IBM

Storage Subsystem Library

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IBM 3990 Storage Control Introduction

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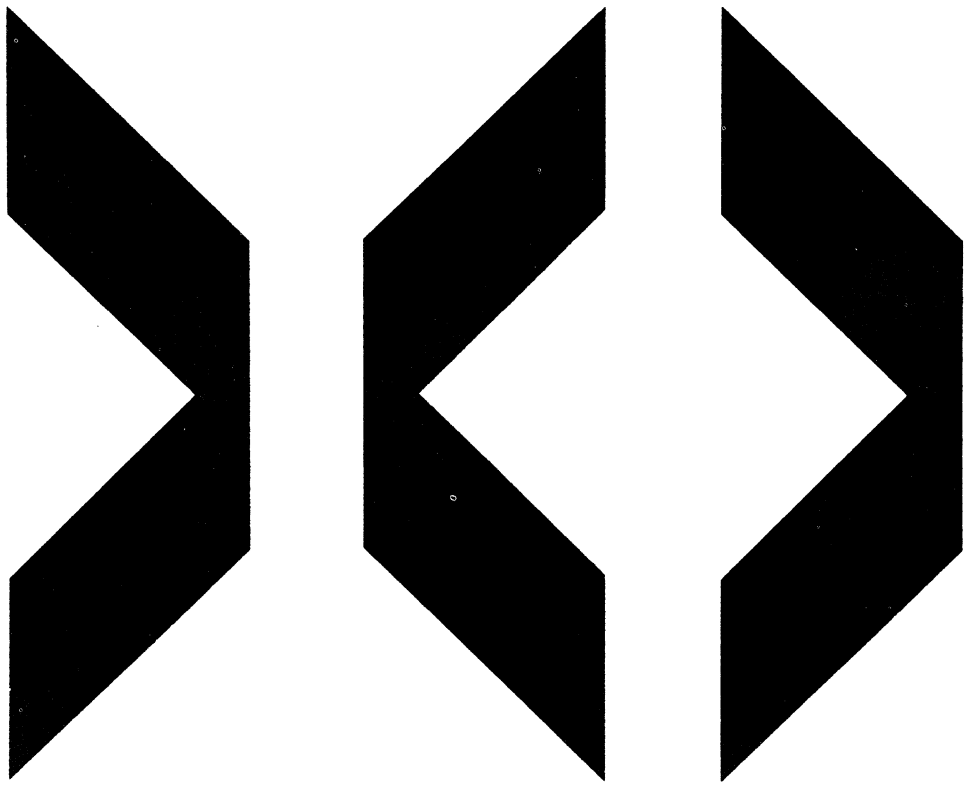

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First Edition (September 1987)

This is the first edition of the IBM 3990 Storage Control Introduction.

Changes are made periodically to the information herein; before using this publication in connection with the operation of IBM systems (or equipment), refer to the latest *IBM System/370, 30XX, and 4300 Processors Bibliography*, GC20-0001, for the editions that are applicable and current.

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Preface

This manual is part of the Storage Subsystem Library (SSL) — a set of manuals that provides information about the hardware components of IBM disk storage subsystems. The SSL includes both direct access storage devices (DASD) and storage control publications. This manual is an introduction to the IBM 3990 Storage Control family and describes its advantages, features, performance characteristics, and software support.

About This Manual

This manual is intended for data processing executives, storage administrators, system programmers, system performance specialists, and IBM marketing representatives and system engineers.

To use this manual productively you should plan to read or have available the other appropriate SSL manuals.

This manual contains the following sections:

Terminology

A comprehensive glossary is provided at the back of this manual. This glossary contains terms used not only in this manual but also in other DASD and storage control manuals in the Storage Subsystem Library.

Before reading further, be sure you understand the way the following terms are used within this manual:

3380, unless otherwise indicated, refers to all models of the IBM 3380 Direct Access Storage except Model CJ2.

Controller refers to the part of the 3380 A-unit that controls the transfer of data between the devices and the storage control.

Device refers to a uniquely addressable part of the 3380 unit that consists of a set of access arms, the associated disk surfaces, and the electronic circuitry needed to locate, read, and write data.

Storage Control refers to the hardware unit that handles interactions between the processor channel and the controller.

Volume refers to the storage space that is accessible by a specific device.

The Storage Subsystem Library

The Storage Subsystem Library describes characteristics, capabilities, and features of the hardware, and it provides instructions for installing, using, and maintaining storage subsystem components effectively in the various operating environments. It is designed to provide both hardware- and software-related information for both direct access storage devices and storage controls.

The Storage Control subset of the Storage Subsystem Library contains the following manuals:

1. *IBM 3990 Storage Control Introduction*, GA32-0098

   Provides an introductory description of the various models of the 3990 Storage Control, including its data availability, performance, and reliability improvements over previous storage controls. In addition, it provides descriptions of the different configuration possibilities, optional features, performance characteristics, and software support of the 3990 Storage Control.

2. *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*, GA32-0100

   Provides a functional description of the IBM 3990 Storage Control. It describes the planning, program installation, and storage management tasks used in typical environments. Configuration examples as well as sample job streams for controlling the various functions of the 3990 Storage Control are provided.

3. *IBM 3990 Storage Control Reference*, GA32-0099

   Provides descriptions and reference information for the 3990 Storage Control. Descriptions include channel commands, error recovery, and sense information.

The DASD subset of the Storage Subsystem Library contains the following manuals:

1. *IBM 3380 Direct Access Storage Introduction*, GC26-4491

   Provides a complete description of the various models of the 3380, including characteristics, features, and capabilities. In addition, the configuration and attachment options are described along with other information that helps in designing a storage subsystem to meet your needs. This manual does *not* cover 3380 Model CJ2.

2. *IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference*, GC26-4497

   Provides a complete description of the 3380 direct channel attach Model CJ2 characteristics, features, capabilities, and string configuration options.

3. *Using the IBM 3380 Direct Access Storage in an MVS Environment*, GC26-4492

   Provides specific guidance for using the 3380 in an MVS/XA or MVS/370 operating environment. The manual provides detailed instruction for planning the addition of new 3380 devices from a logical and physical point of view, installing devices, moving data to new devices, and performing some ongoing activities to maintain a reliable storage subsystem.

4. *Using the IBM 3380 Direct Access Storage in a VM Environment*, GC26-4493

   Provides specific guidance for using the 3380 in a VM/SP, VM/SP HPO, or VM/XA operating environment. The manual provides detailed instruction for planning the addition of new 3380 devices, installing devices, moving data to new devices, and performing ongoing storage management activities to maintain reliable performance and availability. In addition, hardware considerations related to guest systems are addressed.

5. *Using the IBM 3380 Direct Access Storage in a VSE Environment*, GC26-4494

   Provides specific guidance for using the 3380 in a VSE operating environment. The manual provides instruction for planning the addition of new 3380 devices, installing devices, moving data to new devices, and performing ongoing storage subsystem management.

6. *Maintaining IBM Storage Subsystem Media*, GC26-4495

   Describes how the storage subsystem and the various operating systems handle disk storage errors, and provides instruction on using the Environmental Record Editing and Printing (EREP) Program and the Device Support Facilities (ICKDSF) to diagnose and correct disk media errors. Recovery procedures are provided for the various device types. In addition, background material on DASD storage concepts is included.

7. *IBM 3380 Direct Access Storage Reference Summary*, GX26-1678

   Provides a summary of 3380 capacity, performance, and operating characteristics.

8. *Storage Subsystem Library Master Index*, GC26-4496

   Provides a central source of information related to storage subsystem topics. Manuals for IBM 3380 Direct Access Storage, 3380 Direct Channel Attach Model CJ2, and 3990 Storage Controls are indexed in this publication. An overview of the material in the Storage Subsystem Library is provided with this index.

Figure 1 on page vii shows the relationships among the Storage Subsystem Library manuals in terms of high-level tasks described in each manual.

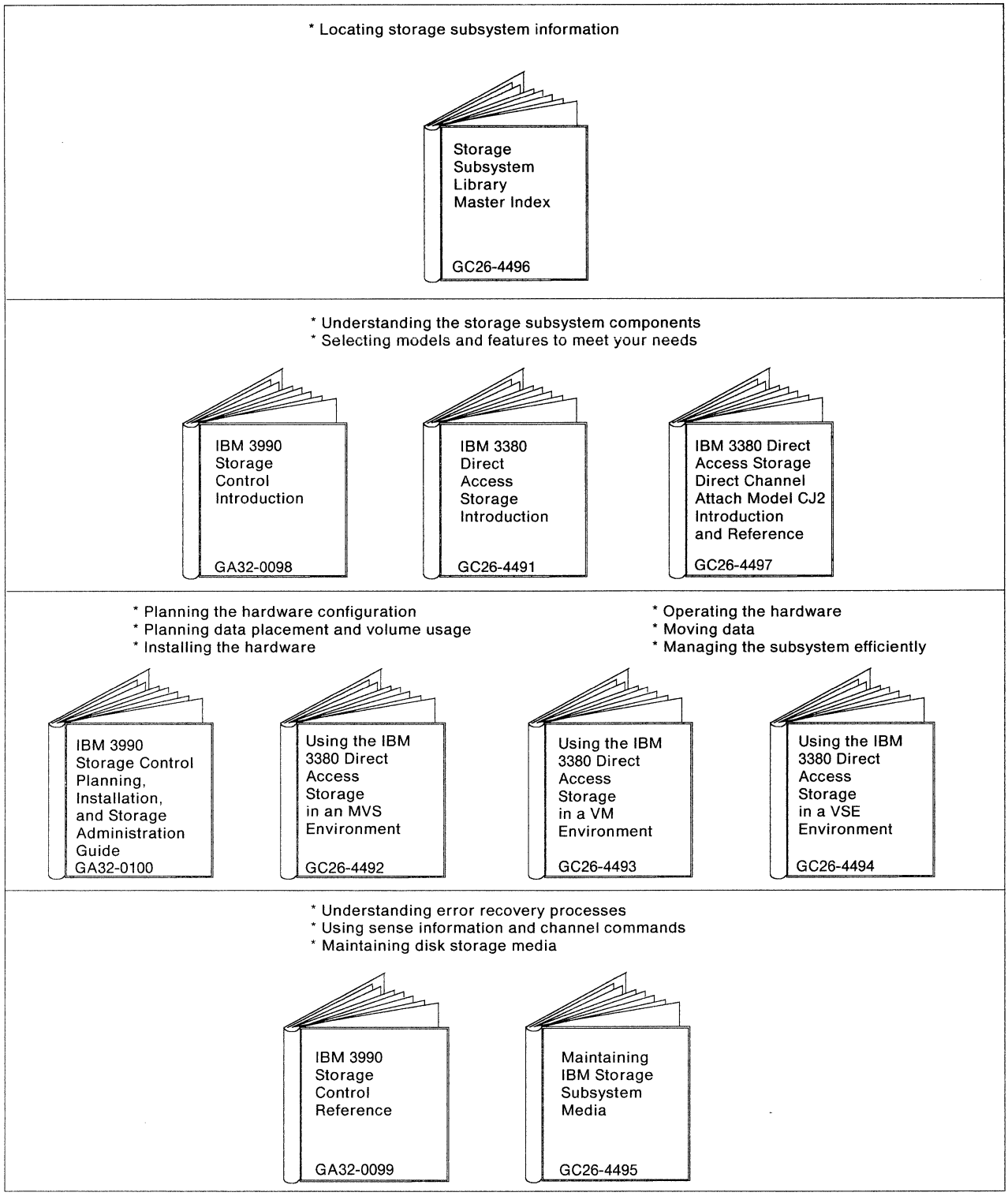


Figure 1. Storage Subsystem Library

SSL Ordering Information

You can obtain a copy of *every manual* in the SSL using one General Bill of Forms (GBOF) number, GBOF-1762. The following GBOF numbers allow you to obtain subsets of the SSL as indicated by the columns in the table below. If you want to order an individual SSL manual, use that manual's order number.

Title	GBOF-1756	GBOF-1757	GBOF-1758	GBOF-1759	GBOF-1760	GBOF-1761	GBOF-0366
IBM 3380 Direct Access Storage Introduction, GC26-4491	X	X	X				
IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference, GC26-4497				X	X	X	
Using the IBM 3380 Direct Access Storage in an MVS Environment, GC26-4492	X			X			
Using the IBM 3380 Direct Access Storage in a VM Environment, GC26-4493		X			X		
Using the IBM 3380 Direct Access Storage in a VSE Environment, GC26-4494			X			X	
Maintaining IBM Storage Subsystem Media,* GC26-4495	X	X	X	X	X	X	
IBM 3380 Direct Access Storage Reference Summary, GX26-1678	X	X	X	X	X	X	
IBM 3990 Storage Control Introduction, GA32-0098							X
IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide, GA32-0100							X
IBM 3990 Storage Control Reference, GA32-0099							X
Storage Subsystem Library Master Index, GC26-4496	X	X	X	X	X	X	X

* *Device Support Facilities: Primer for the User of IBM 3380 Direct Access Storage*, GC26-4498, is distributed with this manual.

Related Publications

These publications, which are not part of the Storage Subsystem Library, describe the various IBM 3880 Storage Control models to which one or more models of the 3380 device can attach:

- *IBM 3880 Storage Control Models 1, 2, 3, and 4 Description*, GA26-1661
- *IBM 3880 Storage Control Model 23 Introduction*, GA32-0082
- *IBM 3880 Storage Control Model 23 Description*, GA32-0083
- *Introduction to IBM 3880 Storage Control Model 13*, GA32-0062
- *IBM 3880 Storage Control Model 13 Description*, GA32-0067.

Cache Device Administration, GC35-0101, describes how to use the MVS utility IDCAMS for the 3990 and the 3880.

Device Support Facilities: Primer for the User of IBM 3380 Direct Access Storage, GC26-4498, is a new publication that is intended for use with the 3380 manuals in the Storage Subsystem Library.

Cache RMF Reporter Program Description/Operation, SH20-6295, provides detailed information on the Cache RMF Reporter.

A bibliography of other publications that may provide additional related information is included at the back of this book. To help you assess the potential usefulness of each reference, the bibliography includes a short description of the relevant contents of each publication.

