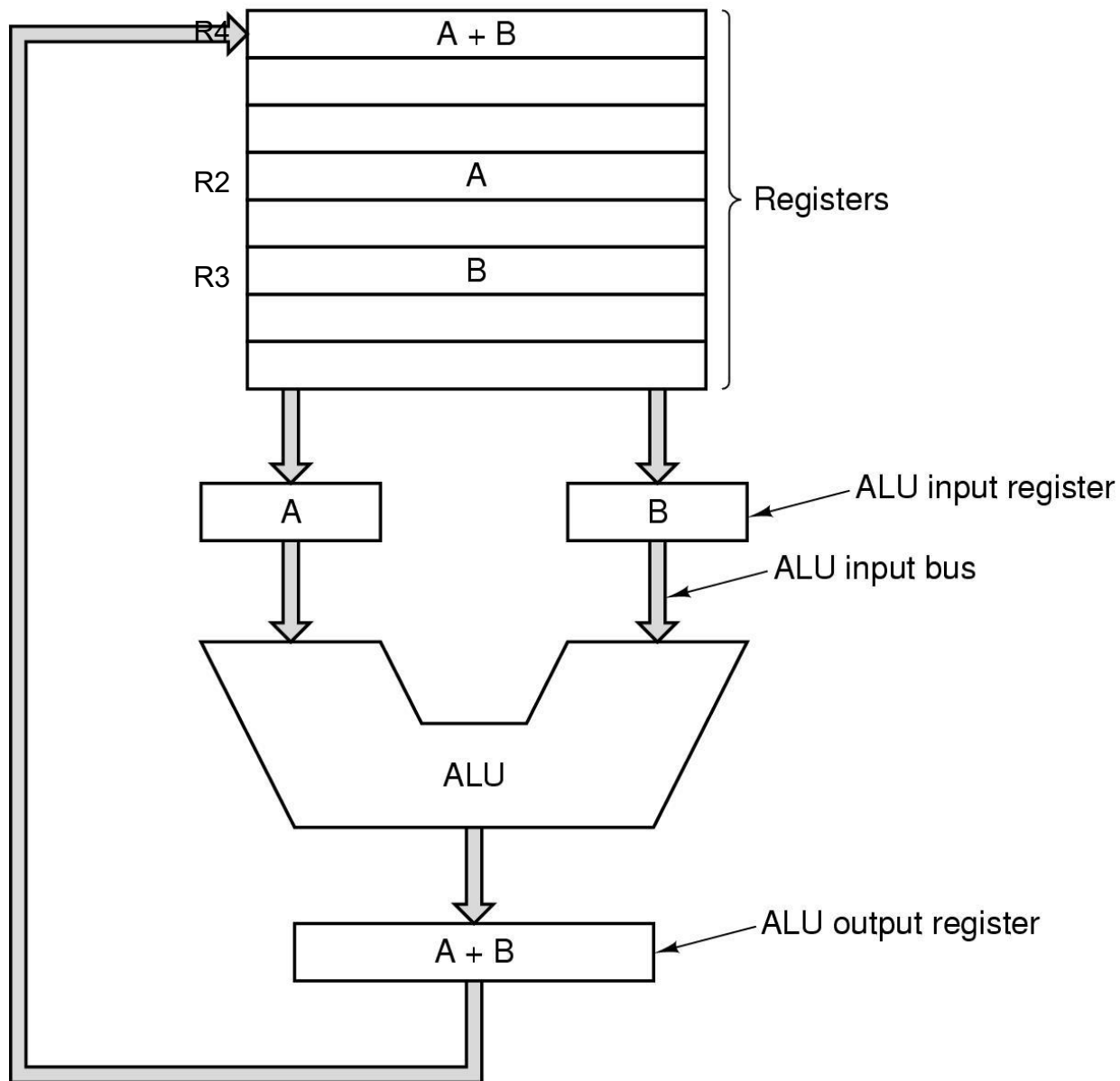