Acknowledgments

This textbook began as a set of notes for the advanced undergraduate course Engineering of Computer Systems (6.033, originally 6.233), offered by the Department of Electrical Engineering and Computer Science of the Massachusetts Institute of Technology starting in 1968. The text has benefited from four decades of comments and suggestions by many faculty members, visitors, recitation instructors, teaching assistants, and students. Over 5,000 students have used (and suffered through) draft versions, and observations of their learning experiences (as well as frequent confusion caused by the text) have informed the writing. We are grateful for those many contributions. In addition, certain aspects deserve specific acknowledgment.

1. Naming (Section 2.2 and Chapter 3)

The concept and organization of the materials on naming grew out of extensive discussions with Michael D. Schroeder. The naming model (and part of our development) follows closely the one developed by D. Austin Henderson in his Ph.D. thesis. Stephen A. Ward suggested some useful generalizations of the naming model, and Roger Needham suggested several concepts in response to an earlier version of this material. That earlier version, including in-depth examples of the naming model applied to addressing architectures and file systems, and an historical bibliography, was published as Chapter 3 in Rudolf Bayer et al., editors, *Operating Systems: An Advanced Course, Lecture Notes in Computer Science 60*, pages 99–208. Springer-Verlag, 1978, reprinted 1984. Additional ideas have been contributed by many others, including Ion Stoica, Karen Sollins, Daniel Jackson, Butler Lampson, David Karger, and Hari Balakrishnan.

2. Enforced Modularity and Virtualization (Chapters 4 and 5)

Chapter 4 was heavily influenced by lectures on the same topic by David L. Tennenhouse. Both chapters have been improved by substantial feedback from Hari Balakrishnan, Russ Cox, Michael Ernst, Eddie Kohler, Chris Laas, Barbara H. Liskov, Nancy Lynch, Samuel Madden, Robert T. Morris, Max Poletto, Martin Rinard, Susan Ruff, Gerald Jay Sussman, Julie Sussman, and Michael Walfish.

3. Networks (Chapter 7 [on-line])

Conversations with David D. Clark and David L. Tennenhouse were instrumental in laying out the organization of this chapter, and lectures by Clark were the basis for part of the presentation. Robert H. Halstead Jr. wrote an early draft set of notes about networking, and some of his ideas have also been borrowed. Hari Balakrishnan provided many suggestions and corrections and helped sort out muddled explanations, and Julie Sussman and Susan Ruff pointed out many opportunities to improve the presentation. The material on congestion control was developed with the help of

extensive discussions with Hari Balakrishnan and Robert T. Morris, and is based in part on ideas from Raj Jain.

4. Fault Tolerance (Chapter 8 [on-line])

Most of the concepts and examples in this chapter were originally articulated by Claude Shannon, Edward F. Moore, David Huffman, Edward J. McCluskey, Butler W. Lampson, Daniel P. Siewiorek, and Jim N. Gray.

5. Transactions and Consistency (Chapters 9 [on-line] and 10 [on-line])

The material of the transactions and consistency chapters has been developed over the course of four decades with aid and ideas from many sources. The concept of version histories is due to Jack Dennis, and the particular form of all-or-nothing and before-or-after atomicity with version histories developed here is due to David P. Reed. Jim N. Gray not only came up with many of the ideas described in these two chapters, he also provided extensive comments. (That doesn't imply endorsement—he disagreed strongly about the importance of some of the ideas!) Other helpful comments and suggestions were made by Hari Balakrishnan, Andrew Herbert, Butler W. Lampson, Barbara H. Liskov, Samuel R. Madden, Larry Rudolph, Gerald Jay Sussman, and Julie Sussman.

6. Computer Security (Chapter 11 [on-line])

Sections 11.1 and 11.6 draw heavily from the paper "The protection of information in computer systems" by Jerome H. Saltzer and Michael D. Schroeder, *Proceedings of the IEEE 63,* 9 (September, 1975), pages 1278–1308. Ronald Rivest, David Mazières, and Robert T. Morris made significant contributions to material presented throughout the chapter. Brad Chen, Michael Ernst, Kevin Fu, Charles Leiserson, Susan Ruff, and Seth Teller made numerous suggestions for improving the text.

7. Suggested Outside Readings

Ideas for suggested readings have come from many sources. Particular thanks must go to Michael D. Schroeder, who uncovered several of the classic systems papers in places outside computer science where nobody else would have thought to look; Edward D. Lazowska, who provided an extensive reading list used at the University of Washington; and Butler W. Lampson, who provided a thoughtful review of the list.

8. The Exercises and Problem Sets

The exercises at the end of each chapter and the problem sets at the end of the book have been collected, suggested, tried, debugged, and revised by many different faculty members, instructors, teaching assistants, and undergraduate students over a period of 40 years in the process of constructing quizzes and examinations while teaching the material of the text.

Certain of the longer exercises and most of the problem sets, which are based on lead-in stories and include several related questions, represent a substantial effort by a single individual. For those problem sets not developed by one of the authors, a credit line appears in a footnote on the first page of the problem set.

Following each problem or problem set is an identifier of the form "*1978–3–14*". This identifier reports the year, examination number, and problem number of the examination in which some version of that problem first appeared.

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