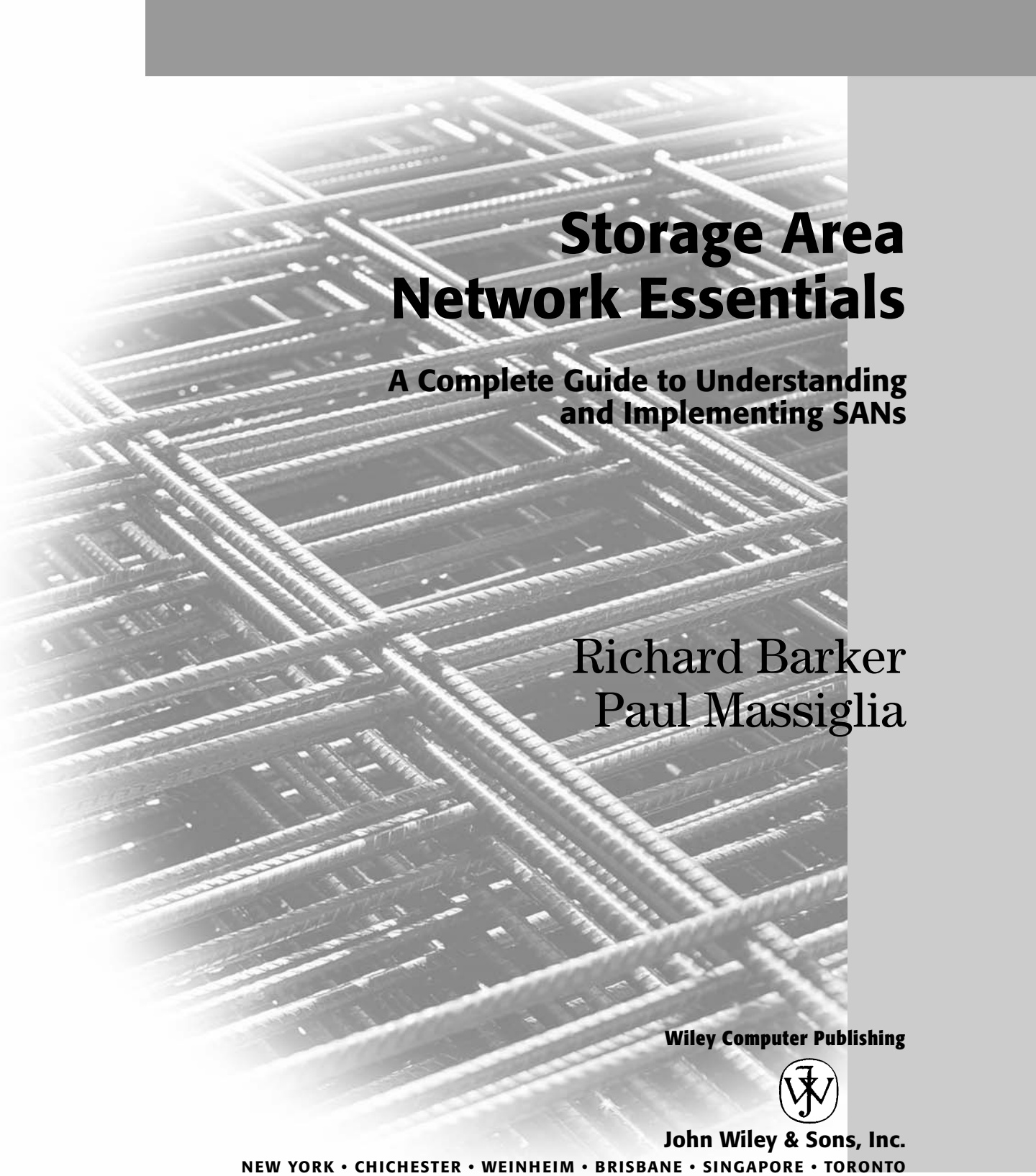


Storage Area Network Essentials

A Complete Guide to Understanding and Implementing SANs

Richard Barker
Paul Massiglia

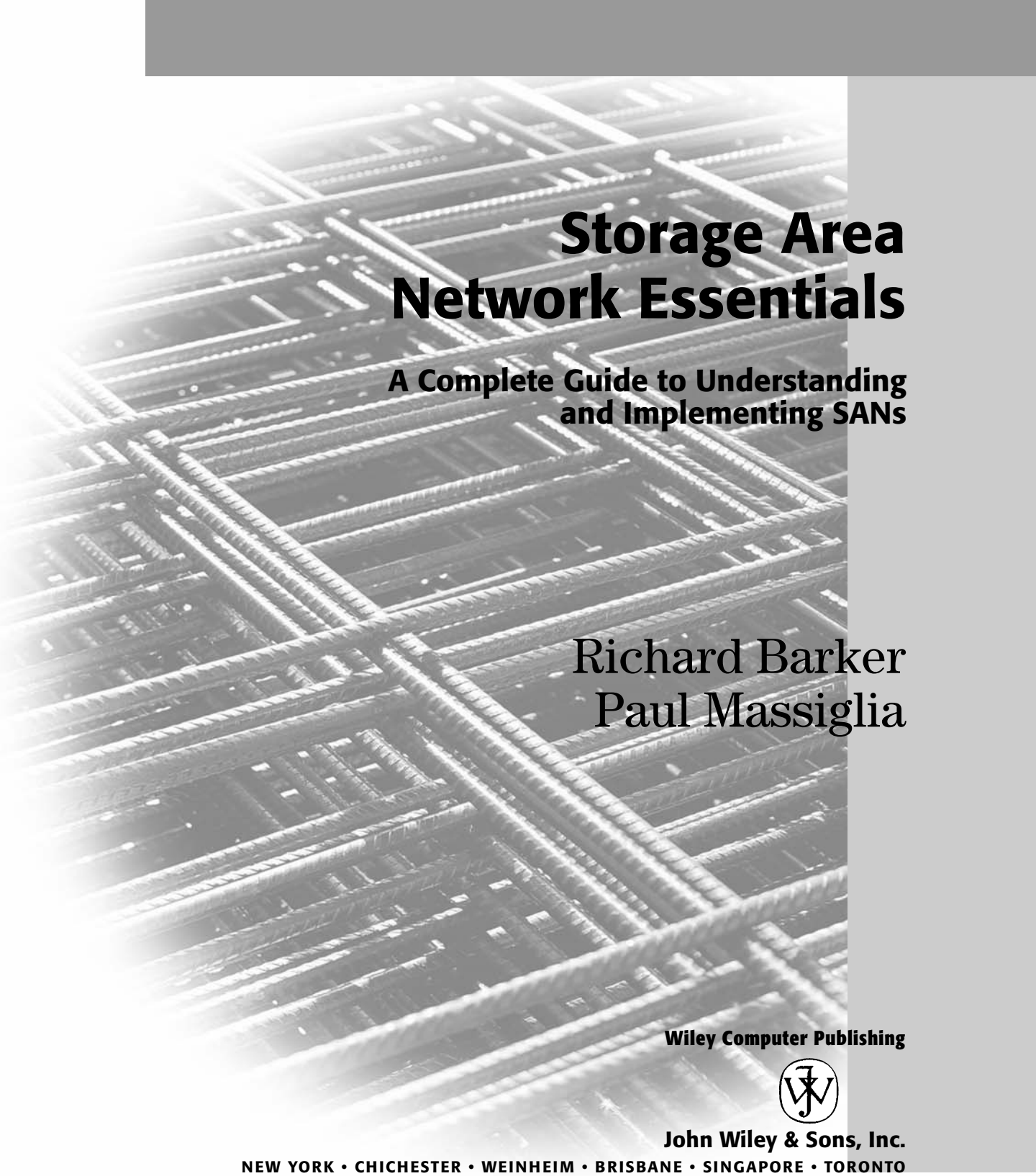
Wiley Computer Publishing

John Wiley & Sons, Inc.
NEW YORK • CHICHESTER • WEINHEIM • BRISBANE • SINGAPORE • TORONTO

Storage Area Network Essentials

Storage Networking Essentials is both useful and readable, a rarity for a treatise on a subject as broad and dynamic as storage networking. Paul and Richard add just the right amount of historical perspective to show why the Storage and Networking communities were destined to meet. Going beyond succinct discussions of technology and implementation, the focus on compelling business motivations make this book an essential introduction approachable by a much wider audience than technical professionals.

Mike Dutch, Director–Strategic Business Development
TROIKA Networks, Inc.



