CHAPTER 1
Introduction

1.1 Overview 1
1.2 The Main Components of a Computer 3
1.3 An Example System: Wading through the Jargon 4
1.4 Standards Organizations 10
1.5 Historical Development 12
1.5.1 Generation Zero: Mechanical Calculating Machines (1642–1945) 12
1.5.2 The First Generation: Vacuum Tube Computers (1945–1953) 14
1.5.3 The Second Generation: Transistorized Computers (1954–1965) 19
1.5.4 The Third Generation: Integrated Circuit Computers (1965–1980) 21
1.5.5 The Fourth Generation: VLSI Computers (1980–????) 22
1.5.6 Moore’s Law 24
1.6 The Computer Level Hierarchy 25
1.7 The von Neumann Model 27
1.8 Non-von Neumann Models 29
Chapter Summary 31
Further Reading 31
References 32
Review of Essential Terms and Concepts 33
Exercises 34
1.1 Overview

- **Computer Organization**
  - We must become familiar with how various circuits and components fit together to create working computer system.

- **Computer Architecture:**
  - It focuses on the structure and behavior of the computer and refers to the logical aspects of system implementation as seen by the programmer.
  - Computer architecture includes many elements such as instruction sets and formats, operation code, data types, the number and types of registers, addressing modes, main memory access methods, and various I/O mechanisms.

- The computer architecture for a given machine is the combination of its hardware components plus its instruction set architecture (ISA).

- The ISA is the agreed-upon interface between all the software that runs on the machine and the hardware that executes it. The ISA allows you to talk to the machine.

1.2 The Main Components of a Computer

- Principle of Equivalence of Hardware and Software: Anything that can be done with software *can also be done* with hardware, and anything that can be done with hardware *can also be done* with software.

1.3 An Example System: Wading through the Jargon

![FIGURE 1.1 A Typical Computer Advertisement](image)

![FIGURE 1.2 Common Prefixes Associated with Computer Organization and Architecture](image)

<table>
<thead>
<tr>
<th>Kilo- (K)</th>
<th>(1 thousand = $10^3 \approx 2^{10}$)</th>
<th>Milli- (m)</th>
<th>(1 thousandth = $10^{-3} \approx 2^{-10}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega- (M)</td>
<td>(1 million = $10^6 \approx 2^{20}$)</td>
<td>Micro- (μ)</td>
<td>(1 millionth = $10^{-6} \approx 2^{-20}$)</td>
</tr>
<tr>
<td>Giga- (G)</td>
<td>(1 billion = $10^9 \approx 2^{30}$)</td>
<td>Nano- (n)</td>
<td>(1 billionth = $10^{-9} \approx 2^{-30}$)</td>
</tr>
<tr>
<td>Tera- (T)</td>
<td>(1 trillion = $10^{12} \approx 2^{40}$)</td>
<td>Pico- (p)</td>
<td>(1 trillionth = $10^{-12} \approx 2^{-40}$)</td>
</tr>
<tr>
<td>Peta- (P)</td>
<td>(1 quadrillion = $10^{15} \approx 2^{50}$)</td>
<td>Femto- (f)</td>
<td>(1 quadrillionth = $10^{-15} \approx 2^{-50}$)</td>
</tr>
</tbody>
</table>

FIGURE 1.1 A Typical Computer Advertisement

FIGURE 1.2 Common Prefixes Associated with Computer Organization and Architecture
• Clock frequencies are measured in cycles per second, or Hertz
• Bus: a group of wires that moves data and instruction to various places within the computer
• SDRAM: synchronous dynamic random access memory
• Level 1 cache (L1): a small, fast memory cache that is built into the microprocessor chip and helps speed up access to frequently used data
• Level 2 cache (L2): a collection of fast, built-in memory chips situated between the microprocessor and main memory
• The cache in our system has a capacity of kilobytes (KB), which is much smaller than main memory.
• In Chapter 6 you will learn how cache works, and that a bigger cache isn’t always better.
• EIDE: Enhanced Integrated Drive Electronics
• Whereas the system bus is responsible for all data movement internal to the computer, ports allow movement of data to and from devices external to the computer.
• Serial ports transfer data by sending a series of electrical pulses across one or two data lines. Parallel ports use at least eight data lines, which are energized simultaneously to transmit data.
• USB (Universal Serial Bus) is a popular external bus that supports Plug-and-Play (the ability to configure devices automatically) as well as hot plugging (the ability to add and remove devices while the computer is running).
• Peripheral Component Interconnect (PCI) is one such I/O bus that supports the connection of multiple peripheral devices. PCI, developed by the Intel Corporation, operates at high speeds and also supports Plug-and-Play such as PCI modem and sound card.
• AGP (Accelerated Graphical Port) graphics card

1.4 Standards Organizations 10
• The Institute of Electrical and Electronic Engineers (IEEE)
  o Promotes the interests of the worldwide electrical engineering community.
  o Establishes standards for computer components, data representation, and signaling protocols, among many other things.
• The International Telecommunications Union (ITU)
  o Concerns itself with the interoperability of telecommunications systems, including data communications and telephony.
• National groups establish standards within their respective countries:
  o The American National Standards Institute (ANSI)
  o The British Standards Institution (BSI)
• The International Organization for Standardization (ISO)
  o Establishes worldwide standards for everything from screw threads to photographic film.
  o Is influential in formulating standards for computer hardware and software, including their methods of manufacture.
1.5 Historical Development

- In modern times computer evolution is usually classified into four generations according to the salient technology of the era.

