SOFTWARE ENGINEERING

A PRACTITIONER'S APPROACH

THIRD EDITION

ROGER S. PRESSMAN

SOFTW ENGINEERING

A PRACTITIONER'S APPROACH

THIRD EDITION

Roger S. Pressman, Ph.D.

McGraw-Hill, Inc.
New York St. Louis San Francisco Auckland Bogotá
Caracas Lisbon London Madrid Mexico City Milan
Montreal New Delhi San Juan Singapore
Sydney Tokyo Toronto

To my parents

SOFTWARE ENGINEERING
A PRACTITIONER'S APPROACH

90 DOC/DOC 99876

ISBN 0-07-050814-3

This book is printed on acid-free paper.

This book was set in New Century Schoolbook
by Beacon Graphics Corporation.
The editors were Eric M. Munson and Bernadette Boylan;
the designer was Jo Jones.
New drawings were done by Fine Line Illustrations, Inc.
Cover painting by Joseph Gillians.
R. R. Donnelley & Sons Company was printer and binder.

Library of Congress Cataloging-in-Publication Data

Pressman, Roger S.
Software engineering: a practitioner's approach / by Roger S. Pressman
p. cm.
Includes bibliographical references and index.
ISBN 0-07-050814-3
1. Software engineering. I. Title.
QA76.758.P75 1992 91-11321
005.1—dc20

ABOUT THE AUTHOR

Roger S. Pressman is an internationally recognized consultant and author in software engineering. He received a B.S.E. (cum laude) from the University of Connecticut, an M.S. from the University of Bridgeport, and a Ph.D. in engineering from the University of Connecticut, and has over two decades of industry experience, holding both technical and management positions with responsibility for the development of software for engineered products and systems.

As an industry practitioner and manager, Dr. Pressman worked on the development of CAD/CAM systems for advanced engineering and manufacturing in aerospace applications. He has also held positions with responsibility for scientific and systems programming.

In addition to his industry experience, Dr. Pressman was Bullard Associate Professor of Computer Engineering at the University of Bridgeport and Director of the University's Computer-Aided Design and Manufacturing Center. His research interests included software engineering methods and tools.

Dr. Pressman is President of R.S. Pressman & Associates, Inc., a consulting firm specializing in software engineering methods and training. He serves as principal consultant, specializing in helping companies establish effective software engineering practices. In addition to consulting services rendered to many Fortune 500 clients, the company markets a wide variety of software engineering training products and services. Dr. Pressman has authored three videotape training series, *Software Engineering Training Curriculum, A CASE Curriculum,* and *Essential Software Engineering,* that are distributed worldwide.

Dr. Pressman has written many technical papers, is a regular contributor to industry newsletters, and is the author of five books. In addition to *Software Engineering: A Practitioner's Approach,* he has written *Making Software Engineering Happen* (Prentice-Hall), a book that addresses the management problems associated with implementing software engineering technology, *Software Engineering: A Beginner's Guide* (McGraw-Hill), an introductory text, and *Software Shock* (Dorset House), a book that focuses on software and its impact on business and society. Dr. Pressman is a member of the ACM, IEEE and Tau Beta Pi, Phi Kappa Phi, Pi Tau Sigma, and Eta Kappa Nu.

PREFACE

Over the past two decades, software engineering has come of age. Today, it is recognized as a legitimate discipline, one worthy of serious research, conscientious study, and tumultuous debate. Throughout the industry, "software engineer" has replaced "programmer" as the job title of preference. Software engineering methods, procedures, and tools have been adopted successfully across a broad spectrum of industry applications. Managers and practitioners alike recognize the need for a more disciplined approach to software development.

But the problems discussed in the first and second editions of this book remain with us. Many individuals and companies still develop software haphazardly. Many professionals and students are unaware of modern methods. And as a result, the quality of the software that we produce suffers. In addition, debate and controversy about the true nature of the software engineering approach continue. The status of software engineering is a study in contrasts. Attitudes have changed, progress has been made, but much remains to be done before the discipline reaches full maturity.

The third edition of *Software Engineering: A Practitioner's Approach* is intended to provide one element of a foundation from which a bridge from adolescence to maturity can be constructed. The third edition, like the two editions that have preceded it, is intended for both students and practitioners, and maintains the same format and style as its predecessors. The book retains its appeal as a guide to the industry professional and a comprehensive introduction to the student at the upper-level undergraduate or first-year graduate level.