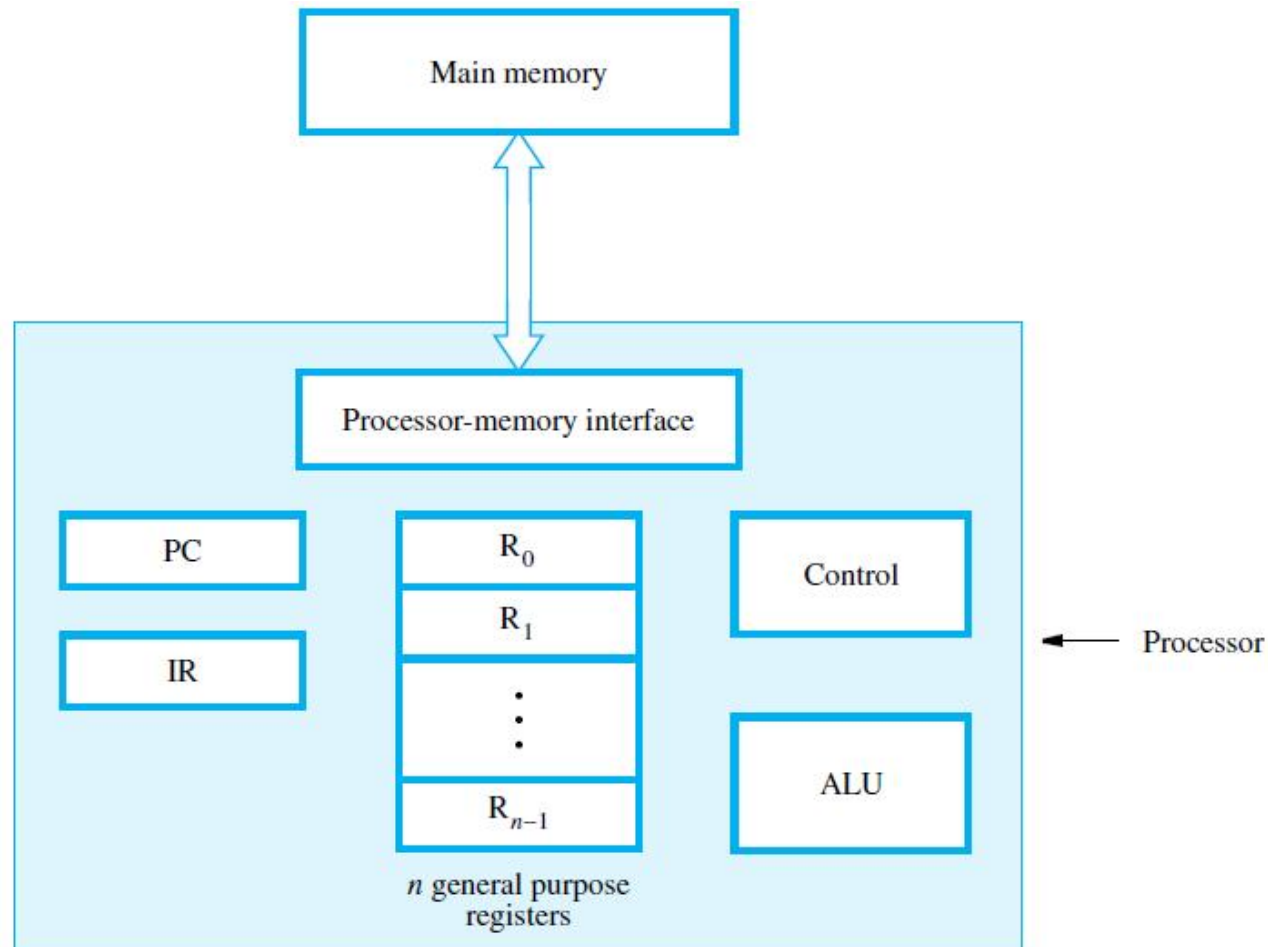**Instruction**

