1.1 What Operating Systems Do

■ 4 Chapter 1 Introduction user 1 user 2 user 3 computer hardware operating system system and application programs compiler assembler text editor database system user n … … Figure 1.1 Abstract view of the components of a computer system. We begin our discussion by looking at the operating system's role in the overall computer system

■ A computer system can be divided roughly into four components: the hardware, the operating system, the application programs, and the users (Figure 1.1). The hardware—the central processing unit (CPU), the memory, and the input/output (I/O) devices—provides the basic computing resources for the system

■ The application programs—such as word processors, spreadsheets, compilers, and Web browsers—de■ne the ways in which these resources are used to solve users' computing problems

■ The operating system controls the hardware and coordinates its use among the various application programs for the various users. We can also view a computer system as consisting of hardware, software, and data

■ The operating system provides the means for proper use of these resources in the operation of the computer system

■ Like a government, it performs no useful function by itself

1.1.1 User View

■ It simply provides an environment within which other programs can do useful work. To understand more fully the operating system's role, we next explore operating systems from two viewpoints: that of the user and that of the system. The user's view of the computer varies according to the interface being used

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■ 5 to monopolize its resources

■ The goal is to maximize the work (or play) that the user is performing

■ In this case, the operating system is designed mostly for ease of use, with some attention paid to performance and none paid to resource utilization—how various hardware and software resources are shared

■ The operating system in such cases is designed to maximize resource utilization— to assure that all available CPU time, memory, and I/O are used ef■ciently and that no individual user takes more than her fair share. In still other cases, users sit at workstations connected to networks of other workstations and servers

■ The user interface for mobile computers generally features a touch screen, where the user interacts with the system by pressing and swiping ■ngers across the screen rather than using a physical keyboard and mouse. Some computers have little or no user view

1.1.2 System View

■ For example, embedded computers in home devices and automobiles may have numeric keypads and may turn indicator lights on or off to show status, but they and their operating systems are designed primarily to run without user intervention. From the computer's point of view, the operating system is the program most intimately involved with the hardware

■ In this context, we can view an operating system as a resource allocator

■ A computer system has many resources that may be required to solve a problem: CPU time, memory space, ■le-storage space, I/O devices, and so on

■ The operating system acts as the manager of these resources

■ Facing numerous and possibly con■icting requests for resources, the operating system must decide how to allocate them to speci■c programs and users so that it can operate the computer system ef■ciently and fairly

■ As we have seen, resource allocation is especially important where many users access the same mainframe or minicomputer. A slightly different view of an operating system emphasizes the need to control the various I/O devices and user programs

■ A control program manages the execution of user programs to prevent errors and improper use of the computer

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■ Computers are present within toasters, cars, ships, spacecraft, homes, and businesses

■ They are the basis for game machines, music players, cable TV tuners, and industrial control systems

■ Computing started as an experiment to determine what could be done and quickly moved to ■xed-purpose systems for military uses, such as code breaking and trajectory plotting, and governmental uses, such as census calculation

■ In the 1960s, Moore's Law predicted that the number of transistors on an integrated circuit would double every eighteen months, and that prediction has held true

■ Computers gained in functionality and shrunk in size, leading to a vast number of uses and a vast number and variety of operating systems

■ (See Chapter 20 for more details on the history of operating systems.) How, then, can we de■ne what an operating system is? In general, we have no completely adequate de■nition of an operating system

■ These programs require certain common operations, such as those controlling the I/O devices. The common functions of controlling and allocating resources are then brought together into one piece of software: the operating system. In addition, we have no universally accepted de■nition of what is part of the operating system

■ Some systems take up less than a megabyte of space and lack even a full-screen editor, whereas others require gigabytes of space and are based entirely on graphical windowing systems

■ A more common de■nition, and the one that we usually follow, is that the operating system is the one program running at all times on the computer—usually called the kernel

■ (Along with the kernel, there are two other types of programs: system programs, which are associated with the operating system but are not necessarily part of the kernel, and application programs, which include all programs not associated with the operation of the system.) The matter of what constitutes an operating system became increasingly important as personal computers became more widespread and operating systems grew increasingly sophisticated

■ In 1998, the United States Department of Justice ■led suit against Microsoft, in essence claiming that Microsoft included too much functionality in its operating systems and thus prevented application vendors from competing

■ (For example, a Web browser was an integral part of the operating systems.) As a result, Microsoft was found guilty of using its operating-system monopoly to limit competition. Today, however, if we look at operating systems for mobile devices, we see that once again the number of features constituting the operating system

1.2 Computer-System Organization

■ 7 is increasing

■ Mobile operating systems often include not only a core kernel but also middleware—a set of software frameworks that provide additional services to application developers

1.2 Computer-System Organization

■ For example, each of the two most promi- nent mobile operating systems—Apple's iOS and Google's Android—features a core kernel along with middleware that supports databases, multimedia, and graphics (to name a only few). Before we can explore the details of how computer systems operate, we need general knowledge of the structure of a computer system

1.2.1 Computer-System Operation

■ The section is mostly concerned with computer-system organization, so you can skim or skip it if you already understand the concepts. A modern general-purpose computer system consists of one or more CPUs and a number of device controllers connected through a common bus that provides access to shared memory (Figure 1.2)

■ To ensure orderly access to the shared memory, a memory controller synchronizes access to the memory. For a computer to start running—for instance, when it is powered up or rebooted—it needs to have an initial program to run