1.5.1 Generation Zero: Mechanical Calculating Machines (1642–1945)
- Calculating Clock - Wilhelm Schickard (1592 - 1635).
- Pascaline - Blaise Pascal (1623 - 1662).
- Difference Engine - Charles Babbage (1791 - 1871), also designed but never built the Analytical Engine.
- Punched card tabulating machines - Herman Hollerith (1860 - 1929).

1.5.2 The First Generation: Vacuum Tube Computers (1945–1953)
- Electronic Numerical Integrator and Computer (ENIAC)
  - John Mauchly and J. Presper Eckert, University of Pennsylvania, introduced to the public in 1946
  - The first all-electronic, general-purpose digital computer.
  - This machine used 17,468 vacuum tubes, occupied 1,800 square feet of floor space, weighted 30 tons, and consumed 174 kilowatts of power.
- Vacuum tubes are still used in audio amplifiers.

1.5.3 The Second Generation: Transistorized Computers (1954–1965)
- In 1948, three researchers with Bell Laboratories – John Bardeen, Walter Brattain, and William Shockley – invented the transistor.
- Transistors consume less power than vacuum tubes, are smaller, and work more reliably.
  - Control Data Corporation (CDC) under the Seymour Cray, built CDC 6600, the world’s first supercomputer. The $10 million CDC 6600 could perform 10 million instructions per second, used 60-bit words, and had an astounding 128 kilowords of main memory.

1.5.4 The Third Generation: Integrated Circuit Computers (1965–1980)
- Jack Kilby invented the integrated circuit (IC) or microchip.
- Integrated Circuit: Multiple transistor were integrated onto on chip
- IBM 360
- DEC PDP-8 and PDP-11
- The Cray-1, in stark contrast to the CDC 6600, could execute over 160 million instructions per second and could support 8 megabytes of memory.

1.5.5 The Fourth Generation: VLSI Computers (1980–????)
- VLSI (Very Large Scale Integration): more than 10,000 components per chip.
- ENIAC-on-a-chip project, 1997
- VLSI allowed Intel, in 1971, to create the world’s first microprocessor, the 4004, which was a fully functional, 4-bit system that ran at 108KHz.
- Intel also introduced the random access memory (RAM) chip, accommodating 4 kilobits of memory on a single chip.
1.5.6 Moore’s Law 24

- In 1965, Intel founder Gordon Moore stated, “The density of transistors in an integrated circuit will **double** every year.”
- The current version of this prediction is usually conveyed as “the density of silicon chips doubles very **18 months**.”

1.6 The Computer Level Hierarchy 25

- We call the hypothetical computer at each level a **virtual machine**.
- Each level’s virtual machine executes **its own particular set of instructions**, calling upon machines at lower levels to carry out the tasks when necessary.
- Level 6, the User Level, is composed of applications such as world processors, graphics packages, or games.
- Level 5, the High-Level Language Level, consists of languages such as C, C++, FORTRAN, Lisp, Pascal, and Prolog.
  - These languages must be translated (using either a compiler or an interpreter) to a language the machine can understand.
  - Compiled languages are translated into assembly language and then assembled into machine code (They are translated to the next lower level).
• Even though a programmer must know about data types and the instructions available for those types, she need not know about how those types are actually implemented.

• Level 4, the Assembly language Level, encompasses some type of assembly language.
  o One-to-one translation: One assembly language instruction is translated to exactly one machine language.

• Level 3, the System Software Level, deals with operating system instructions.
  o This level is responsible for multiprogramming, protecting memory, synchronizing processes, and various other important functions.
  o Often, instructions translated from assembly language to machine language are passed through this level unmodified.

• Level 2, the Instruction Set Architecture (ISA) or Machine Level, consists of the machine language recognized by the particular architecture of the computer system. We will study ISA in Chapter 4 and 5.

• Level 1, the Control Level, is where a control unit makes sure that instructions are decoded and executed properly and that data is moved where and when it should be.
  o Control units can be designed in one of two ways: They can be hardwired or they can be microprogrammed.
  o In hardwired control units, control signals emanated from blocks of digital logic components: fast, very difficult to modify
  o A microprogram is a program written in a low-level language that is implemented directly by the hardware: slow, easily to modify

• Level 0, the Digital Logic Level, is where we find the physical components to the computer system: the gates and wires. Chapter 3 presents the Digital Logic Level.

1.7 The von Neumann Model 27

![FIGURE 1.4 The von Neumann Architecture]
1.8 Non-von Neumann Models 29

- Parallel computing
  - The first parallel-processing system were built in late 1960s and had only two processors.
  - In 1999, IBM announced the construction of a supercomputer called the Blue Gene. The massively parallel computer contains over 1 million processors, each with its own dedicated memory.

Chapter Summary 31

- A brief overview of computer organization and computer architecture.
- Principle of Equivalence of Hardware and Software
- Moore’s Law
- The von Neumann architecture is predominate in today’s general-purpose computers.