OPERATING SYSTEMS

Internals and Design Principles

Seventh Edition

William Stallings

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Prentice Hall

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No artifact designed by man is so convenient for this kind of functional description as a digital computer. Almost the only ones of its properties that are detectable in its behavior are the organizational properties. Almost no interesting statement that one can make about on operating computer bears any particular relation to the specific nature of the hardware. A computer is an organization of elementary functional components in which, to a high approximation, only the function performed by those components is relevant to the behavior of the whole system.

THE SCIENCES OF THE ARTIFICIAL, HERBERT SIMON

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Describe the basic elements of a computer system and their interrelationship.
- Explain the steps taken by a processor to execute an instruction.
- Understand the concept of interrupts and how and why a processor uses interrupts.
- List and describe the levels of a typical computer memory hierarchy.
- Explain the basic characteristics of multiprocessor and multicore organizations.
- Discuss the concept of locality and analyze the performance of a multilevel memory hierarchy.
- Understand the operation of a stack and its use to support procedure call and return.

An operating system (OS) exploits the hardware resources of one or more processors to provide a set of services to system users. The OS also manages secondary memory and I/O (input/output) devices on behalf of its users. Accordingly, it is important to have some understanding of the underlying computer system hardware before we begin our examination of operating systems.

This chapter provides an overview of computer system hardware. In most areas, the survey is brief, as it is assumed that the reader is familiar with this subject. However, several areas are covered in some detail because of their importance to topics covered later in the book. Further topics are covered in Appendix C.

1.1 BASIC ELEMENTS

At a top level, a computer consists of processor, memory, and I/O components, with one or more modules of each type. These components are interconnected in some fashion to achieve the main function of the computer, which is to execute programs. Thus, there are four main structural elements:

- **Processor:** Controls the operation of the computer and performs its data processing functions. When there is only one processor, it is often referred to as

2.1 OPERATING SYSTEM OBJECTIVES AND FUNCTIONS

An OS is a program that controls the execution of application programs and acts as an interface between applications and the computer hardware. It can be thought of as having three objectives:

- **Convenience:** An OS makes a computer more convenient to use.
- **Efficiency:** An OS allows the computer system resources to be used in an efficient manner.
- **Ability to evolve:** An OS should be constructed in such a way as to permit the effective development, testing, and introduction of new system functions without interfering with service.

Let us examine these three aspects of an OS in turn.

The Operating System as a User/Computer Interface

The hardware and software used in providing applications to a user can be viewed in a layered or hierarchical fashion, as depicted in Figure 2.1. The user of those applications, the end user, generally is not concerned with the details of computer hardware. Thus, the end user views a computer system in terms of a set of applications. An application can be expressed in a programming language and is developed by an application programmer. If one were to develop an application program as a set of machine instructions that is completely responsible for controlling the computer hardware, one would be faced with an overwhelmingly complex undertaking. To ease this chore, a set of system programs is provided. Some of these programs are referred to as utilities, or library programs. These implement frequently used functions that assist in program creation, the management of files, and the control of
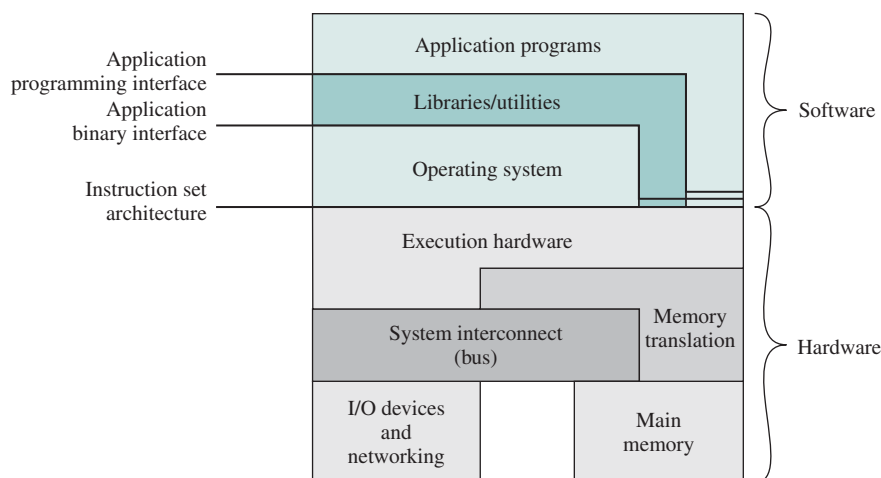

Figure 2.1   Computer Hardware and Software Structure

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