Storage Area Network Essentials

A Complete Guide to Understanding and Implementing SANs

Richard Barker
Paul Massiglia

Wiley Computer Publishing

John Wiley & Sons, Inc.
NEW YORK • CHICHESTER • WEINHEIM • BRISBANE • SINGAPORE • TORONTO

Publisher: Robert Ipsen
Editor: Carol A. Long
Assistant Editor: Adaobi Obi
Managing Editor: Micheline Frederick
Text Design & Composition: North Market Street Graphics

Published by John Wiley & Sons, Inc., New York

Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:

Barker, Richard, 1946–
Storage area network essentials : a complete guide to understanding and implementing SANS / Richard Barker, Paul Massiglia.
p. cm.
ISBN 0-471-03445-2 (cloth : alk. paper)
1. Computer networks. 2. Information storage and retrieval systems.
3. Computer storage devices. I. Massiglia, Paul.

TK5105.5 .B347 2001
004.6—dc21

2001044410

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

The authors wish to dedicate this work to their respective families, always the unsung heroes of all-consuming projects like this. Not only did they support us throughout, but Barbara Barker spent countless hours in the early stages of the project editing Richard's prose and trying to make the manuscript *look* like a manuscript. For her part, Judy Massiglia spent hours driving across boundless tracts of the American southwest one summer so her husband could write while they rode. Now *that's* dedication.

In a very real sense, it wouldn't have happened without you both.

Thanks.

About the Authors

Richard Barker is a Senior Vice President of VERITAS Software Corporation, where he takes a particular interest in storage area networks and network-attached storage devices, especially as they relate to the deployment of highly scalable and usable storage solutions in the global enterprise market. He is a well-known author on CASE topics having written three best selling books in the Oracle CASE (computer-aided systems engineering) Method series. Before joining VERITAS, he served as Senior Vice President of the Consulting and Technical Services Division of OpenVision International, Ltd. and later as Senior Vice President, Product Division. From 1984 through 1994, he was a Senior Vice President of Oracle, responsible for worldwide development and marketing of Oracle's Development Methodology and CASE product set. Prior to that, he managed the development center for the IDMSX mainframe database product for International Computers Limited (ICL) and developed a distributed database system for the U.K. health service. Mr. Barker is also a former board member of the Storage Networking Industry Association (SNIA), the premiere international organization for development and promotion of storage networking technology.

Paul Massiglia is a Technical Director at VERITAS Software Corporation. He represents VERITAS at several standards and industry marketing associations, and writes and lectures extensively. His 21 years in the data storage industry segment have included marketing, engineering, and engineering management positions with the former Digital Equipment Corporation, Adaptec Inc., and Quantum Corporation.

Mr. Massiglia is the former Vice Chairman of the RAID Advisory Board and is currently a member of the Board of Directors of the SNIA.

ACKNOWLEDGMENTS

My thanks to the board members of the Storage Networking Industry Association, who have contributed ideas and comments and have also reviewed early drafts.

My thanks also to Bill North, Guy Bunker, Paul Scammell, and Fred van den Bosch of VERITAS for their input and support.

Several suppliers of SAN software and hardware products offered assistance in the form of images to help illustrate this book. Their inclusion does not suggest that the particular supplier is any better or worse than any other—simply that the picture fit very well. We thank them all for their assistance.

—Richard Barker

I joined this project, which was originated by my manager and coauthor Richard Barker, in June 2000. Richard often jokes (at least, I *hope* he's joking) that I infiltrated his short project to produce a 100-page overview of SANs and turned it into a 500-page tome. Well, right he is about that! As I began to write, I discovered that there was a lot to be said about SANs and particularly about the systems and capabilities they enable that I felt hadn't been adequately covered in the existing literature. So the more we wrote, the more I felt there was to write. Even as we go to press, I can think of additional topics I'd like to cover, such as the role of a putative storage administrator, as well as more I'd like to say on several topics that are covered, like the emerging SAN technologies, whose descriptions are likely to be obsolete before this book reaches the shelves.

But I couldn't have come close to doing my part of this book alone. I wish to take this opportunity to thank the countless VERITAS colleagues and friends who contributed, sometimes unknowingly, to the constantly changing kaleidoscope through which I perceive SAN technology and the enterprise computer systems based on it. Some people who contributed in ways clearly above and beyond the call deserve to be singled out for special thanks:

To Andrea Westerinen, former Technical Director of the Storage Networking Industry Association, who provided the material for Appendix A on standards organizations and industry associations.