Contents

Figures

Chapter 1. 3990 Overview

This chapter is an **overview** of the IBM 3990 family of storage controls. Today's businesses expect an ever increasing level of performance from their storage subsystems. The 3990 family of storage controls is designed to meet and exceed the data availability, performance, and reliability requirements that businesses demand. More detailed descriptions are provided in Chapter 2, "IBM 3990 Family" on page 11.

The 3990 Storage Control is available in a full range of configurations and models:

- **3990 Model 1**, designed for mid-range systems with a requirement for two DASD paths.
- **3990 Model 2**, designed for intermediate-to-large systems requiring more than two DASD paths.
- **3990 Model 3**, also designed for intermediate-to-large systems requiring more than two DASD paths *and* also offering four cache sizes from 32 to 256 megabytes and 4 megabytes of nonvolatile storage (NVS).

Figure 2 shows a 3990 Model 3 Storage Control with the new 4-path 3380 Models AJ4/BJ4 and AK4/BK4.

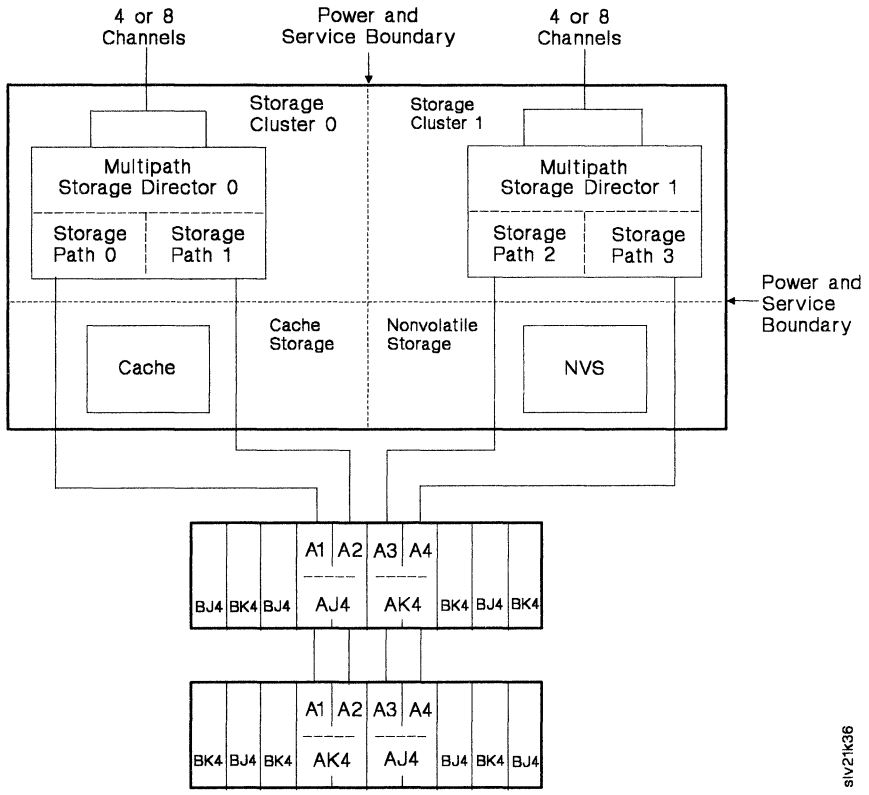


Figure 2. A 3990 Model 3 Storage Control with the New 4-Path 3380 Models AJ4/BJ4 and AK4/BK4

3990 Standards of Data Availability and Performance

All 3990 models address data availability and performance requirements by using:

- Internal processing that is faster than that in previous IBM Storage Controls, reducing the time it takes to move data.
- Faster access to data on the DASD is achieved because control information that formerly was kept in the DASD A-unit is now kept in the 3990.

In addition, the 3990 Models 2 and 3 provide:

- Four storage paths between the 3990 Storage Control and the DASD; twice as many paths as available with the 3880 Models 3 or 23.
- Four independent I/O operations can be active concurrently within the same 4-path string when attached to the IBM 3380 Models AJ4 or AK4.
- Two independent Storage Clusters per frame provide separate power and service regions.

In addition to those improvements given above, the 3990 Model 3 provides:

- Larger cache sizes that result in finding the requested data in cache more often, thus reducing subsystem response time.
- A 4.5 megabytes per second cache data transfer rate.
- Use of IBM's one million bit chip for cache storage.
- Improved cache slot segmentation resulting in more efficient cache space utilization.
- Improved internal cache algorithms resulting in greater efficiency.
- Two new fast write capabilities, **DASD fast write** and **cache fast write**, each allowing cache speed write operations.
- A **dual copy** capability that greatly increases the availability and accessibility of data. The dual copy capability writes all selected data to two different devices, independent of host processing. Immediate access to the information is automatically available on the secondary device if access to the primary device is not possible.

  The **DASD fast write** and the **dual copy** capabilities can be combined resulting in a performance enhancing **fast dual copy**.

- Dual data transfer and branching data transfers between the 3990 and the channel and the 3990 and the device.
- Separate power and service regions for cache and nonvolatile storage.

3990 Standards of Reliability, Availability, and Serviceability

All models of the 3990 family address reliability, availability, and serviceability requirements by using new components and design enhancements including:

- Each storage cluster, within its own power and service region, contains a separate microprocessor-controlled support facility. These independent support facilities provide effective availability and serviceability functions.
- Service Information Messages (SIMs) for improved problem determination and impact assessments.

- Internal design enhancements and newly designed, reliable components to assure a high level of reliable hardware and efficient operation.
- Improved fault isolation for more efficient problem determination.

In addition, the 3990 Models 2 and 3 provide:

- A *nondisruptive DASD installation* capability that allows additional BJ4 or BK4 units or a second 4-path DASD string to be installed in a 3990 subsystem without disrupting host access to the existing DASD.
- Two independent Storage Clusters per frame providing separate power and service boundaries.
- Better reliability, availability, and serviceability characteristics than similarly configured 3880s.

In addition to those improvements given above, the 3990 Model 3 provides:

- A 4 megabyte nonvolatile storage (NVS) that supports both the DASD fast write and the dual copy capabilities.
- In cache storage, all single- and double-bit errors are detected and corrected. All triple-bit errors are detected and most are corrected.

Note: For maximum data availability, all 3990 Model 3 subsystems using either dual copy or DASD fast write should be dual-frame configurations. A dual-frame configuration using the dual copy capability duplicates all common components that may prevent access to data — from the processor channel to the 3990 Model 3 to the DASD record.

The 3990 Storage Control answers the needs of both today and the future's data processing requirements. In all respects, the 3990 Storage Control extends the features and capabilities of the 3880 Storage Controls. Each model of the 3990 Storage Control directly addresses the data availability, performance, and reliability issues of storage management. Even greater performance is available from those 3990 models with cache and the nonvolatile storage.

3990 Performance Features

The 3990 provides a number of attractive performance features. The features described below are significant performance improvements over the previous family of IBM storage controls.

Faster and More Efficient Microprocessing

All the 3990 Storage Controls use faster internal processing techniques than previously available and more efficient microprocessing that permits faster data access.

Four Storage Paths

As a new standard of data availability and overall performance, twice as many storage paths are provided in the 3990 Models 2 or 3 than in the 3880 Model 3 or 23 Storage Controls. When attached to the new 4-path 3380 Models AJ4/AK4, the 3990 can operate in a new high performance and high data availability mode: Device Level Selection Enhanced (DLSE).

When the 3990 Model 2 or 3 is attached to the new 4-path 3380 Models AJ4/AK4, the accessibility of data is even greater than the accessibility of data when attached to 3380 AD4/AE4 devices operating in Device Level Selection (DLS) mode. Attaching to the new 3380 AJ4/AK4 devices allows the 3990 to operate in the new DLSE mode giving twice as many paths to each device. (See "Device Level Selection Enhanced Mode of Operation" on page 16 for more information.)

With the new Device Level Selection Enhanced mode of data transfer, simultaneous data transfer is possible over all four storage paths within the same 4-path string. A DLSE storage subsystem, even with one of its four paths disabled, performs better than a DLS subsystem with both of its paths available. The performance of three paths of a DLSE subsystem is approximately the same as the performance of two DLS subsystems (with two paths each). (See "Device Level Selection Mode of Operation" on page 16 for more information.)

Figure 3 shows the data transfer capabilities of both the DLS subsystem and the DLSE subsystem.

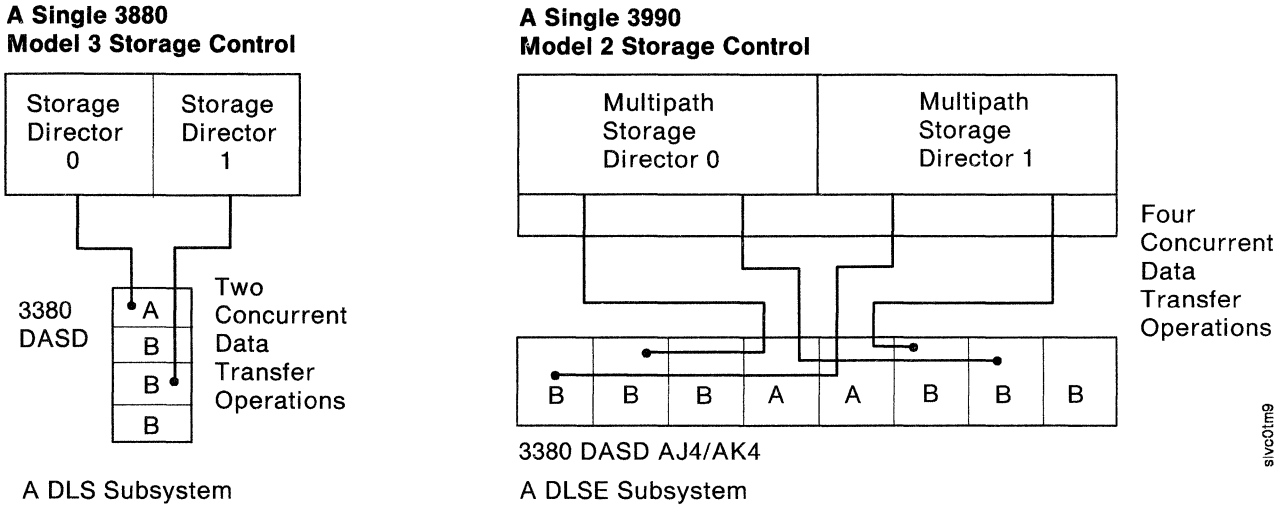


Figure 3. Examples of Data Transfer Capabilities of DLS and DLSE Subsystems

Cache (3990 Model 3 Only)

3990 Model 3 cache performance enhancements include:

- Cache sizes of 32, 64, 128, or 256 megabytes.
- Sequential cache management algorithms have been refined to provide faster cache access to sequential data.
- Cache is managed in 16K segments providing more efficient use of the cache.
- Up to eight concurrent operations inside the cache provide more internal efficiency. This efficiency means less contention for components within the subsystem and a higher data throughput.

Fast Write Capabilities (3990 Model 3 Only)

Two significant performance benefits to 3990 Model 3 users are:

- **DASD fast write:**
  - Permits write operations to be performed at cache speeds.
  - Provides data integrity equivalent to DASD writes.
  - Eliminates the requirement to write the data to the DASD immediately.
  - Frees the channel for other activities and additional operations.
  - Maintains a copy of the data in the NVS until it is destaged (written from the cache to the DASD).
- **Cache fast write:**
  - Recommended for small- to intermediate-size sort work files, cache fast write permits the selected write operations to be performed at cache speeds without requiring writes to DASD.

DASD Fast Write and Cache Fast Write Advantages

Both fast write capabilities permit write operations to be performed at cache speed, eliminating the need to write data to the DASD immediately. These capabilities provide faster response times, particularly for DASD volumes with high write activity resulting in improved overall subsystem performance. (See "Fast Write" on page 20 for more information on the DASD fast write and cache fast write capabilities.)

4.5 or 3.0 Megabytes Per Second Channel Speed

The 3990 Model 3 has the capability to transfer cache data at either 4.5 or 3.0 megabytes per second. The actions required to run the 3990 Model 3 at the 4.5 megabytes per second channel speed are: set the channel speed at installation time and execute the I/O Configuration Program (IOCP) specifying 4.5 megabytes per second as the channel speed.

On the same 3990 Model 3, some channel interfaces can operate at 4.5 megabytes per second while other channel interfaces can operate at 3.0 megabytes per second, depending on the processor type. However, any storage control using 4.5 megabytes per second channel speed must be installed first on the channel interface and be connected to the channel with blue channel interface cables (channel set 0185).

All 3990 Storage Controls must use the blue channel interface cables (channel set 0185).

All storage controls that are installed ahead of a 3990 must also be installed with blue channel interface cables. The 3990 Storage Controls that operate only at 3.0 megabytes per second are not required to be ahead of all other storage controls, but it is recommended.

3990 Reliability, Availability, and Serviceability Features

The 3990 provides a number of reliability, availability, and serviceability features. New components and several design enhancements improve the IBM 3990's reliability, availability, and serviceability (RAS) characteristics over those of the previous family of IBM Storage Controls. These features are briefly described below.

Dual Copy

A major improvement in data reliability and availability is provided by **dual copy**. Available on the 3990 Model 3, dual copy provides a duplicate copy of a volume on two devices. Dual copy is user-defined for a volume. For a dual copy volume, each time the primary device is updated, the 3990 Model 3 automatically updates the secondary device. The data transfer operations are automatically switched to the secondary device if a failure occurs on the primary device.

Dual copy provides important advantages:

- Protects a critical volume from a single device failure.
- Permits the concurrent writing of data to separate devices.
- Provides for near-continuous operations by providing a back-up copy if loss of access occurs to one of the dual copy devices.
- Ensures that the second copy is identical to the primary copy.

See "Dual Copy" on page 23 for more information on the dual copy capability.

The DASD fast write capability and the dual copy capability can be combined resulting in a **fast dual copy**. When the user specifies both DASD fast write and dual copy operations, the performance is approximately equal to that of normal cache operations. (See Chapter 7, "Performance Characteristics" on page 57 for additional information.)