1.3   Basic Operational Concepts

- Program Execution

  - Example: Load R2, LOC

    - Fetch the instruction from the memory into the processor register (IR)

    - Read the operand at LOC and load it into register R2

  - Store R4, LOC

    - Copy the operand in register R4 to LOC

  - Add R4, R2, R3

    - Add the contents of register R2 and R3

    - Place the sum into register R4

1.3 Basic Operational Concepts

- Program Execution
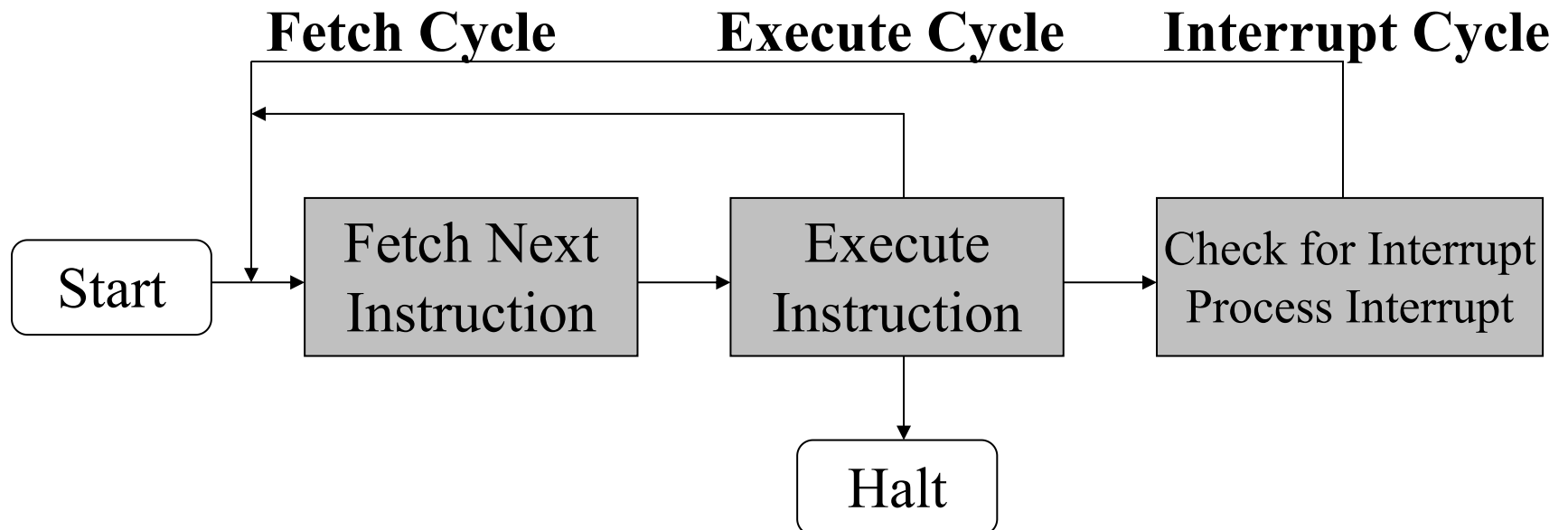
1.3 Basic Operational Concepts

- Program Execution

  - Two important registers:

    - PC: points to the next instruction to be executed

    - IR: holds the instruction that is currently being executed

1.3   Basic Operational Concepts

- ## Program Execution
  - ### Interrupt
    - An interrupt is a request from an I/O device for service by the processor.

Fetch Cycle   **Execute Cycle**   **Interrupt Cycle**

Start → Fetch Next Instruction → Execute Instruction → Check for Interrupt Process Interrupt

Halt

1.6 Performance

- The most important measure of the performance of a computer is how quickly it can execute programs.

- It is affected by the design of instruction set, hardware and software.

  - VLSI technology

    - Smaller transistors switch faster

  - Parallelism: performing a number of operations in parallel

    - Instruction-level parallelism (pipelining)

    - Multicore processors

    - Multiprocessors

    - Multicomputers

1.7   Historical Perspective

- Computer Generations
  - The Zero Generation: Mechanical Computers (1642-1945)
    - 1642, Blaise Pascal: The first person to build a working calculating machine (only do addition and subtraction).
    - 1672, Leibniz: multiplication and division
    - 1834, Babbage: Difference Engine, Analytical Engine
    - Late 1930s, Konrad Zuse: Z1 was the first working electro-magnetic relay calculating machine