To the entire SNIA Technical Council for allowing me to participate in the discussions that led to Chapter 5 on storage network system architectures and particularly to David Black of EMC who kept my interpretation at least somewhat aligned with the

SNIA model. Also thanks to Bruce Naegel of VERITAS for several helpful suggestions on how to describe storage network architectures.

To Steve Macfarlane, Peter Grimmond, and Alan Randolph of the VERITAS Software Corporation consulting organization for providing real-world expertise on which Chapter 11 on SAN adoption processes is based. Particular thanks to Alan Randolph for his exhaustive review of the chapter and for enlightening me about the current state of SAN component interoperability as seen through the eyes of an implementer.

To Brett Cooper of the VERITAS SANPoint Control team for suggesting how to deal with the sprawling topic of SAN management and for reviewing and redirecting my interpretation of the topic.

I thank all these people for their contributions to this project and hasten to add that any remaining errors and omissions are to be laid solely at my door.

Last, I reiterate my thanks to my coauthor, Richard Barker, who managed to seamlessly merge me into a going project and who remained unruffled each time he discovered that his words had been morphed into something else. Richard proves over and over again that less management is more.

–Paul Massiglia

Storage Networking Essentials: A Systems Approach, by Richard Barker and Paul Massiglia, is one of the most complete works addressing storage networking available today. Richard and Paul's thoroughly refreshing approach addresses storage networking from the data center. This is the first work I have had the opportunity to review that focuses on the complete solution from the enterprise application viewpoint. This unique approach to the highly complex topic of storage networking addresses the relevant topics required by systems administrators, implementers, and users of storage networking.

In order to understand my enthusiasm, I would like to take you on a short history of recent trends in storage networking.

> Storage networking has been maturing since the introduction of Fibre Channel in the early 1990s. At first, Fibre Channel interfaces to storage devices were basically server-attached storage (SAS)—a faster, fatter pipe that would allow storage to be located at a greater distance from the server, but it was still a point-to-point connection. All of the storage was dedicated to a single server, and the data was locked to the server. If there was a failure of the system, the data could not be recovered until the system was operational again.
>
> The introduction of Fibre Channel Arbitrated Loop (FCAL) for the first time allowed multiple servers and storage devices to exist on the same connection. FCAL marked the early demonstrations of storage networking, but it was not a very robust server connection. As a bus, it had shared bandwidth connection, it was cumbersome to implement, and it was wrought with early product failures and numerous compatibility issues. FCAL enjoyed limited deployment as a server to storage interconnection. Today it appears mainly as back-end disks to intelligent controller interconnect.
>
> The full, modern-day SAN potential was not realized until the introduction of the first cost-effective Fibre Channel switch, resulting in a switched fabric (FCSW). For the first time, multiple servers as well as data storage devices could exist on a single storage network. Multiple servers could now effectively share large storage devices, allowing open systems the advantage of options previously available only to data center configurations. For the first time data protection, high availability, disaster recovery, and data center wide backup are now available to open system environments.

Bringing us back to the present. Today, a physical interconnection has been defined. What does the future hold? Two discernable directions are emerging.

The first is the quest for a better interconnection scheme. Advancements continue in the Fibre Channel arena—technology that is faster, cheaper, smaller, and cooler, with more intelligence, will be emerging. New interconnection technologies also continue

to emerge. SANs over IP and Infiniband are just two of these emerging technologies that will be competing with Fibre Channel in the future.

These new technologies will enable new functionality within the SAN. Interprocessor communications for data sharing and mobility, increased performance that allows more data to move more freely in the networks, longer and more reliable lines of communications, and much more.

The second development is the exciting new area of storage networking software, embracing the promise of technological breakthroughs. Storage networking has successfully demonstrated that a fundamental, interoperable interconnection infrastructure is alive and healthy, and is well on its way down the deployment path. We can now focus our attention on the real benefits of storage networking, software services, management, and automated policy-based operations. These areas will become the dominant focus of storage networking, propelling storage networking beyond mere interconnection strategies and into the realm of intelligent storage networking. . . . But I am getting ahead of myself.