Two Independent Storage Clusters

Single-frame 3990 Models 2 and 3 provide a *pair* of independent *storage clusters* (usually shortened to clusters). A clear benefit of each of the clusters is that they are independent components. Each cluster provides a separate power and service region and two separate paths to the DASD. Loss of power to one cluster does not disable the storage control because processing continues through the other storage cluster. A service representative can take one cluster for maintenance activities while cache and DASD access continues through the remaining cluster's two paths.

In the 3990 Model 3, cache storage and nonvolatile storage are shared by the storage paths, but are logically and physically separate from the storage clusters.

Support Facility

Each storage cluster has its own support facility. A major RAS enhancement, the support facility permits concurrent maintenance and provides a remote maintenance support capability. Among other tasks, the support facility monitors subsystem activity, generates the service information messages (SIMs), communicates with the other support facility (in 3990 Models 2 and 3), runs maintenance analysis programs (MAPs) and diagnostics, and logs error conditions on diskette storage.

The concurrent maintenance and remote maintenance support capabilities of the support facility (in each independent storage cluster) in combination with the service information messages (SIMs) significantly reduce problem determination time and effort, and the total maintenance time.

Concurrent Maintenance

The concurrent maintenance provided through the 3990 Models 2 and 3 support facility greatly improves the availability of DASD data. Because of the power and service boundaries built into the 3990, one storage cluster can continue to access cache and DASD while maintenance activities are taking place on the other storage cluster.

A service action can be performed on cache while direct access to DASD is provided through the storage clusters.

A service action can be performed on nonvolatile storage while caching operations and direct access to DASD continues through the storage clusters.

Remote Maintenance Support

The remote maintenance support capability permits a support representative in a remote field support center to establish communication with either storage cluster in a 3990 through an external modem. Once the communication link is established, the remote support representative can analyze the error data and send maintenance information to the service representative on site.

An access code, valid for one hour, is required to authorize a remote connection. All remote maintenance support sessions are protected by a 3990-generated access code. Having the 3990 generate the access code ensures the integrity of the remote session and prevents unauthorized data links to the 3990.

Writeable Diskette

The diskette contains 3990 microcode, microcode patches, error log, and the soft-copy maintenance analysis procedures (MAPs).

During either local or remote maintenance support activities, microcode patches can be transmitted to the 3990 support facility and stored on the 3990's diskette. Microcode patches written on the diskette are not lost across IMLs.

The installation retains control of when microcode patches are implemented. Those patches written on the diskette are not implemented until the installation asks a local service representative to do so.

Service Information Messages (SIMs)

Service information message-format sense data (SIMs) and SIM alert messages provide a much improved method of notifying the user of any failure.

SIM Alert Messages

SIM alert messages inform operators of a hardware failure. The SIM alert messages are displayed by a host error recovery program (ERP).

SIM Messages

The SIM message identifies the impact of the failure, and the effect of the repair action through an EREP exception report. The installation can use this information to schedule the repair action, based on the severity of the failure, and the resource required to repair it. These messages provide information about the failure so that the service representative can bring the most likely repair parts, significantly reducing repair time and the possibility of return calls. (For more information on SIM messages, see the *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*.)

Because of the service information message and the SIM alert message, any failure can, in most cases, be fixed quickly through replacement parts identified by the SIM message. Also, the installation can make a more informed decision about scheduling any repair action.

Ease of Migration

All 3990 features (including Four Channel Switch, Additional) are field-installable and field-upgradable. Any 3990 model can be upgraded to a higher model number in the customer's installation and larger cache size increments can be added to a 3990 Model 3. (See Chapter 6, "Optional Features" on page 55 for information on the features available on a 3990 Storage Control.)

Nondisruptive DASD Installation

Businesses with expanding DASD configurations will appreciate the nondisruptive installation capability of the 3380 Models AJ4/AK4 attached to 3990 Storage Controls. When adding 3380 Models AJ4/BJ4 and AK4/BK4 as 4-path strings to an installed 3990 DLSE subsystem with at least one 4-path 3380 Model AJ4 or AK4 installed, the additional devices can be installed and brought online:

- Without disrupting any application
- Without removing power from the 3990
- Without stopping the operating system
- Without taking any channel path offline.

When 4-path 3380 Models AJ4 and/or AK4 are attached to a 3990 Model 2 or 3, it is possible to add BJ4s or BK4s to the string without disrupting operation and availability of existing devices on the string. Similarly, a second 4-path 3380 Model AJ4 or AK4 string can be attached to the 3990 Storage Control without disrupting the operation and availability of an existing 4-path string. During this nondisruptive DASD installation process, only one of the four paths to the DASD string is offline to the subsystem. To take advantage of the nondisruptive DASD installation capability, it is a requirement that the devices planned for future installation have assigned addresses that are predefined to the operating system, the storage control, and the processor channel subsystem in 3090, 308X, and 4381 environments.

Intermixed Strings of DASD

Strings of 3380 Models AJ4 or AK4 (2- or 4-path capability) can be intermixed with strings of 3380 AA4, AD4, or AE4 (2-path capability) to form a single DASD storage subsystem. However, it is not possible to intermix 2-path and 4-path 3380 AJ4 or AK4 strings in the same subsystem.

Environmental Features

Improved technology and packaging techniques reduce the power and cooling requirements for a 3990 Storage Control from those required for the 3880 Storage Control on a per path basis comparison.

For information on power and cooling requirements, see the *IBM Input/Output Equipment Installation – Physical Planning for System/360, System/370, and 4300 Processors*.

Also, because four paths to DASD are built into each single-frame 3990 Model 2 or 3, twice as many paths to DASD are provided over the number of paths available in the previous family of storage controls. For example, *one 3990 Model 2* provides the same number of paths (four) to the DASD as there are in *two 3880 Model 3s or 23s*. The 3990 Model 2 or 3 provides four paths to DASD in the same floor space as two paths from a 3880 to DASD. Because side clearance is no longer required, the total required floor space is reduced by more than half.

Thus, twice as many device actuators can be attached to the 3990 Model 2 or 3 as can be attached to the 3880 Model 3 or 23.

Chapter 2. IBM 3990 Family

The structure and features of the 3990 family are a logical extension and significant improvement over the structure and capabilities of the IBM 3880 family of storage controls. The IBM 3990 Storage Control attaches all models of the IBM 3380 Direct Access Storage Devices except Model A04 and CJ2.

The 3990 is available in three models:

- 3990 Model 1 with two separate storage paths to DASD
- 3990 Model 2 with four separate storage paths to DASD
- 3990 Model 3 with four separate storage paths to DASD and 32, 64, 128, or 256 megabytes of cache, and 4 megabytes of nonvolatile storage.

A single 3990 Model 2 or a single 3990 Model 3 can attach up to 16 different channels and provides four paths to DASD.

The 3990 Models 1 and 2 are supported by MVS/370, MVS/XA, VM/XA SF, VM/XA SP, VM/SP, VM/SP HPO, VSE, and TPF. Basic 3990 Model 3 cache operations are supported by MVS/XA, MVS/370, VM/SP HPO and VM/XA SF. The 3990 Model 3 extended function cache operations of **dual copy** and **DASD fast write** will be supported by MVS/XA.

3990 Model 1

A single 3990 Model 1 provides the same function as a single-frame 3880 Model 3 plus the performance and reliability characteristics of the 3990 family. It is intended for midrange systems that require two storage paths to the DASD.

See Figure 4 on page 13 for a comparison of a 3880 Model 3 and a 3990 Model 1. See "3990 Model 1" on page 35 for a more complete description of a 3990 Model 1.

3990 Model 2

A single 3990 Model 2 provides the same function as two cross-configured 3880 Model 3s plus the performance and reliability characteristics of the 3990. It is intended for intermediate-to-large systems that require up to four storage paths to the DASD.

The single 3990 Model 2 is a fundamental enhancement of two cross-configured 3880 Model 3s. Because of its improved data availability, performance, and the increased reliability, availability, and serviceability characteristics, the 3990 Model 2 will satisfy most DASD configuration requirements. A dual-frame configuration option is available for the 3990 Model 2.

See Figure 5 on page 14 for a comparison of two 3880 Model 3s and a single 3990 Model 2. See "3990 Models 2 and 3" on page 37 for a more complete description of a 3990 Model 2.

3990 Model 3

The 3990 Model 3, with 32 to 256 megabytes of cache and 4 megabytes of NVS, provides all of the performance and reliability characteristics of the 3990. It expands the capabilities of a dual-frame 3880 Model 23.

The single 3990 Model 3 is a fundamental enhancement of a dual-frame 3880 Model 23. In one 3990 Model 3, with the added benefits of cache fast write, DASD fast write, and dual copy:

- The cost per path to DASD is substantially less than a pair of 3880 Model 23s in a dual-frame configuration.
- The performance is much better.
- The DASD availability is significantly improved.

A dual-frame configuration option is available for the 3990 Model 3.

See Figure 6 on page 15 for a comparison of a pair of 3880 Model 23s in a dual-frame configuration and a single 3990 Model 3. See "3990 Models 2 and 3" on page 37 for a more complete description of a 3990 Model 3.

Summary of 3990 Models 1, 2, and 3 Improvements

The following figures summarize the 3990 Model 1, 2, and 3 improvements over the 3880 Storage Controls.

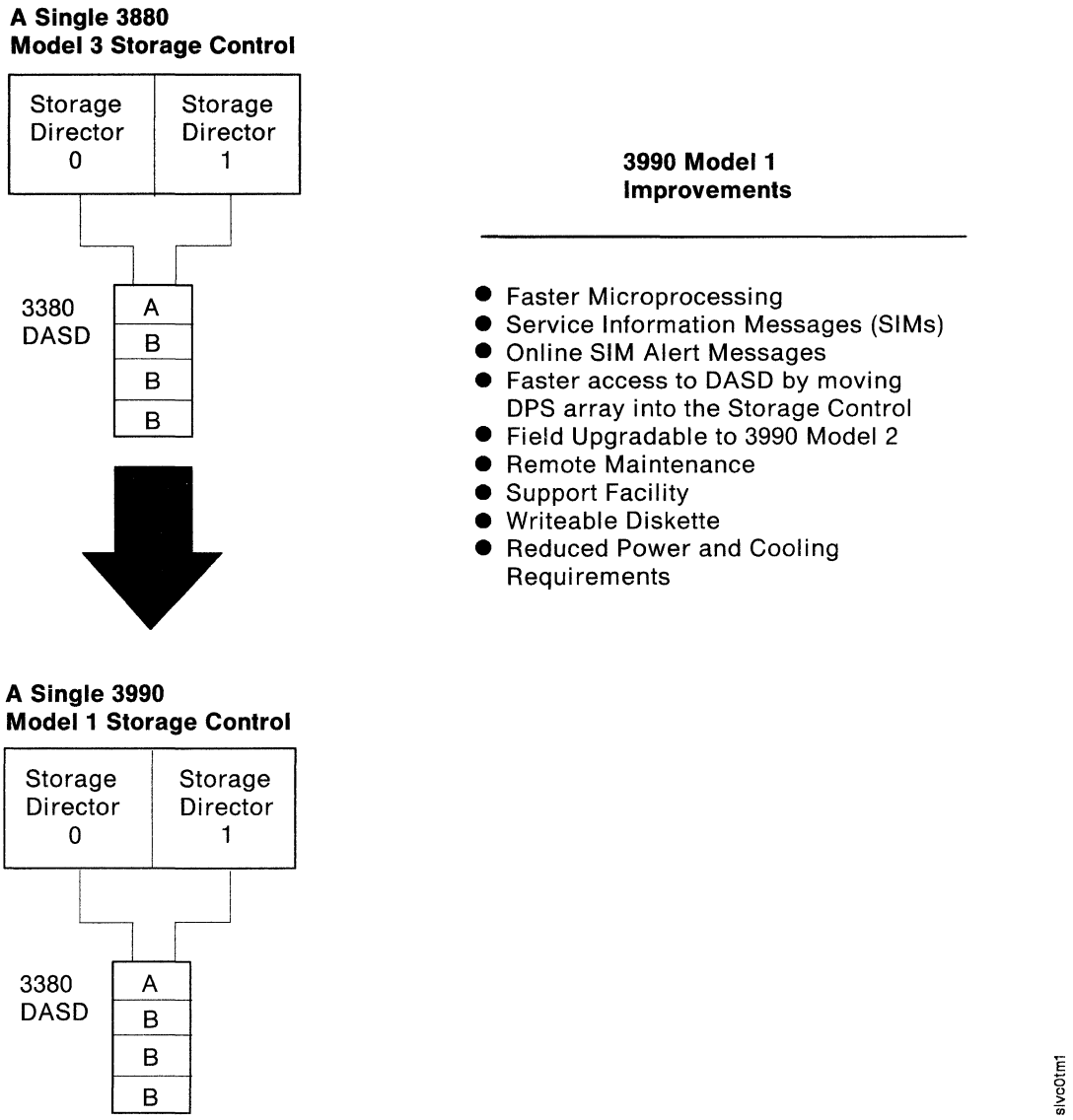
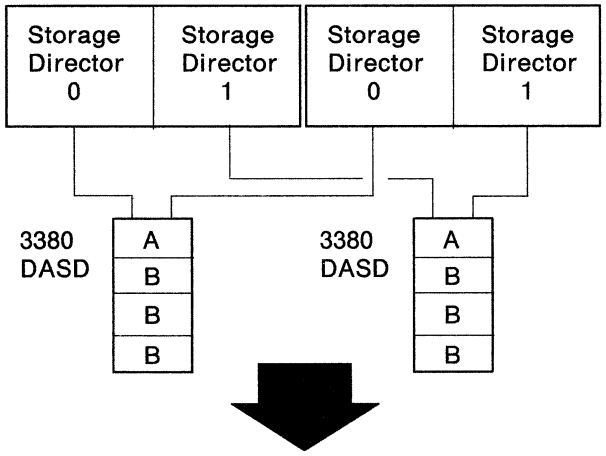
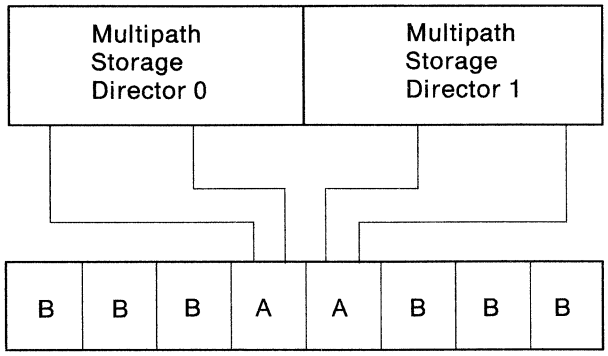


