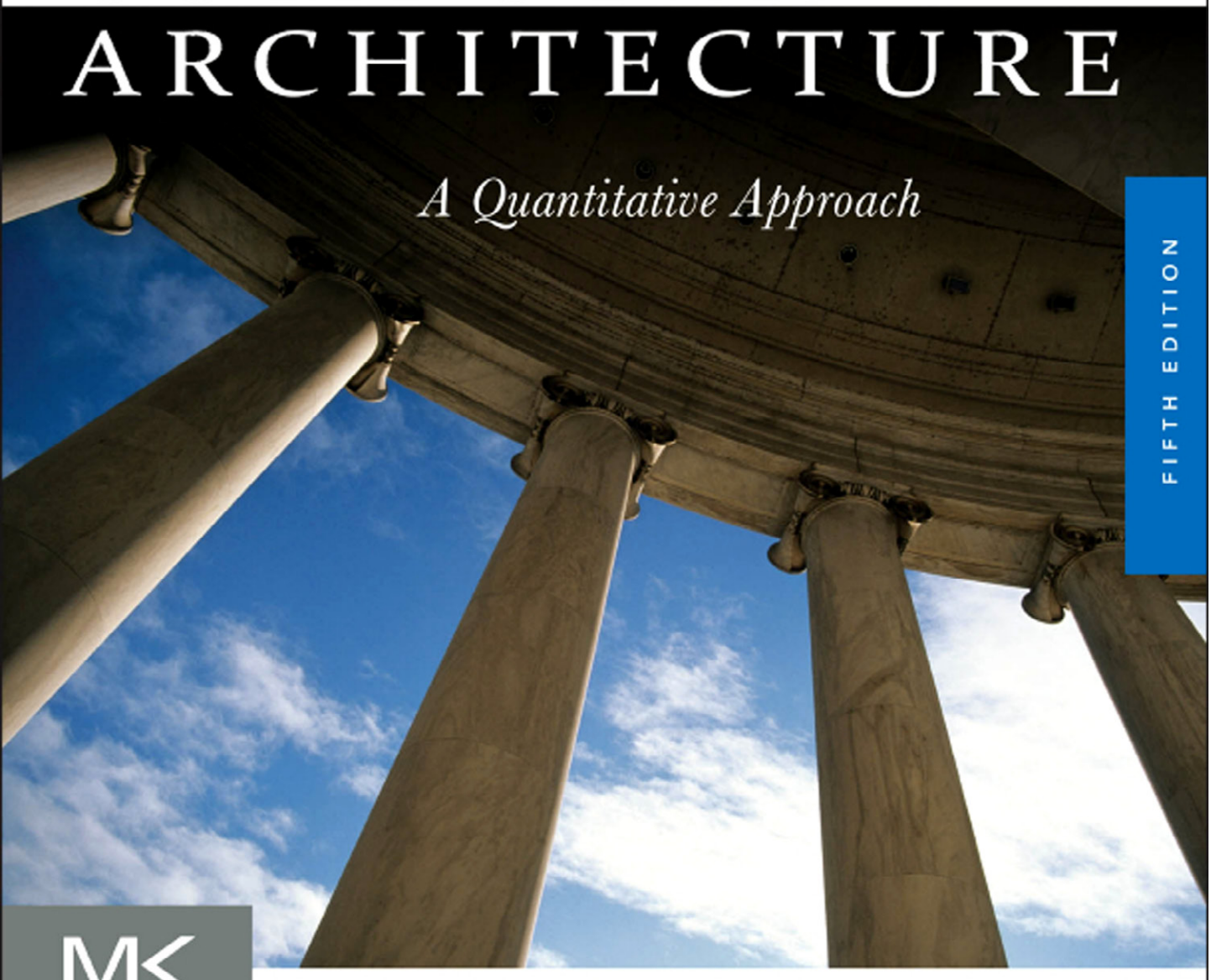
JOHN L. HENNESSY DAVID A. PATTERSON

# COMPUTER ARCHITECTURE

## A Quantitative Approach

FIFTH EDITION



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**John L. Hennessy** is the tenth president of Stanford University, where he has been a member of the faculty since 1977 in the departments of electrical engineering and computer science. Hennessy is a Fellow of the IEEE and ACM; a member of the National Academy of Engineering, the National Academy of Science, and the American Philosophical Society; and a Fellow of the American Academy of Arts and Sciences. Among his many awards are the 2001 Eckert-Mauchly Award for his contributions to RISC technology, the 2001 Seymour Cray Computer Engineering Award, and the 2000 John von Neumann Award, which he shared with David Patterson. He has also received seven honorary doctorates.

In 1981, he started the MIPS project at Stanford with a handful of graduate students. After completing the project in 1984, he took a leave from the university to cofound MIPS Computer Systems (now MIPS Technologies), which developed one of the first commercial RISC microprocessors. As of 2006, over 2 billion MIPS microprocessors have been shipped in devices ranging from video games and palmtop computers to laser printers and network switches. Hennessy subsequently led the DASH (Director Architecture for Shared Memory) project, which prototyped the first scalable cache coherent multiprocessor; many of the key ideas have been adopted in modern multiprocessors. In addition to his technical activities and university responsibilities, he has continued to work with numerous start-ups both as an early-stage advisor and an investor.

**David A. Patterson** has been teaching computer architecture at the University of California, Berkeley, since joining the faculty in 1977, where he holds the Pardee Chair of Computer Science. His teaching has been honored by the Distinguished Teaching Award from the University of California, the Karlstrom Award from ACM, and the Mulligan Education Medal and Undergraduate Teaching Award from IEEE. Patterson received the IEEE Technical Achievement Award and the ACM Eckert-Mauchly Award for contributions to RISC, and he shared the IEEE Johnson Information Storage Award for contributions to RAID. He also shared the IEEE John von Neumann Medal and the C & C Prize with John Hennessy. Like his co-author, Patterson is a Fellow of the American Academy of Arts and Sciences, the Computer History Museum, ACM, and IEEE, and he was elected to the National Academy of Engineering, the National Academy of Sciences, and the Silicon Valley Engineering Hall of Fame. He served on the Information Technology Advisory Committee to the U.S. President, as chair of the CS division in the Berkeley EECS department, as chair of the Computing Research Association, and as President of ACM. This record led to Distinguished Service Awards from ACM and CRA.

At Berkeley, Patterson led the design and implementation of RISC I, likely the first VLSI reduced instruction set computer, and the foundation of the commercial SPARC architecture. He was a leader of the Redundant Arrays of Inexpensive Disks (RAID) project, which led to dependable storage systems from many companies. He was also involved in the Network of Workstations (NOW) project, which led to cluster technology used by Internet companies and later to cloud computing. These projects earned three dissertation awards from ACM. His current research projects are Algorithm-Machine-People Laboratory and the Parallel Computing Laboratory, where he is director. The goal of the AMP Lab is develop scalable machine learning algorithms, warehouse-scale-computer-friendly programming models, and crowd-sourcing tools to gain valueable insights quickly from big data in the cloud. The goal of the Par Lab is to develop technologies to deliver scalable, portable, efficient, and productive software for parallel personal

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*Morgan Kaufmann* is an imprint of Elsevier
225 Wyman Street, Waltham, MA 02451, USA



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**Library of Congress Cataloging-in-Publication Data**
Application submitted

**British Library Cataloguing-in-Publication Data**
A catalogue record for this book is available from the British Library.

ISBN: 978-0-12-383872-8



Printed in the United States of America
11 12 13 14 15 10 9 8 7 6 5 4 3 2 1

*Typeset by*: diacriTech, Chennai, India

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