Like in the earlier editions, software engineering methods are presented in the chronological sequence that they are applied during software development. However, the third edition is more than a simple update. The book has been restructured to accommodate the dramatic growth in the field and to emphasize new and important software engineering methods and tools. Rather than maintaining a strict life-cycle view, this edition presents generic activities that are performed regardless of the software engineering paradigm that has been chosen.

Chapters that have been retained from earlier editions have been revised and updated to reflect current trends and techniques. Major new sections have been added to chapters on computer system engineering, requirements analysis fundamentals, data flow-oriented design, object-oriented design, real-time design, software quality assurance, software testing techniques, and maintenance. In addition to these revisions, eight new chapters have been added to the third edition.

The original chapter on software project management has been removed and replaced by three new chapters on software metrics, estimation, and project planning. A new chapter on structured analysis presents the notation and approach for both conventional and real-time applications. A chapter on object-oriented analysis and data modeling provides a detailed treatment of these new and important modeling techniques.

The five existing chapters on software design have been further bolstered with a new chapter on user interface design. Software configuration management—a topic that has become pivotal to successful software development—is now treated in a separate chapter. The role of automation in software engineering is considered in two new chapters on computer-aided software engineering (CASE). One chapter emphasizes software tools and their application and the other discusses integrated CASE environments and the repository. The final chapter (also new) looks toward the twenty-first century and examines changes that will affect our approach to software engineering.

Many new examples, problems, and points to ponder have been added, and the "Further Readings" sections (one of the more popular tidbits in earlier editions) have been expanded and updated for every chapter.

The 24 chapters of the third edition have been divided into five parts. This has been done to compartmentalize topics and assist instructors who may not have the time to complete the entire book in one term. Part I—"Software—the Process and Its Management"—presents a thorough treatment of software project management issues. Part II—"System and Software Requirements Analysis"—contains five chapters that cover analysis fundamentals and requirements modeling methods and notation. Part III—"The Design and Implementation of Software"—presents a thorough treatment of software design, emphasizing fundamental design criteria that lead to high-quality systems and design methods that translate an analysis model into a software solution. Part IV—"Ensuring, Verifying, and Maintaining Software Integrity"—emphasizes the activities that are applied to

ensure quality throughout the software engineering process. Part V— "The Role of Automation"—discusses the impact of CASE on the software development process.

The five-part organization of the third edition enables an instructor to "cluster" topics based on available time and student need. An entire one-term course can be built around one or more of the five parts. For example, a "design course" might emphasize only part III; a "methods course" might present selected chapters in parts II, III, IV, and V; and a "management course" would stress parts I and IV. By organizing the third edition in this way, I have attempted to provide an instructor with a number of teaching options.

An *Instructor's Guide* for the third edition of *Software Engineering: A Practitioner's Approach* is available from McGraw-Hill. The *Instructor's Guide* presents suggestions for conducting various types of software engineering courses, recommendations for a variety of software projects to be conducted in conjunction with a course, solutions to selected problems, and reference to a variety of complementary teaching materials that form a "system" for teaching software engineering.

The software engineering literature continues to expand at an explosive rate. Once again, my thanks to the many authors of books, papers, and articles who have provided me with additional insight, ideas, and commentary over the past decade. Many have been referenced within the pages of each chapter. All deserve credit for their contribution to this rapidly evolving field. I also wish to thank the reviewers of the third edition, James Cross, Auburn University; Mahesh Dodani, University of Iowa; William S. Junk, University of Idaho; and Laurie Werth, University of Texas. Their comments and criticism have been invaluable.

The content of the third edition of *Software Engineering: A Practitioner's Approach* has been shaped by hundreds of industry professionals, university professors, and students who have used the first and second editions of the book and have taken the time to communicate their suggestions, criticisms, and ideas. In addition, my personal thanks go to our many industry clients throughout North America and Europe, who certainly teach me as much or more than I can teach them.

Finally, to Barbara, Mathew, and Michael, my love and thanks for tolerating my travel schedule, understanding the evenings at the office, and encouraging still another edition of "the book."

Roger S. Pressman

CONTENTS