Figure 4. A 3880 Model 3 and a 3990 Model 1

Two Cross-Configured 3880 Model 3 Storage Controls



A Single 3990 Model 2 Storage Control in DLSE Mode



3380 DASD AJ4/AK4

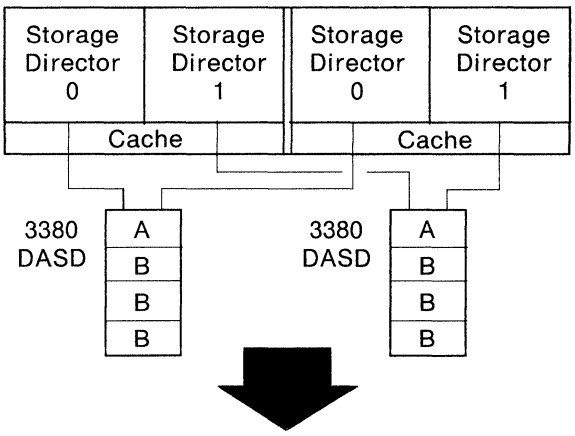
3990 Model 2 Improvements

- Nondisruptive DASD Installation
- DLS or DLSE Mode (Two or Four Data Transfer Paths to DASD)
- Multipath Storage Directors
- Concurrent Maintenance
- Independent Support Facilities
- Two Independent Storage Clusters
- Uses Less than Half the Floor Space of Two Cross-Configured 3880 Model 3s with Service Clearance
- Faster Microprocessing
- Service Information Messages (SIMs)
- Online SIM Alert Messages
- Faster Access to DASD by Moving DPS Array Into the Storage Control
- Field Upgradable to 3990 Model 3
- Remote Maintenance
- Writeable Diskette
- Reduced Power and Cooling Requirements

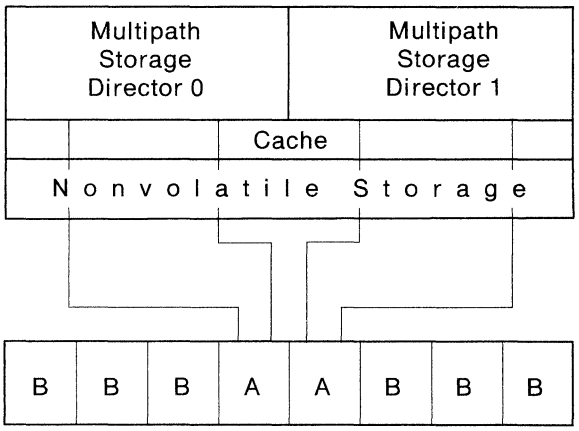
slvc0tm2

Figure 5. Two Cross-Configured 3880 Model 3s and a Single 3990 Model 2

A Dual-Framed 3880
Model 23 Storage Control



A Single 3990
Model 3 Storage Control in DLSE Mode



3380 DASD AJ4/AK4

3990 Model 3
Improvements

- 32, 64, 128, or 256 Mb Cache
- 4 Mb Nonvolatile Storage (NVS)
- DASD Fast Write
- Dual Copy
- Cache Fast Write
- 4.5 Megabyte Per Second Cache Data Transfer Speed
- Dual Data Transfer
- More Efficient Use of Cache Storage
- Nondisruptive DASD Installation
- DLS or DLSE Mode (Two or Four Data Transfer Paths to DASD)
- Multipath Storage Directors
- Concurrent Maintenance
- Independent Support Facilities
- Two Independent Storage Clusters
- Uses Less than Half the Floor Space of a Dual-Frame 3880 Model 23 with Service Clearance
- Faster Microprocessing
- Service Information Messages (SIMs)
- Online SIM Alert Messages
- Faster Access to DASD by Moving DPS Array into the Storage Control
- Field Upgradable to Larger Cache Sizes
- Remote Maintenance
- Writeable Diskette
- Reduced Power and Cooling Requirements

slvc0tm3

Figure 6. Two 3880 Model 23s in Dual-Frame and a Single 3990 Model 3

Advantages of 3990 Storage Controls

The 3990 may be operated in either of two modes: Device Level Selection (DLS) or Device Level Selection Enhanced (DLSE). Both DLS and DLSE modes allow the 3990 to select the most appropriate and efficient path to any attached device. Fast write and dual copy operations can be used in either DLS or DLSE mode.

DLSE mode fundamentally enhances the performance and data availability characteristics over those of DLS mode.

Device Level Selection Mode of Operation

Device Level Selection (DLS) Support Mode permits two single-path storage directors to access data in the DASD subsystem. In DLS support mode, there is a one-to-one relationship between the storage director and the storage path.

DLS provides DASD strings with two paths to each actuator and simultaneous data transfer to any two actuators in the 2-path string (except 3380 Model AA4).

When the 3990 attaches to 3380 AD4 or AE4, it operates in DLS (2-path) support mode (shortened to DLS mode for the remainder of this manual). When the 3990 is attached to 3380 AA4, the 3990 operates according to the dynamic path selection capability of the 3380 AA4. When the 3990 is attached to 3380 AJ4/AK4 DASD, and the logical subsystem operates in DLS mode, feature 9432 must be installed on the 3380 AJ4/AK4.

A storage path is a *single-path storage director* in DLS mode. For 3990 Models 2 and 3 in DLS mode, there are two independent logical DASD subsystems within this configuration (3990 Model 1 has only one logical DASD subsystem). As with two 3880s, the operating system addresses each of the four storage paths. Storage director 0 and 2 address one set of devices, storage director 1 and 3 address a different set of devices.

Note: For a description of the features that are required when attaching the different models of the 3380 DASD to the 3990, see Chapter 6, "Optional Features" on page 55.

Device Level Selection Enhanced Mode of Operation

Device Level Selection Enhanced (DLSE) Support Mode permits two *multipath storage directors* to access data in the DASD subsystem. Each multipath storage director has two storage paths. In DLSE support mode (shortened to DLSE mode for the remainder of this manual), there is a one-to-one relationship between the storage director and the storage cluster, consisting of two storage paths.

DLSE provides DASD strings with four paths to each actuator and *simultaneous data transfer* to any four actuators in the attached 4-path strings. DLSE allows any device to be selected over any of four paths, including those of the same head disk assembly (HDA), instead of either of two paths, as in DLS—resulting in a significant improvement in data throughput and overall subsystem performance.

DLSE is a logical extension of DLS. However, the physical configuration and the mode of operation are somewhat different. In the same way that the channel subsystem relieves an extended architecture (XA) processor of the path management task, so the 3990 DLSE subsystem relieves the channel subsystem (or operating

system for non-XA system control programs) of the need to select the storage path from the storage control to the DASD. This is done by pairing storage paths within a cluster into one multipath storage director. Thus, the host processor addresses the multipath storage director just as it does a 3880 single-path storage director. The multipath storage director allocates the storage path to use for data transfer operations.

Note: The dynamic path reconnection capability of the 3380 is only available with XA system control programs. In a non-XA system, switching can only be done between the two storage paths within a multipath storage director.

When the 3990 Model 2 or 3 is attached to 3380 Models AJ4 or AK4, two modes of operation are possible: DLS or DLSE. DLS mode with 3990 Model 2 or 3 attached to Models AJ4 or AK4 works just as it does when the 3990 Model 2 or 3 is attached to Models AA4, AD4, or AE4. (The 3990 Model 1 operates in DLS mode only.)

The Device Level Selection Enhanced (DLSE) mode is available only when 3990 is attached to 3380 Models AJ4/BJ4 or AK4/BK4 and they are configured as 4-path strings. *DLSE mode permits concurrent and independent data transfer with any four devices within a 4-path DASD string.* Only the Models 2 and 3 can be configured as DLSE subsystems, which can have up to 64 device addresses in a single logical subsystem (twice as many addresses as in a 3880 Model 3 or 23 subsystem).

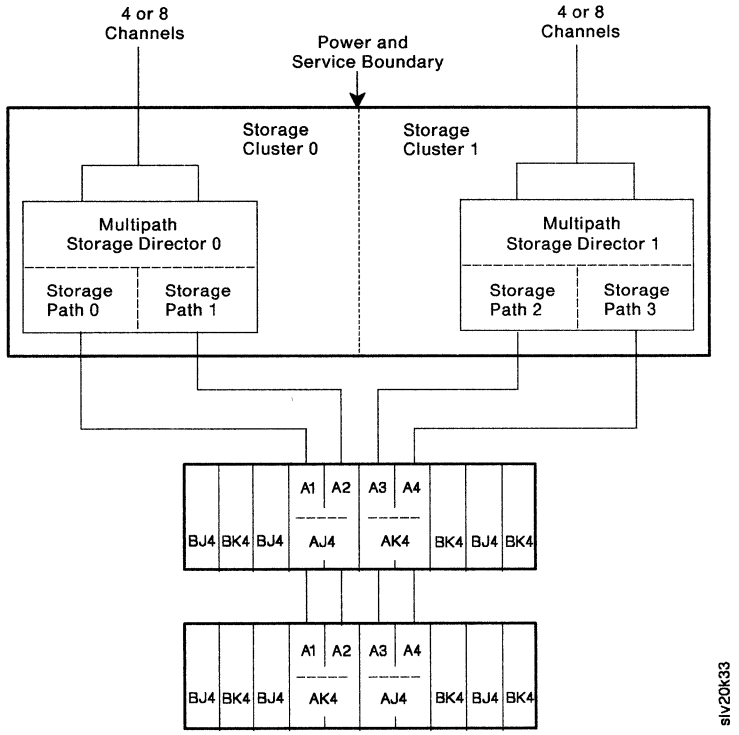
DLSE provides important performance advantages:

- Four independent and simultaneous data transfer paths to the same DASD strings from the 3990 Storage Control. Also, in an XA environment an I/O operation can be dynamically reconnected on any one of the four paths; in fact, with DLSE there are four complete independent paths to the DASD, substantially improving the availability of the data.
- The performance impact of the loss of one of the four paths is substantially less than the performance impact of the loss of a path in a DLS subsystem. A DLSE storage subsystem, even with one of its four paths disabled, performs better than a DLS subsystem with both of its paths available. The performance of three paths of a DLSE subsystem is approximately the same as the performance of two DLS subsystems (with two paths each).
- The decision on which storage-control-to-DASD path to use is usually determined at the storage control level, eliminating possible delays if the selected path is busy.

Figure 7 shows the physical connections of a 3990 Model 2 or 3 Storage Control in DLSE mode attached to 3380 Models AJ4 or AK4 4-path strings. The 3990 Model 2 or 3 can attach one or two 4-path DASD strings or one 4-path DASD string and one or two 2-path DASD strings.

The DLSE configuration requires feature 9433 be installed on the 3380 AJ4 or AK4.

Figure 7 shows a 3990 Model 2 or 3 in DLSE mode.

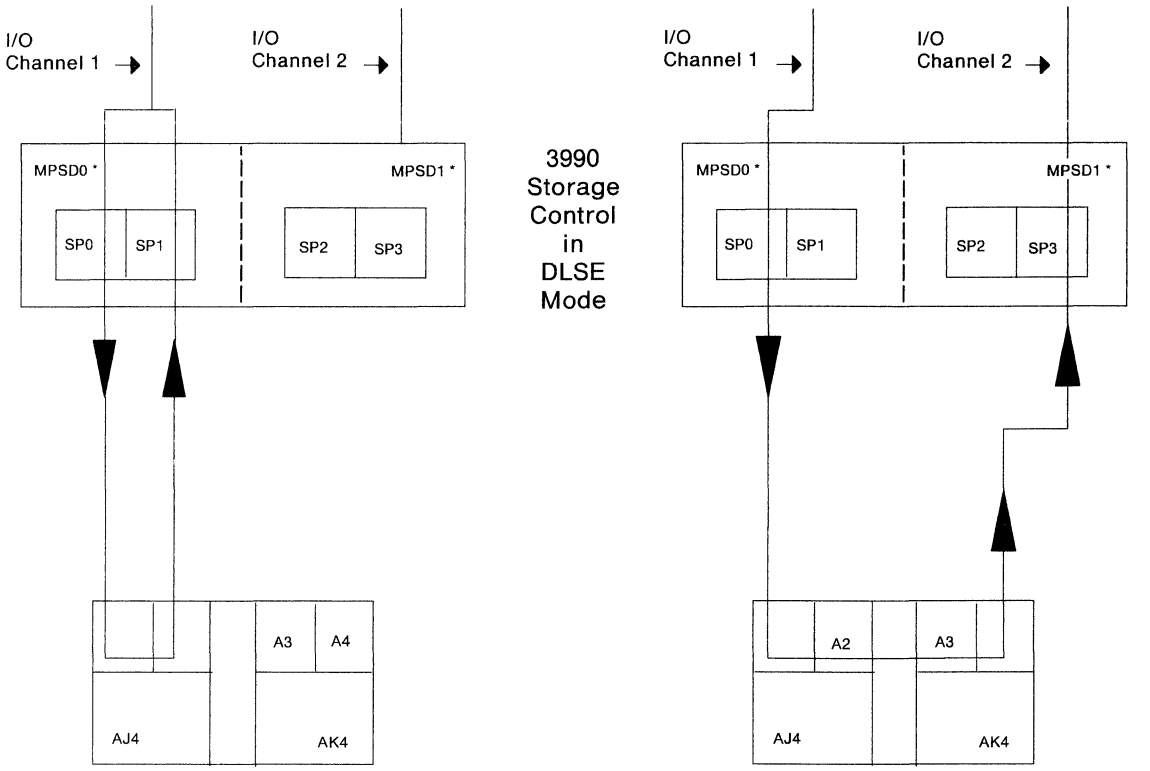


Note: The figure shows a maximum configuration of four A-units and 12 B-units. A minimum configuration consists of two A-units in the same string.

