Preface

The history of storage systems from their creation 50 years ago to the present abounds with dramatic technological advances, changes in user requirements, and emerging engineering challenges. In this issue of the *IBM Systems Journal*, one overview paper and 11 additional papers trace the evolution of storage systems, discuss the major issues facing the storage industry today, and describe a range of IBM-developed solutions for dealing with these issues. We thank our guest editors, Robert Morris and Brian Truskowski, for their efforts in soliciting and acquiring the contributed papers, and in shaping the issue to reflect their vision and experience in storage systems.

In their introductory paper, Morris and Truskowski trace the evolution of storage systems and emphasize the major developments: hard disk drives, storage control units, RAID (redundant array of independent disks), and networked storage. Then they discuss the complexity and high cost of managing storage, and the solutions that have been put forward, such as block virtualization, SAN (storage area network) file systems, and autonomic storage systems. Finally, they discuss future challenges in the storage industry and the research undertaken to address these challenges.

The widespread adoption and commoditization of Ethernet LANs running the TCP/IP protocol have caused increasing interest in extending the use of IP to SANs. In "Internet Protocol storage area networks," Sarkar et al. examine the issues that need to be resolved before this technology gains wide acceptance, and, in particular, the issues of naming and discovery, standardization of protocol, security, and performance.

In "The software architecture of a SAN storage control system," Glider, Fuente, and Scales describe a prototype of a storage control system that provides the hosts in a heterogeneous open systems environment with a logical view of physical storage, thus implementing block virtualization. Preliminary results show that block virtualization brings significant benefits to users, such as, improving the utilization of storage, providing a common platform for advanced functions, and simplifying the job of the storage administrator.

IBM Storage Tank* (ST) is a SAN-based distributed file system for heterogeneous open-systems environments that provides shared file access, centralized management, and enterprise-wide scalability. In their paper on ST, Menon et al. describe its architecture, which includes a client component residing on each participating host, a server component known as the meta-data server, and a protocol for communication between an ST client and the ST server.

In recent years, and especially since September 11, 2001, many businesses require that their IT (information technology) systems survive disasters. For state-of-the-art storage systems, advanced copy functions, such as point-in-time virtual copy and remote continuous copy, are key for satisfying the requirement. In their paper on this topic, Azagury, Factor, and Micka describe the design and implementation of the ESS function Peer-to-Peer Remote Copy. They also discuss at length how different types of remote copy represent trade-offs between levels of performance, consistency, and copy currency.

The IBM TotalStorage Enterprise Storage Server* (ESS) provides unique capabilities for eServer zSeries* and S/390* environments. In their paper on

the z/OS* support for ESS, Meritt et al. describe two new ESS functions, parallel access volumes and I/O request priority, discuss the mechanisms used to exploit and manage these capabilities, and demonstrate the resulting benefits in increased performance and simplified configuration planning.

Policy-based management is frequently mentioned in connection with systems that have self-managing properties, a desirable "autonomic" feature. In their paper on Data Facility Storage Management Subsystem (DFSMS) for OS/390* and z/OS operating systems, Ashton et al. provide an overview of policy-based storage management and then discuss a number of recent enhancements to the product.

In "Beyond backup toward storage management," Kaczmarski, Jiang, and Pease discuss the advanced techniques used to implement IBM Tivoli Storage Manager (TSM). TSM provides backup, archiving, and space management functions in a highly complex hierarchical storage environment: hundreds of network-connected computers—from laptops to mainframes—running a dozen different operating systems and business-critical applications that must be available 24 hours a day and 365 days a year.

Over the past 45 years, the areal magnetic storage density of the hard disk drive has increased by seven orders of magnitude. This led to increases in storage capacity, performance, and availability, and concurrently to miniaturization of form factor and reduced power requirements, all present in RAIDs. In their paper "The technological impact of hard disk drives on storage systems," Grochowski and Halem document the breathtaking evolution of the disk drive and point out that the defining features of state-of-the-art storage systems are due in large part to this evolution. They also make cautious predictions on future increases in areal density for disk drives, on the likelihood of a new technology surpassing magnetic recording as the predominant storage technology, and on future challenges in designing storage systems.

The environment in which we design computing and communications systems is continuously changing because the three basic technologies—processor, communications, and storage—evolve at different paces. In "Characteristics of I/O traffic in personal computer and server workloads" Hsu and Smith empirically examine the physical I/O traffic on a wide range of workloads, and provide a multi-faceted characterization of the I/O traffic data, which is key to our understanding of this changing environment. The paper contains a wealth of data that is likely to be put to good use by researchers and developers when designing future systems or modeling their performance.

In a Technical Note, Dillon et al. discuss the engineering challenges encountered in the combined hardware and software testing of ESS. Although the authors focus on testing a specific set of functions, they suggest their methodology can be applied to many other systems.

IBM TotalStorage Enterprise Storage Server (ESS) is the storage server for high-end disk storage systems. In his paper on ESS, Hartung reviews briefly the evolution of disk storage systems, describes the core functions of ESS, and then discusses the major decisions associated with its architecture and design.

The next issue of the *Journal* is dedicated to e-business management.

Alex Birman
Associate Editor

John J. Ritsko
Editor-in-Chief

*Trademark or registered trademark of International Business Machines Corporation.