


OPERATING SYSTEMS

Internals and Design Principles

Seventh Edition



William Stallings



OPERATING SYSTEMS

INTERNALS AND DESIGN

PRINCIPLES

SEVENTH EDITION

William Stallings

Prentice Hall

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montreal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

**DOCKET
ALARM**

Find authenticated court documents without watermarks at docketalarm.com.

Editorial Director: Marcia Horton
Editor in Chief: Michael Hirsch
Executive Editor: Tracy Dunkelberger
Assistant Editor: Melinda Haggerty
Editorial Assistant: Allison Michael
Director of Marketing: Patrice Jones
Marketing Manager: Yezan Alayan
Senior Marketing Coordinator: Kathryn Ferranti
Production Manager: Pat Brown

Art Director: Jayne Conte
Cover Designer: Bruce Kenselaar
Media Director: Daniel Sandin
Media Project Manager: Wanda Rockwell
Full-Service Project Management/Composition:
Shiny Rajesh/Integra Software Service Pvt. Ltd.
Interior Printer/Bindery: Edwards Brothers
Cover Printer: Lehigh-Phoenix Color

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on appropriate page within text.

Microsoft® and Windows® are registered trademarks of the Microsoft Corporation in the U.S.A. and other countries. Screen shots and icons reprinted with permission from the Microsoft Corporation. This book is not sponsored or endorsed by or affiliated with the Microsoft Corporation.

Copyright © 2012, 2009, 2005, 2001, 1998 Pearson Education, Inc., publishing as Prentice Hall, 1 Lake Street, Upper Saddle River, New Jersey, 07458. All rights reserved. Manufactured in the United States of America. This publication is protected by Copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission(s) to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, 1 Lake Street, Upper Saddle River, New Jersey, 07458.

Many of the designations by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and the publisher was aware of a trademark claim, the designations have been printed in initial caps or all caps.

Library of Congress Cataloging-in-Publication Data

Stallings, William.
Operating systems : internals and design principles / William Stallings. — 7th ed.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-13-230998-1 (alk. paper)
ISBN-10: 0-13-230998-X (alk. paper)
1. Operating systems (Computers) I. Title.
QA76.76.O63S733 2011
005.4'3 dc22
2010048597

10 9 8 7 6 5 4 3 2 1—EB—15 14 13 12 11

Prentice Hall
is an imprint of

PEARSON

ISBN 10: 0-13-230998-X

DOCKET
ALARM

Find authenticated court documents without watermarks at docketalarm.com.

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 an 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

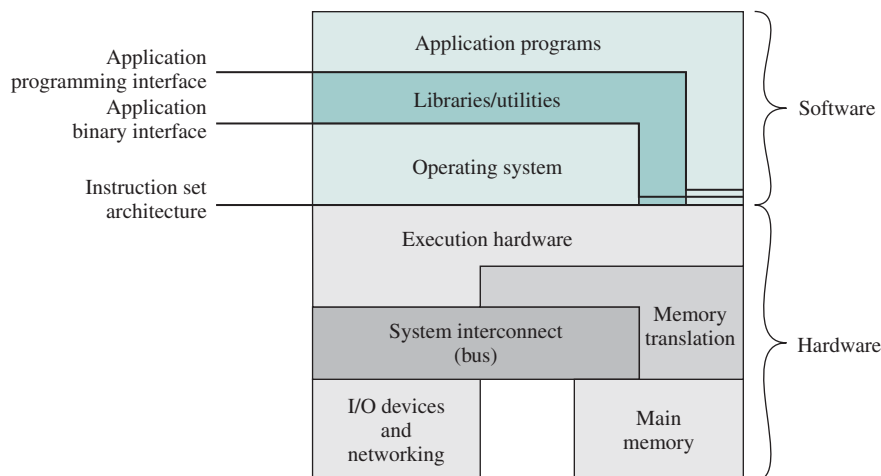


Figure 2.1 Computer Hardware and Software Structure

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.