Figure 7. 3990 Model 2 or Model 3 in DLSE Mode Attached to 3380 Models AJ4 or AK4 4-Path Strings

Figure 8 shows an example of an I/O operation of the 3990 in DLSE mode in S/370 and 370/XA environments. In S/370, DLSE allows an I/O operation to complete on either of the storage paths in the multipath storage director that initiates the I/O operation. In 370/XA, DLSE allows an I/O operation to return over any of the available paths.

Note: For a description of the features that are required when attaching the different models of the 3380 DASD to the 3990, see Chapter 6, "Optional Features" on page 55.



Note: S/370 Input/Output MUST start and complete on the same channel path.

Note: 370/XA Input/Output may start and complete on either path.

* MPSD = Multipath Storage Director

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Figure 8. S/370 and 370/XA Input/Output Operation Example, 4-Path DASD (DLSE)

Fast Write

There are two types of fast write operations: **DASD fast write** and **cache fast write.** Both fast write operations can improve performance for write hits or full track format write operations. Fast write operations can be used in either DLS or DLSE mode.

DASD Fast Write

DASD fast write improves storage subsystem performance because immediate access to DASD is not required for write hits and full track format writes. DASD fast write stores data simultaneously in cache and in nonvolatile storage (NVS).

Using DASD fast write requires no modifications to access methods or applications. Access to DASD is not required to complete the DASD fast write operation for write hits. Because a copy of the data is put into the NVS, the storage director returns channel-end and device-end status together at the end of the data transfer to cache and NVS. This allows the program to continue processing without waiting for the data to be put on DASD. The data remains in cache and in nonvolatile storage until the data is written to DASD to free space in the cache or NVS. Most write operations operate directly with the cache without going to the DASD, resulting in the same performance as a read hit operation.

Figure 9 shows the **DASD fast write** operation.

DASD Fast Write - Improved Data Performance

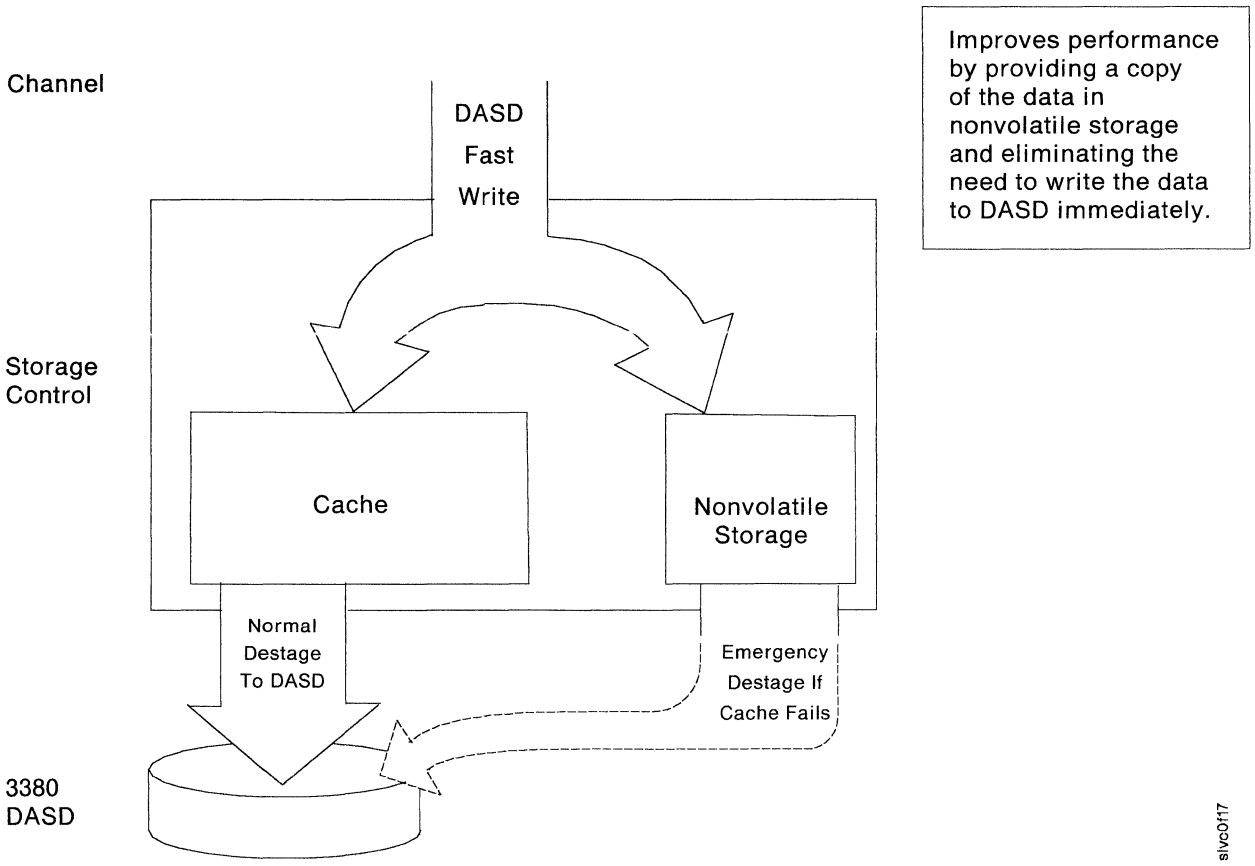


Figure 9. DASD Fast Write Operation

Cache Fast Write

Cache fast write is an option designed for use with special kinds of data, such as temporary data created as a DFSORT work file. When DFSORT work files are allocated on a 3990 Model 3, the intermediate work files are kept temporarily in the cache. The data might not be written to the DASD. The channel program is complete when the data is written to cache. Cache fast write does not use the nonvolatile storage. DFSORT Release 9 supports cache fast write.

Figure 10 shows the **cache fast write** operation.

Cache Fast Write - Cache Write of Temporary Data

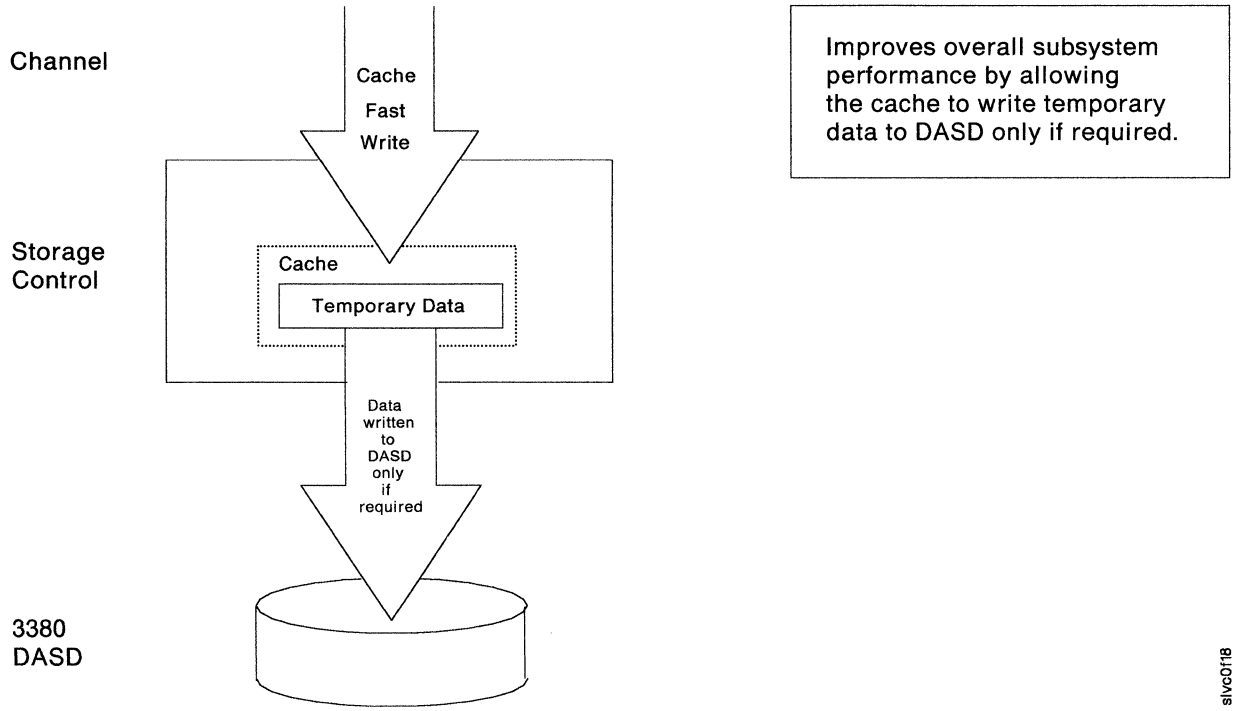


Figure 10. Cache Fast Write Operation

Dual Copy

Dual copy allows the Model 3 to create a duplicate copy of the data on a volume and store it on a different device in the same subsystem.

Dual copy provides important advantages:

- Protects a critical volume from a single device failure.
- Permits the concurrent writing of data to separate devices.
- Data transfer operations are automatically switched to the secondary if a failure occurs on the primary. The switching is transparent to the application.
- Provides for near-continuous operations by providing a back-up copy if loss of access occurs to one of the dual copy devices.
- Ensures that the second copy is identical to the primary copy.

Dual copy improves the availability of data. The status of the dual copy operation is kept in the nonvolatile storage. Dual copy is activated or deactivated by a system utilities command. Using dual copy should require no modifications to access methods or applications.

The two physical devices are a **duplex pair**; a primary device and a secondary device. The dual copy operation is managed by the subsystem. All I/O operations are directed to the primary volume. The 3990 Model 3 automatically updates both copies of the data. Data is accessed from the secondary device if the primary device is not available. The duplex pair is established by a system command. The secondary device is automatically synchronized with the primary when both volumes remain available to the subsystem.

Because the secondary device is offline, the processor knows of only one device—the primary device. After the processor writes the data to the primary device, channel-end and device-end are presented and the storage control later completes the write operation from the cache to the secondary device. The write operation to the secondary device is transparent to the host.

The DASD fast write capability and the dual copy capability can be combined to produce a **fast dual copy**. Using **fast dual copy** results in an optimum of data availability, performance, and reliability. See Chapter 7, "Performance Characteristics" on page 57 for examples of the performance effects of combining both the DASD fast write and the dual copy capabilities.

Figure 11 shows the dual copy operation.

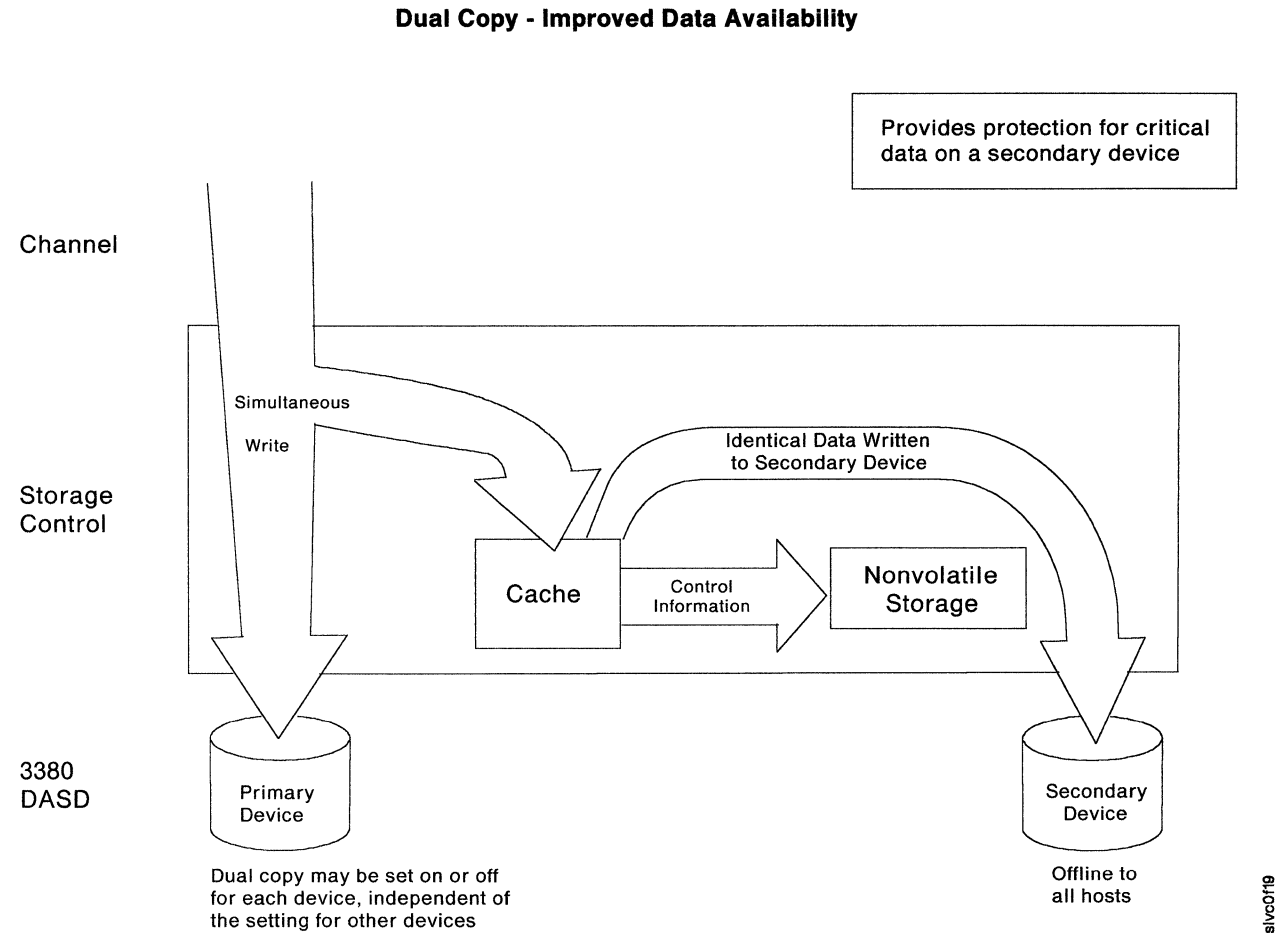


Figure 11. Dual Copy Operation

When a read error occurs on the primary device, the Model 3 will retrieve (stage) the data from the secondary device. The failure is reported by a console message so that the installation can take action to correct it later.