Richard Barker and Paul Massiglia have assembled the essentials of the state of the art in storage networking with a focus on systems and software. Abundant high-quality illustrations, explanations, and definitions make this a must-read for anyone contemplating storage networking. "How This Book Is Organized" will give you some insight into the overall approach and recommendations for which section is best suited to your background.

I would also highly recommend this book for even the most battle-scarred veteran of storage networking.

It's in my library.

–Larry Krantz
Chairman, Storage Networking Industry Association (www.snia.org)

Welcome to *Storage Area Network Essentials: A Complete Guide to Understanding and Implementing SANs*, the book that cuts through jargon, simplifies storage networking concepts, and helps you determine how your organization's information services department can exploit this exciting new technology to meet evolving information processing needs.

Why is this book necessary? High-speed interconnect technology has made *storage area networks*[1] (SANs) based on both Fibre Channel and Gigabit Ethernet a reality. Every major storage and server vendor offers *SAN-enabled* products that use these advanced interconnects. We predict that essentially every enterprise will eventually employ storage networking, simply because it will be the only alternative. The question for information services departments is whether they will be able to manage SAN deployment or whether it will just happen to them. The successful information services administrators and executives will be those who understand storage networking and become its master.

Storage area networks enable new ways of moving, storing, and accessing data that promote more reliable and cost-effective enterprisewide information processing. SANs simplify data processing and management by off-loading many resource-hungry routine functions to intelligent devices and networks dedicated to and optimized for storage I/O traffic.

It's a safe bet that your competitors are considering storage networking if they are not already using it. As with most compelling new technologies, you either adapt and adopt or you're left in the competitive dust.

About This Book

This book is designed to help the reader understand storage area networks—the properties, benefits, architectural concepts, technologies, and, most important, the pitfalls of storage networking. You won't find detailed descriptions of Fibre Channel protocols or RAID subsystems; other books cover those and, in the authors' opinion, they aren't of primary interest to our intended audience. What you will find that we believe is unique is a description of how the new capabilities enabled by storage networking are implemented in products you can buy. How do they work? Which ones are easy?

[1] If it's *storage networking*, why isn't it just *storage networks?* Where did the *area* come from? We give our view of how storage area networks got their name in Chapter 1.

Which ones are hard? Which ones should be implemented early and which should be delayed until you have some SAN experience under your belt? These are the questions that we think other books on storage networking *don't* cover.

We've spent relatively little time on the emerging interconnects iSCSI, FCIP, iFCP, and Infiniband, which are undergoing development and standardization as this book goes to press. We have concentrated instead on things you can buy today, because those are the products that create the issues you will have to grapple with for the next couple of years.

Who Are You?

So who is our intended audience? In writing this book, we have made some assumptions about our readership. First and foremost, you are up-to-date enterprise information processing technology professionals and are familiar with distributed client/server computing. Your concerns are not so much with the details of any one technology as with acquiring an overall grasp of what technologies can do for you and what they're going to cost you in new skills and ways of doing things. In addition . . .

Networking

You use networks and understand how they have revolutionized enterprise information usage. Your daily professional life includes electronic mail and other client/server applications. The more adventurous among you may operate home networks to share resources among your personal computers. We've spent little time selling the benefits of interconnected enterprises.

Storage

Likewise, we anticipate that you are familiar with the principles of enterprise data storage and management. You know about formatting and partitioning hard disks. On a larger scale, you are familiar with *enterprise RAID subsystems* that provide storage for several servers and employ advanced techniques such as mirroring to improve data reliability and availability. You understand why backups and archives of important data are business necessities and you're familiar with techniques for creating and managing them and what a pain in the neck they are for the people who have to keep applications running.

Strategy

We assume that you are either undecided about introducing storage networking into your organization or that your organization has made the decision to introduce a storage network and *now what?* We believe you want to learn how a SAN can improve your organization's ability to exploit its information assets before you make significant capital and human investments in the technology.

And Last . . .

We believe that you're a professional who fashions the constantly changing mix of computer and network system products on the market into solutions to your organization's information handling problems. Our goal with this book is to make your job easier by giving you a comprehensive introduction to a radically new enterprise data processing paradigm that's sweeping the information services community: *storage networking*.

How This Book Is Organized

There are three parts to this book.