1.7 Historical Perspective

- **Computer Generations**
  - **The First Generation: Vacuum Tubes (1945-1955)**
    - **ENIAC** (Electronic Numerical Integrator And Computer)
      - The world's first general-purpose electronic digital computer
      - The Moore school of the University of Pennsylvania
      - Consisted of 18,000 vacuum tubes and 1500 relays
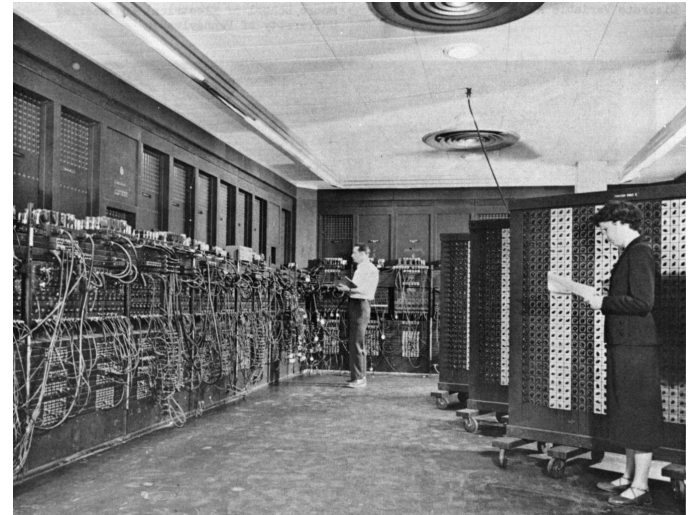
1.7 Historical Perspective

- Computer Generations
  - The First Generation: Vacuum Tubes (1945-1955)
    - Stored-program concept (John von Neumann)
      - Data and instructions are stored in a single read-write memory.
      - The contents of this memory are addressable by location , without regard to the type of data contained there.
      - Execution occurs in a sequential fashion (unless explicitly modified) from one instruction to the next.
    - Assembly Language was used to prepare programs.
    - Mercury delay-line memory was used at first.
    - Magnetic core memories and magnetic drum storage devices were also developed.
    - I/O functions were performed by devices similar to typewriters.

1.7 Historical Perspective

- Computer Generations
  - The Second Generation: Transistors (1955-1965)
    - AT&T Bell Laboratories invented transistors in the late 1940s
    - Magnetic core memories and magnetic drum storage devices were widely used.
    - Magnetic disk storage devices were developed.
    - The earliest high-level languages, such as Fortran, were developed.
    - Compiler were developed.
    - IBM became a major computer manufacturer during this time.

1.7 Historical Perspective

- Computer Generations
  - The Third Generation: Integrated Circuits (1965-1975)
    - Integrated-circuit technology
      - Fabricate many transistors on a single silicon chip
      - Developed by Texas Instruments and Fairchild Semiconductor
    - Integrated-circuit memories began to replace magnetic core memories.
    - Microprogramming, parallelism, pipelining
    - Cache, Virtual memories
    - IBM360 Computer family, PDP-11, …

1.7 Historical Perspective

- Computer Generations
  - The Fourth Generation: LSI & VLSI (1975-)
    - VLSI technology makes complete processors and large sections of the main memory of small computers could be implemented on single chips.
      - Desktop personal computers, embedded computers, portable notebook computers, and versatile mobile telephone handsets
      - Intel 8088, …
    - A particular form of VLSI technology: FPGA (Field Programmable Gate Array)
    - Organizational concepts such as parallelism and hierarchical memories have evolved.

1.7   Historical Perspective

- Evolution of Performance

  - Technology

    - Vacuum Tubes: 100- to 1000-fold speed increase

    - Transistors: 1000-fold speed increase

    - LSI & VLSI: 1000-fold speed increase

  - Computer Architecture

    - Cache, Pipelining, …

Summary

- Computer Types
  - Embedded computers, Personal computers, Servers & Enterprise systems, Supercomputers & Grid computers

- Five basic functional units of computers
  - Input unit
  - Output unit
  - Memory
  - Arithmetic and logic unit
  - Control unit

Summary

- Computer generations
  - The first generation: vacuum tubes
  - The second generation: transistors
  - The third generation: integrated circuits
  - The fourth generation: LSI&VLSI

Quiz (1)

- Which of the following is an example of both input and output device?

  A. Touchpad   B. Display   C. Printer   D. Keyboard

- List the names of five functional units of a computer.

  Arithmetic and logic unit, control unit, memory,

  input unit, output unit

Quiz (2)

- Which technology marked the start of the first/second/third generation of electronic digital computers?

  A. integrated-circuit

  B. VLSI

  C. transistor

  D. vacuum tube