When a write request error occurs and the primary device has failed, the secondary device is made the operational device. All further write requests are to the secondary device as it now becomes the primary device. The failure is reported by a console message so that the installation can take action to correct it later.

For more information on the DASD fast write, cache fast write, or dual copy operation, see the *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide.*

Branching Transfers and Dual Data Transfer

Branching Transfers

The 3990 Model 3 uses branching transfers to permit simultaneous transfer of data from the channel to DASD and the cache, and from the DASD to the channel and cache. Branching transfers provide a substantial reduction in storage control and device busy time for certain operations and an overall improvement in performance.

Dual Data Transfer

Dual data transfer allows the staging or destaging of up to four simultaneous and independent operations on lower ports and at the same time, up to four simultaneous and independent operations on the upper ports. Up to eight operations are permitted in the 3990 Model 3 (only two operations are permitted at any one time in the 3880 Model 23).

Advantages of Branching Transfers and Dual Data Transfer

Both capabilities: branching transfers and dual data transfer permit the 3990 Storage Control to perform more tasks simultaneously, resulting in greater performance for the user.

Nonvolatile Storage

The nonvolatile storage (NVS) provides random-access electronic storage for 4 megabytes of data. The NVS has its own separate power region for data protection. If power is lost to the 3990 before DASD fast write and/or dual copy operations have completed to DASD, a battery-backup system maintains power in the nonvolatile storage for up to 48 hours with a fully-charged battery to prevent data loss. When power is restored, the Model 3 destages any data in nonvolatile storage to DASD and completes any operation in process at the time of the failure.

3990 Storage Control Components

To improve data availability and serviceability, the major components of the 3990 are grouped into independent power and service regions. These regions include the storage clusters, the cache, and the nonvolatile storage. The 3990 Model 1 has one storage cluster, the 3990 Models 2 and 3 have two. Each storage cluster contains channel attachments, storage directors, storage paths, and a support facility for maintenance. In a 3990 Model 3, the cache and the nonvolatile storage are

shared by all the storage paths in both clusters, but are physically and logically separate from the storage clusters.

A clear benefit of each of the clusters is that they are independent components. Each provides a separate power and service region and two separate paths to the DASD. Because DASD strings are attached with at least one path in each cluster, loss of power to one cluster, the cache, or the NVS, does not disable the 3990 as processing can continue through the other storage cluster. Depending on the 3990 configuration, two paths in DLSE mode and one path in DLS mode would remain available for access to the DASD should one of the storage clusters become unavailable. A service representative can take one-half of the machine for maintenance activities without inhibiting DASD access through the remaining paths.

The 3990 Model 3 contains cache and nonvolatile storage; each is in a separate power and service region. Cache and nonvolatile storage are accessed by both storage clusters. Cache and/or nonvolatile storage service actions can take place while I/O activity continues through the storage cluster. In most cases, a nonvolatile storage service action can occur while the two storage clusters continue to operate with the cache and DASD.

Figure 12 shows the power and service boundaries of a Model 3 that allow operations to continue on the remaining paths to DASD should a cluster, the cache, or the NVS become unavailable.

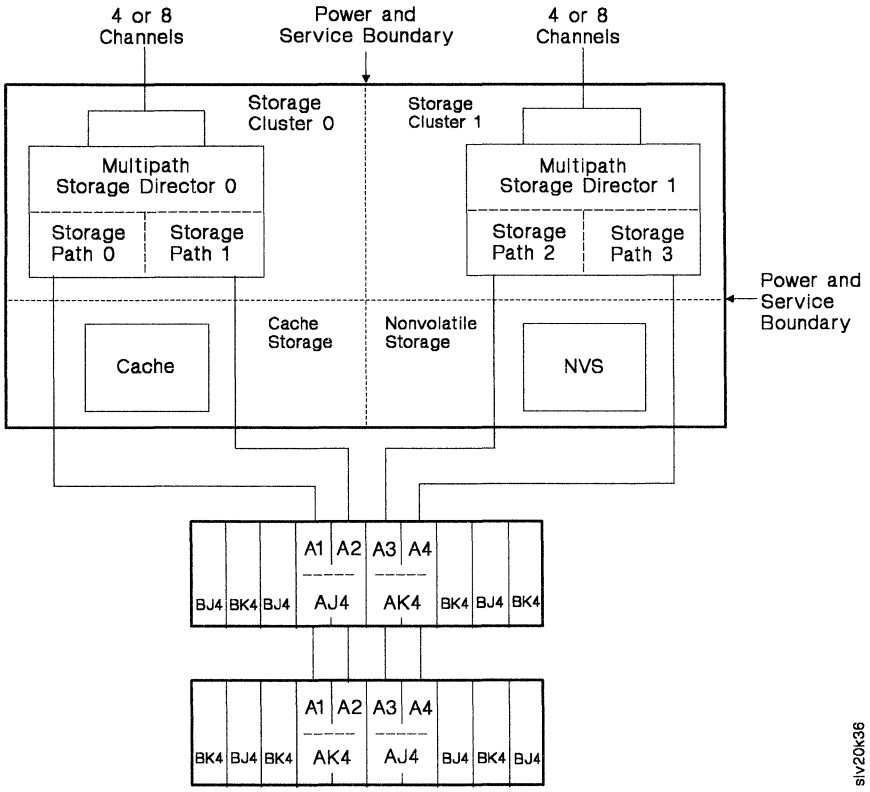


Figure 12. Power and Service Boundaries of the 3990 Model 3

Channels

Each storage cluster can be attached to either four or eight channels. For 3990 Models 2 and 3, each channel is connected to the two storage paths in the cluster. Therefore, a processor can have several paths to data, or each of several processors can have its own path (or paths) to data. For 3990 Model 1, each channel attaches to one storage path by being assigned to one storage director or the other.

Storage Directors

The storage directors interpret channel commands and control the storage paths, cache, nonvolatile storage, and attached DASD.

In DLS mode, the storage director is called a single-path storage director.

In DLSE mode, the storage director is called a multipath storage director.

Each storage director has a unique channel address.

Storage Paths

Each storage cluster contains two storage paths. Each storage path separately connects to DASD. During channel-connected operations, the storage path is coupled with a particular channel.

In DLS mode, there is a one-to-one relationship between the storage director and the storage path. In 3990 subsystems, DLS mode defines the storage paths as single-path storage directors. Single-path storage directors are functionally equivalent to 3880 storage directors. Each single-path storage director provides, through a single channel address, a path to DASD. In DLS mode, there are two storage paths to each device in a 2-path string.

In DLSE mode, there is a one-to-one relationship between the storage director and the storage cluster (consisting of two storage paths). In 3990 subsystems, DLSE mode defines the storage clusters as two multipath storage directors. The multipath storage director provides, through a single channel address, multipath access to DASD. Through one storage director address, the multipath storage director selects either storage path in the cluster for data transfer operations, thereby improving response time. In DLSE mode, there are four storage paths to each device in a 4-path string.

Support Facility

Each independent storage cluster has its own support facility.

A major RAS benefit of the 3990, the support facility permits concurrent maintenance and provides a remote maintenance support capability. Among other tasks, the support facility generates the service information messages, communicates with the other support facility (in the Models 2 and 3), runs the maintenance analysis programs (MAPs) and diagnostics, maintains logs for the storage cluster, and provides a nonvolatile microcode patch area on its writeable diskette.

The concurrent maintenance and the remote maintenance support capabilities of the support facility (in each independent storage cluster) in combination with the service information messages should meaningfully reduce the time it takes to diagnose and perform maintenance and migration activities.

Each storage cluster contains a microprocessor-controlled support facility that communicates with:

- A diskette drive
- The cluster storage paths
- A remote support adaptor
- The cluster power sequence controls
- The support facility in the other cluster (in Models 2 and 3)
- The operator panel
- The maintenance panel.

The support facility provides the following reliability, availability, and serviceability functions:

- Monitors power to the storage cluster
- Maintains a record of errors and reports those errors that exceed established thresholds for the storage control
- Detects, logs, and reports problems in the other cluster's support facility (in two-cluster storage controls)
- Provides maintenance analysis procedures (MAPs) for a service representative
- Permits support personnel to analyze certain machine conditions from a remote location through an external modem
- Disables paths determined to be defective
- Provides nonvolatile microcode update capability.

Cache

Cache is high-density, electronic storage in the 3990 Model 3 that is shared by all storage paths. Frequently used data can be transferred to and from the cache and the channel at channel speeds. Access time between the cache and the channel is much faster than between the DASD and the channel because there are no DASD seek or rotational delays. A least-recently-used algorithm (and other algorithms) keeps high-activity data in the cache because it has the highest probability of reuse.

Cache is divided into 16K byte segments. When a specified amount of cache space is needed, only the segments needed to contain the specified space are used. Further, the 3990 Model 3 can logically relate separated segments in the cache and treat them as a unit of data.

Cache is in a separate power region from the storage clusters. If a storage cluster is offline, cache processing still continues through the other storage cluster.

Data transfers between the cache and the channel operate at the maximum speed of the channel, either 4.5 or 3.0 megabytes per second. All data transfers requiring access to the physical DASD will occur at the DASD data transfer rate, 3.0 megabytes per second.

Branching data transfers and dual data transfers provide a substantial improvement in storage control utilization, a reduction in device busy time and an overall improvement in performance.

Cache Operations

With the 3990 Model 3, there are three different caching operations:

- Subsystem caching (read only caching)
- DASD fast write
- Cache fast write.

Subsystem caching is a prerequisite for DASD fast write and cache fast write. With subsystem caching, only read operations benefit from cache. With DASD fast write and cache fast write, the performance benefits of caching read operations is extended to write operations.

Read Caching Operations

If a copy of the data is in the cache when the processor initiates a read request (read hit), the storage control transfers the desired data from the cache to the channel. If a copy of the data is not in the cache (read miss), the storage control sends the requested data directly to the channel from the DASD and, at the same time, writes that data (plus the rest of the data from that record to the end of the track) into the cache in anticipation of future use. Requests for following records on that track are read from the cache and are read hits.

Basic Write Caching Operations

If a copy of the data is in the cache when the channel initiates a write request (write hit), the storage control writes the data directly to the DASD and, at the same time, writes that data into the cache. The record in cache is updated because it may be referred to again. However, before the storage control can signal the operation as complete, it must ensure that the record has been successfully written to the DASD. The record is simultaneously written to the cache and to the DASD, with the device-end signal returned at completion. This is an example of branching data transfers. Writing to the DASD provides data integrity because copies in the cache and on the DASD are identical.

When the record being updated is not found in the cache, the condition is called a write miss. The record is written directly to the DASD, and is NOT written in the cache.

Extended Function Fast Write Operations (With Either DASD Fast Write or Cache Fast Write)

The cache management algorithms for both fast write functions are the same. They differ in the way they are invoked, and in the fact that DASD fast write also uses the NVS to provide protection against power failures, but they both process read and write hits and misses the same way.

Most write operations are write hits because typical applications read a record before updating it, or the write operation itself creates a new record. This last operation is called a format write. In a format write, the new record is written, and the rest of the track is formatted for new data. Thus, there is no need to verify the data on the track before allowing the cache write. Format writes are considered cache hits.

For either DASD fast write or cache fast write operations, if a copy of the data is not in the cache when the channel initiates a write request or the operation is not a format write the storage control writes the data to DASD and the cache. The remainder of the track is staged into the cache.

For DASD fast write, all writes from the channel to the cache are also stored in the NVS.

Both cache fast write and DASD fast write operations are explained in "Fast Write" on page 20.

Caching Algorithms

Several caching algorithms determine how the cache is managed for a specific type of I/O operation. Caching algorithms include normal, sequential, bypass-cache, and inhibit cache loading. These algorithms are used for the duration of an I/O operation (a channel program).

The cache uses normal caching algorithms unless directed otherwise by software. Normal caching means that the data is staged to the cache after being referred to in a read operation and remains in the cache until least-recently-used (LRU) algorithms permit the data to be overlaid by other data. Normal caching applies to both read operations and both fast write operations. This is the most appropriate algorithm for random access methods, including the Basic Direct Access Method (BDAM), the keyed direct processing of Virtual Storage Access Method (VSAM) key-sequenced data sets (KSDS), the Partitioned Access Method (PAM), and the Overflow Sequential Access Method (OSAM).

Sequential access methods such as Basic Sequential Access Method (BSAM), Queued Sequential Access Method (QSAM), and sequential processing of VSAM entry sequenced data sets invoke sequential caching.

Sequential caching of a channel program is determined by a bit in the Define Extent command, just as it was in the 3880 Model 23. For the 3990 Model 3, the sequential algorithm is improved to provide more data in the cache and to keep the data in the cache longer. These improvements to sequential caching greatly increase hit ratios resulting in better performance.

During sequential caching, the 3990 Model 3 pre-stages anticipated data so that, usually, five tracks are in the cache.

Bypass-cache does not use the cache and the I/O operation goes directly to the DASD. The IBM Program Product Device Support Facilities (ICKDSF) uses bypass-cache to direct operations to DASD.

Inhibit cache loading is set by the Define Extent command and uses existing copies of tracks if they are in the cache, but does not load any new tracks into the cache. The purpose of this cache mode is to avoid the overhead that may be caused by track promotion when there is no benefit (that is, whenever these tracks are not likely to be accessed again in the near future).

Inhibit cache loading is not used by any of the MVS or VM access methods but Data Facility Data Set Services (DFDSS) uses inhibit cache loading.

Channel Commands

The 3990 command sets supports the Count, Key, and Data (CKD) data format and the CKD and Extended CKD (ECKD) command set as used for 3380 disk storage operations. The command sets are described in the *IBM 3990 Storage Control Reference*.

The channel command set includes commands that support cache control and 3990 statistical and status information.