Part One: Understanding Storage Networking

In this part, we present an overview of the SAN concept. We describe what SANs are, how they evolved, what they do, and why enterprises should be using them. We expect this part to be of interest to executives and managers whose responsibilities include enterprise budgeting and planning. The SAN overview and benefits description contained in this part should give budgeters some ideas about the value of SANs to their organizations.

Part Two: The Parts: What's in a SAN

In this part, we drill down into the architectural, storage, networking, and software components that constitute SAN technology, with particular emphasis on the software components. Because other books have covered storage and networking concepts extensively, we've concentrated more on what we perceived to be the white space—architecture and software. We expect this part to be of interest to SAN-based application developers and managers. The technology descriptions should be of assistance when designing application topologies and data center operational procedures.

Part Three: SAN Implementation Strategies

In this part, we describe strategies for moving an enterprise from *server-centric* computing with local storage to a *storage-centric* information processing environment in which the central resource is universally accessible data. We have also included an extensive chapter (Chapter 12) on taming the beast—managing a storage network once you have one. We expect this part to be of interest to IT planners and technical strategists whose responsibilities include planning and leading SAN adoption for their organizations, as well as to IT administrators who will have to keep storage networks up, running, and servicing the organization's information needs.

Other Stuff

There's a lot of churning going on in the data storage and networking industries as we write this book. New interconnects, new management paradigms, and components with new functional splits are starting to appear. We've included an afterword in which we speculate a bit about the future and what it might bring in the way of changes to enterprise data processing and management.

The appendixes contain handy reference information, including a list of standards organizations and other industry groups that concern themselves with storage networking and a glossary of the terminology likely to be encountered during further study of storage networking.

Some Conventions: Terminology to Start With

We define terms that we believe may be unfamiliar to some readers in place as they are introduced. Our usage corresponds to the Storage Networking Industry Association's *Dictionary of Storage Networking Terminology*,[2] which is reproduced in part in Appendix 2. In addition, here are a few terms to get you started.

In this book, we mention *enterprises* frequently. We have chosen this as a blanket term to represent corporations, academic and research institutions, government organizations, and other institutions that use computers to support their business. The focus of this book is on larger enterprises that have multiple servers.

We use the term *data center* to refer to a room or set of adjacent or nearby rooms whose primary purpose is to house computing, networking, and storage equipment. Larger enterprises typically operate several data centers.

It is remarkable that in an industry as mature as data storage, consistent terminology for very fundamental concepts has not been widely adopted. Through its online dictionary, the Storage Networking Industry Association is attempting to standardize storage networking terminology. In general, we have tried to be consistent with the SNIA's usage. There a few key terms whose definitions will be especially helpful. These include:

- The term *disk drive* is used to represent the familiar rotating magnetic media random access nonvolatile data storage device.
- The term *disk* is used to denote either a disk drive (as above) or a virtual disk (sometimes called a logical unit number, or LUN) presented by a RAID controller. This book does not deal with removable disk media such as diskettes or other cartridge devices.
- The term *tape* is used to denote the linear magnetic recording media on which data is stored and accessed sequentially.
- The term *tape drive* is used to denote the transport mechanism in which tapes (as above) may be mounted in order to record and read data. In some cases, the term

[2] The Storage Networking Industry Association's Dictionary of Storage Networking Terminology can be found at www.snia.org/dictionary.

tape drive denotes both the mechanism and the media installed in it (e.g., *data is written to the tape drive . . .*).

- The term *media* is used to refer to objects on whose surfaces data can be permanently stored. Although the term *media* describes the circular platters on which a disk drive stores data, in practice, it is encountered more often when referring to storage objects like tapes and optical disks that can be separated from the mechanisms used to record data on them.
- The terms *library*, *media library*, and *robotic media library* are all used interchangeably to denote a machine that includes removable media storage, one or more tape drives, and a robotic mechanism to move individual tapes between storage and tape drives.
- The term *RAID subsystem* is used to denote a collection of one or more intelligent disk controllers that coordinate the operation of a common set of disk drives. Where the distinction is significant, the terms *embedded RAID controller* and *external RAID controller* are used to distinguish controllers mounted in server enclosures from those packaged separately from the servers they support. Large-scale RAID subsystems, which typically interconnect between dozens of disk drives and two or more computer access ports, are referred to as *enterprise RAID subsystems*.
- The term *storage device* is used to denote either a disk drive, a tape drive, a RAID subsystem, or a tape library containing both tape drives and a robotic media handler.