Hardware and Data Availability Considerations

The 3990 Model 2 and Model 3 provide higher levels of hardware and data availability.

These new levels of hardware and data availability are provided by a number of fundamental technological enhancements:

- Up to four data paths to DASD
- Standard two-cluster design provides internal hardware redundancy
- Use of fewer components, cards and connections
- Improved caching technology and algorithms
- Factory stress screening of cards reduces failures in the field
- Independent power and service regions (the two clusters, the cache, and the nonvolatile storage)
- Concurrent maintenance
- Remote maintenance
- Writeable diskette
- Dual frame configurations available
- Nondisruptive DASD installation
- Control information shared by both clusters
- Enhanced error checking circuitry.

The 3990 Model 3 substantially improves DASD availability through use of dual copy.

The 3990 Model 3 continues several important availability capabilities used with the 3880 Model 23 storage control, among them:

- For cache storage, single, double and triple bit error detection for all errors, single and double bit error correction for all errors and triple bit error correction for most errors.
- Automatic reinitializing of the cache after a cache directory error.

These improvements result in a new level of hardware and data availability of DASD subsystems. The new storage control technology, with its circuit redundancy, data path redundancy, and multiple power and service regions reduces the single points of failure to three, all associated with primary power distribution: a

circuit breaker, line filter, and the power cord. These parts have such a low failure rate that many installations will be able to configure their DASD subsystems using a single 3990 Model 2. For those installations that desire to protect against the failure of even these highly reliable parts, the dual frame configuration is available.

A properly configured pair of 3990 Model 3s in a dual-frame configuration with dual copy used on all volumes eliminates all single points of failure that may prevent access to data—from processor channels to storage control to DASD. All 3990 Model 3 subsystems using dual copy or DASD fast write should use the dual-frame configuration because a single 3990 Model 3 has common circuitry between the cache and the nonvolatile storage. In the remote event of a failure of this component, temporary loss of access to data could occur until this hardware component is replaced. Of course, the data would always be protected by the nonvolatile storage. The dual-frame configuration, because of the way it cross-configures the cache and nonvolatile storage of the two 3990 Model 3s, duplicates the common circuitry.

Processor Attachment

The 3990 Storage Control can be attached to the following IBM processors:

- 3081
- 3083
- 3084
- 3090
- 4381
- 9370.

DASD Attachment

The 3990 must be configured with two storage paths in a subsystem in DLS mode and four storage paths in a subsystem in DLSE mode. Every DASD in the subsystem can be accessed by each storage path of the subsystem (except for 2-path DASD in DLSE intermixed configuration). Multiple paths in a subsystem provide alternate path capability from the processor for both data availability and performance.

The 3990 attaches IBM 3380 Models AA4 (except devices with serial numbers 10,001 through 14,999) AD4, AE4, AJ4, and AK4. The 3990 does not attach IBM 3380 Models A04 and CJ2.

Figure 13 on page 33 shows which 3380 models can be intermixed on the same string. Subject to these intermix rules, up to three B-units can be attached to each A-unit.

3380 Models	AA4	AD4	AE4	AJ4	AK4
B04	Yes	—	—	—	—
BD4	—	Yes	Yes	—	—
BE4	—	Yes	Yes	—	—
BJ4	—	—	—	Yes	Yes
BK4	—	—	—	Yes	Yes

Figure 13. 3380 Models that can be Intermixed on the Same String

Figure 14 shows the combinations of 3380 models and capabilities (2-path or 4-path) that can be intermixed in the same logical DASD subsystem. If there are two strings of 3380s in the logical DASD subsystem, both strings must attach to the same storage paths, except when 2-path strings are intermixed with a 4-path string. In this case, one 2-path string attaches to two of the storage paths, and the other 2-path string attaches to the remaining two storage paths.

Models and Capabilities	2-Path Strings of 3380 Models A, D, and E	2-Path Strings of 3380 Models J and K	4-Path Strings of 3380 Models J and K
2-Path Strings of 3380 Models A, D, and E	Yes	Yes	Yes
2-Path Strings of 3380 Models J and K	Yes	Yes	—
4-Path Strings of 3380 Models J and K	Yes	—	Yes

Figure 14. 3380 String Intermix Capabilities Within the Same Subsystem

Chapter 3. 3990 Storage Control Models and Configurations

3990 Model 1

The 3990 Model 1 Storage Control attaches to 3380 DASDs in installations requiring only two storage paths to the DASD. In a 3990 Model 1, the two storage paths form one storage subsystem operating in DLS mode. In a 3990 Model 1, there is a one-to-one relationship between the storage path and the storage director.

The 3990 Model 1 has one storage cluster with two storage paths (storage directors) to DASD. Each storage director is an addressable storage path to DASD. Four channels can attach to the 3990 Model 1. One channel cannot attach to both storage directors. With the Four Channel Switch, Additional feature, eight channels can attach to the 3990 Model 1. The 3990 Model 1 has one support facility for maintenance activities.

The 3990 Model 1 does not provide dual-frame, DLSE support mode capability, nondisruptive DASD installation, concurrent maintenance, cache, or attachment to 4-path 3380 DASD strings.

The 3990 Model 1 can be upgraded to a Model 2 and then to a Model 3 with cache and nonvolatile storage. Upgrading the 3990 Model 1 to a Model 2 provides DLSE capability, concurrent maintenance, and dual-frame capability.

In any 3990, there is no requirement that the channels be evenly divided between the storage directors. The installation has the flexibility to connect either storage director to any of four or eight channels. With a 3990 Model 1, the two storage directors do not share channels. Each channel can attach to either storage director, but not to both.

The 3990 Model 1 cannot cross-connect to another Model 1. If cross-connection is desired, a single 3990 Model 2 provides cross-connection to all attached devices.

Figure 15 shows the major components of a 3990 Model 1.

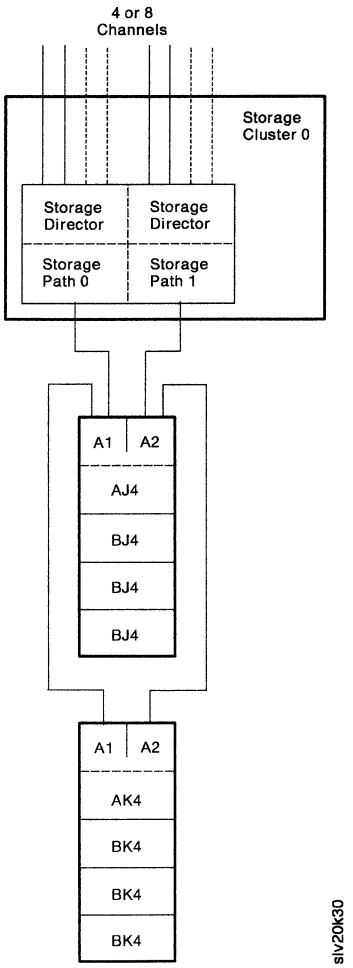


Figure 15. 3990 Model 1 in DLS Mode Attached to 2-Path DASD Strings

Notes:

1. A single 3990 Model 1 attaches to four channels. In Figure 15, the dotted lines show the extra channels added by the Four-Channel Switch, Additional feature.
2. See Chapter 6, "Optional Features" on page 55 for descriptions of the optional features available on a 3990 Model 1.

3990 Models 2 and 3

The 3990 Models 2 and 3 operate in either DLS or DLSE support modes. Each 3990 Model 2 and 3 has two storage clusters. Each storage cluster has two paths to the DASD. A 3990 Model 2 does not have cache or NVS. A 3990 Model 3 has either 32, 64, 128, or 256 megabytes of cache and 4 megabytes of nonvolatile storage.

In any 3990, there is no requirement that all channels be connected to both storage directors. The installation has the flexibility to connect either storage director to any of four or eight channels. Normally, all channels connect to all storage directors.

Figure 16 shows the maximum configuration of a 3990 Model 3 with two 4-path DASD strings.

Note: A 4-path DASD string has two A-units and two sub-strings from 0 to 3 B-units. A 2-path DASD string has one A-unit and a string from 0 to 3 B-units.

The 3990 Model 3 DASD attachment is the same as the 3990 Model 2 and all storage paths attach to cache and to the nonvolatile storage.

For high data availability, the two storage paths in a subsystem in DLS mode are not in the same storage cluster. One storage path is in storage cluster 0 and the other is in cluster 1. In DLSE mode with four storage paths, two storage paths are in storage cluster 0 and the other two are in cluster 1.

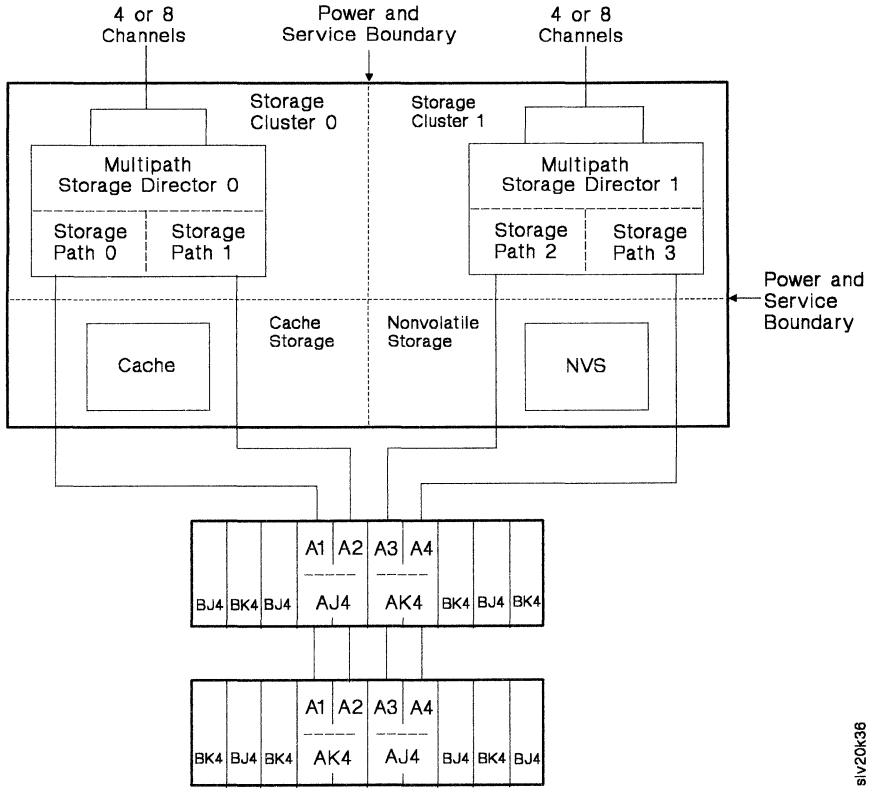


Figure 16. 3990 Model 3 In DLSE Mode Connected to 3380 Models AJ4 or AK4 4-Path Strings

Figure 17 shows the 3990 Model 2 with two logical DLS subsystems.

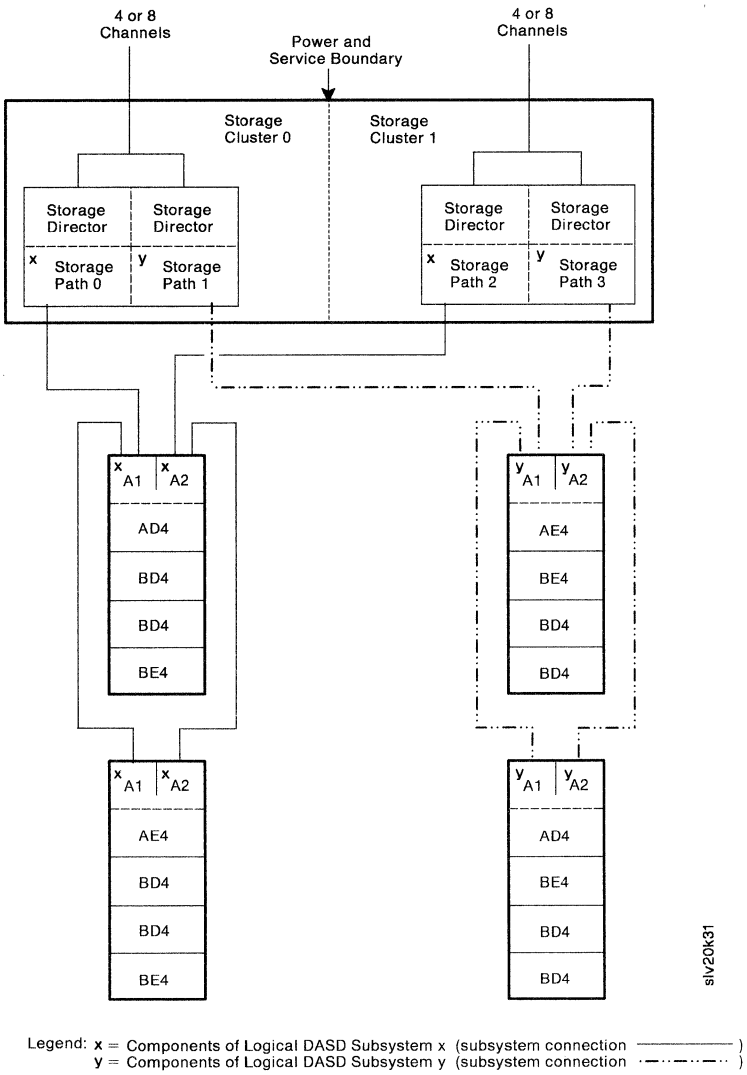


Figure 17. 3990 Model 2 In DLS Mode Attached to 2-Path DASD Strings

Each storage cluster in a 3990 Model 2 or 3 can attach to four channels for a total of eight channels in the logical DASD subsystem. If the Four Channel Switch, Additional feature is installed, each cluster can attach to eight channels, for a total of 16 channels in the logical DASD subsystem.

In DLSE mode, 2-path DASD strings can be intermixed with a 4-path DASD string. In this case, the 4-path DASD strings can concurrently transfer data from any of four actuators within the string. The 2-path DASD strings can concurrently transfer data from any of two actuators within the string, except for 3380 AA4 strings.

Cache is available in the 3990 Model 3 in four sizes: 32, 64, 128, or 256 megabytes. The size of the cache determines the specific model number.

3990 Model	Megabytes of Cache
G03	32
J03	64
L03	128
Q03	256

Figure 18. Model Designation by Cache Size

See Chapter 6, "Optional Features" on page 55 for descriptions of the optional features available on a 3990 Model 2 or 3.

3990 Dual-Frame Configuration

A dual-frame configuration physically connects two 3990 Model 2 or two 3990 Model 3 Storage Controls. The two frames are physically bolted together and the storage clusters, caches, and nonvolatile storages are interconnected.

Installing a dual-frame configuration requires that both models be 3990 Model 2 or both be 3990 Model 3 Storage Controls. Each 3990 Model 3 can have a different cache size.

In a dual-frame configuration, a DASD string is attached to one of the storage directors in each frame. In DLSE (4-path) mode, multipath storage director 0 in one storage control and multipath storage director 1 in the other storage control are connected to the same DASD string as shown in Figure 19.

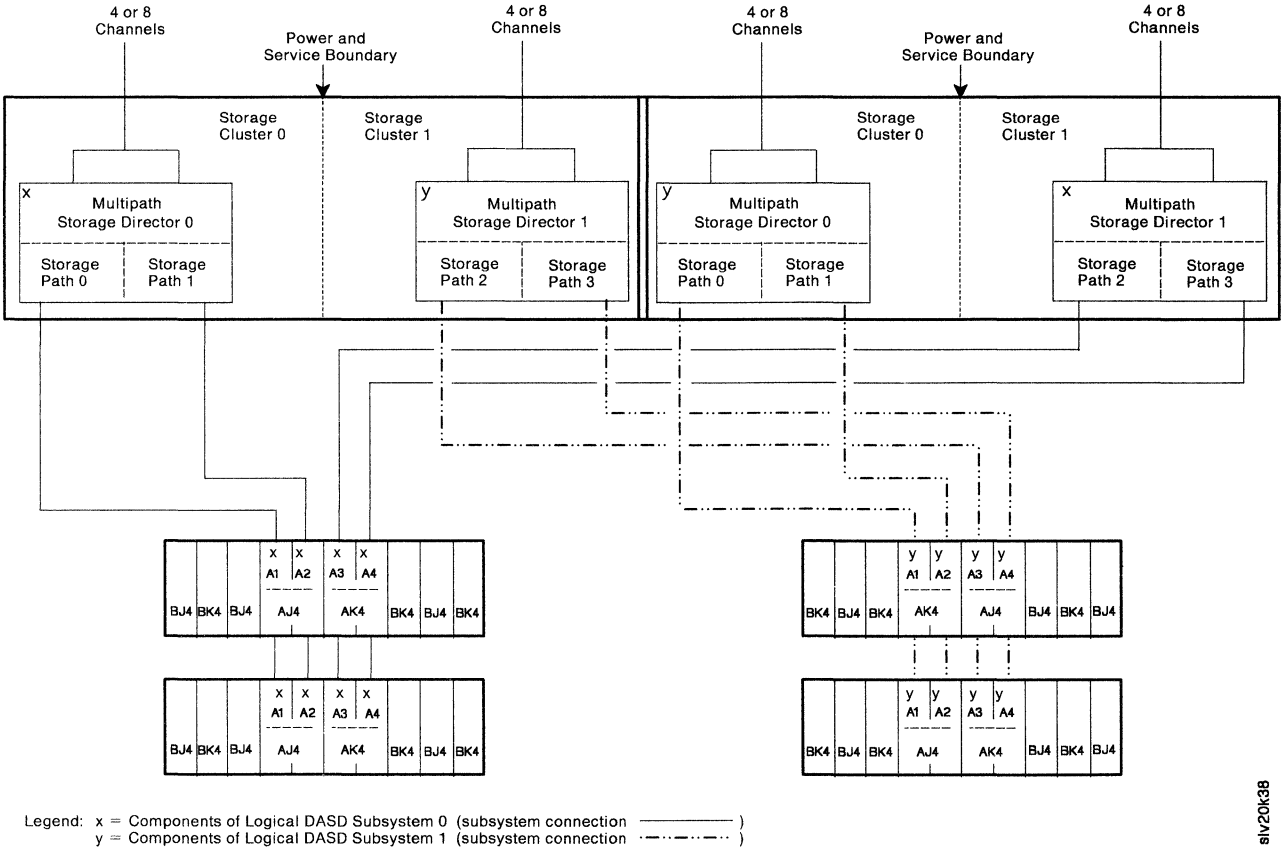


Figure 19. Dual-Frame 3990 Model 2 in DLSE Mode Attached to 4-Path DASD Strings

Note: For more information on the dual-frame configuration, see "Hardware and Data Availability Considerations" on page 31.

Chapter 4. Programming Support

MVS Support for the 3990

The 3990 runs under MVS/370 and MVS/Extended Architecture, in caching and noncaching modes. Only MVS/XA supports the 3990 extended functions DASD fast write and dual copy, and provides IDCAMS support for subsystem cache fast write.

All systems sharing volumes using extended functions should be at the same MVS/XA software levels.

Minimum MVS/XA and MVS/370 Program Levels for 3990 Basic Operations

The minimum release level of MVS programs, with the appropriate PTFs, required to support 3990 basic operations is:

- MVS/XA
  - MVS/System Product Version 2 Release 1.2
  - MVS/XA Data Facility Product (DFP/XA) Version 2 Release 2.3 or Version 1 Release 1.3
  - Data Facility Data Set Services (DFDSS) Version 2 Release 2.0
  - Device Support Facility (ICKDSF) Release 9.0
  - DFSORT Release 9.0
  - EREP Version 3 Release 3.2.
- MVS/370
  - MVS/System Product Version 1 Release 3.5
  - MVS/370 Data Facility Product Version 1 Release 1.2
  - Data Facility Data Set Services Version 2 Release 2.0
  - Device Support Facility (ICKDSF) Release 9.0
  - DFSORT Release 9.0
  - EREP Version 3 Release 3.2.

This support includes:

- Service Information Message (SIM) processing

  When a SIM is issued by the storage control, a SIM Alert message is issued to the host operator's console and the information is written to SYS1.LOGREC.

- IDCAMS support for remote support

  The IDCAMS LISTDATA ACCESSCODE command will provide an access code to permit a remote support session to be established. This support is available for all models of the 3990. SAF authorization checking is invoked.

- Reset Event

  Software recognizes the resetting of DASD devices attached to a 3990 and responds by rebuilding the dynamic pathing arrays, rather than rebuilding them as part of error recovery.

MVS/XA Software Capabilities for 3990 Model 3 Extended Functions

The software support for extended function operations will be provided by a later release of MVS/XA. This support includes:

- IDCAMS support of NVS, DASD fast write, cache fast write, and dual copy

  The IDCAMS SETCACHE command will have new parameters to enable/disable the DASD fast write, cache fast write, and NVS, and manage the dual copy capabilities.

- TSO execution of IDCAMS LISTDATA and SETCACHE commands

  LISTDATA and SETCACHE commands can be invoked as TSO commands in addition to being submitted as batch jobs. The normal TSO help functions will be available for these commands.

- DEVSERV

  The MVS/XA operator command Device Services (DEVSERV) has been modified to add information on caching status of volumes. This will include information about DASD fast write and dual copy for volumes attached to a 3990 Model 3 Storage Control.

- ISMF support for subsystem status display

  ISMF Volume Application will support caching subsystems by recognizing a subsystem identifier and using that identifier to select volumes for the volume list. In addition, caching status, DASD fast write status, dual copy status, and subsystem identifier will be provided for each volume in the volume list.

- SAF authorization

  IDCAMS commands will use the System Authorization Facility to restrict invocation of certain commands to only authorized users if RACF or a user routine is available. All IDCAMS SETCACHE functions as well as LISTDATA ACCESSCODE will check user authorization. This authorization checking is performed for all SETCACHE functions whether directed at 3880 or 3990 storage controls.

- SMF Type 22 records

  System Management Facility will include records to indicate changes in the status of the 3990 Model 3 and attached devices. At each change of subsystem or device status, such as setting caching on or off or enabling DASD fast write, MVS/XA will create an SMF Type 22 record. These records can be used to build an audit trail of all device/subsystem status changes.

VM Support for the 3990

The following text describes the VM support for the 3990.

Minimum VM Program Levels for 3990 Models 1 and 2 Support

For VM support of the 3990 Model 1 and 3990 Model 2, the minimum release level of programs, with the appropriate PTFs, required to support 3990 Model 1 and 3990 Model 2 basic operations includes:

- VM/XA SP Release 1.0
- VM/XA SF Release 2.0
- VM/SP HPO Release 4.2
- VM/SP Release 4.0
- EREP Version 3 Release 3.2
- Device Support Facility (ICKDSF) Release 9.

VM Software Capabilities for 3990 Model 3 Basic Caching

Basic caching support for the 3990 Model 3 will be provided by a future release of VM/SP HPO and a future release of VM/XA SP.

VSE Support for the 3990

The following text describes VSE programming support for the 3990.

Minimum VSE Program Levels for 3990 Models 1 and 2 Support

VSE support of the 3990 Model 1 and 3990 Model 2 will be provided in future refreshes of VSE/SP Version 2 and Version 3. Also required are:

- EREP Version 3 Release 3.2
- Device Support Facility (ICKDSF) Release 9.

See *Using the IBM 3380 Direct Access Storage in a VSE Environment* for program levels required for specific 3380 models.

TPF Support for the 3990

TPF (Transaction Processing Facility) support for the 3990 Models 1 and 2 will be provided in an update to TPF 2.3.

Chapter 5. Uses of Dual Copy, DASD Fast Write, and Cache Fast Write in MVS Environments

This chapter describes uses for dual copy, DASD fast write, and cache fast write in MVS environments.

Dual copy and DASD fast write are supported in MVS/XA with the installation of DFP/XA Extended Function programming support. Cache fast write is supported for sort work files in DFSORT Release 9.

MVS/370 supports cache fast write for sort work files in DFSORT Release 9, but does not provide software support for dual copy or DASD fast write.

Uses of Dual Copy in MVS/XA Environments

The 3990 Model 3 dual copy function provides for significant improvement in data availability.

Properly configured 3990 Model 3s in a dual-frame configuration with dual copy used on all volumes eliminates all single points of failure which might prevent access to data--from processor channels to storage control, to DASD volume, to record. All path components are replicated. Failing operations are retried through another path, possibly to the alternate device. Using dual copy may result in fewer application outages, fewer IPLs, and a reduced frequency of DASD recovery activity.

Use of dual copy on important system and application volumes may provide significant relief in scheduling batch applications and routine backups. With the shrinking batch window and growing numbers of installations with 24-hour operations, many installations cannot backup as often as they would prefer. Some installations are copying key volumes while their applications are running (and updating the volumes). Using dual copy on key system and application volumes ensures that the subsystem maintains duplicate, up-to-date copies of these volumes. As a side benefit, installations may be able to reduce the frequency of full volume backups or Image Copies of data bases.

Note: Backups and log tapes cannot be completely eliminated because of the need to recover from application logic errors as well as multiple hardware failures.

Implementation of dual copy is straightforward. No application changes are necessary as long as standard access methods are used.

Programs that access volumes using dual copy or DASD fast write must meet the following requirements:

- Do not perform Write Home Address Record Zero operations
- Use only standard Record 0 format (MVS/XA access methods use the standard Record 0 format)
- Do not define duplicate Record IDs on a track

Normally, using the dual copy function requires no special attention from the installation beyond having procedures in place to establish the dual copy pairs and perform recovery actions when required.

Volume-Specific Examples of Using Dual Copy

The following examples describe current recovery scenarios for several important classes of volumes that are candidates for dual copy, and how dual copy might be used effectively in conjunction with, or in addition to, the current procedures. The volume classes include:

- MVS System Data Sets
- ICF catalog volumes
- RACF control data set volumes
- Critical system volumes (such as load libraries and IMS libraries)
- JES SPOOL volumes (both JES2 and JES3)
- IMS data base volumes
- CICS application volumes
- DB2 data base volumes
- Various user volumes.

MVS System Data Sets

Examples of data sets that are critical to the availability of an MVS system include:

- SYS1.LINKLIB
- SYS1.LPALIB
- SYS1.PARMLIB
- SYS1.PROCLIB
- ICF Master Catalog
- SYS1.NUCLEUS.

Using dual copy may prevent a system IPL caused by a hardware failure on a volume containing one of these data sets.

Without dual copy, an I/O error on the SYSRES volume may cause a system IPL. Installation response is to IPL again with the alternate SYSRES. Depending on recovery/restart requirements, the outage duration could be from 10 minutes to an hour or more. By using dual copy on SYSRES, IPLs due to DASD hardware failure can be reduced. The result is fewer end user outages and less recovery/restart activity for the operations staff.

Master Catalog considerations are discussed later.

RACF Control Data Set

The Resource Access Control Facility (RACF) control data set is another critical system resource. An I/O error on this data set may lead to operations intervention.

RACF provides a facility for maintaining a software duplicate of information in the RACF control data set. If an error occurs on the primary copy, the installation may switch to the duplicate copy.

The installation may wish to evaluate the use of the 3990 Model 3 dual copy function for the RACF control data set.

ICF Catalogs

The effects of a hardware failure on an Integrated Catalog Facility (ICF) catalog volume are different for Master Catalogs and user catalogs. If the Master Catalog fails, a system IPL is required. If a user catalog fails, application data is unavailable for allocation.

ICF Master Catalog

Without the 3990 Model 3 dual copy function, hardware failure of the Master Catalog volume may lead to a system IPL using the MVS Alternate Master Catalog Facility. During the NIP (nucleus initialization program) processing, the operator is prompted for an alternate nucleus member describing the alternate Master Catalog. Common practice today is to limit update activity to the Master Catalog by having it contain just the critical system data sets and pointers to user catalogs. Thus, if the Master Catalog has no changes, the alternate can be invoked with no difficulty. Using dual copy may reduce the IPLs caused by DASD hardware failures.

User Catalogs

User catalogs typically have a fairly high level of change activity. For this reason, many installations backup their more critical user catalogs frequently. Without dual copy, recovery typically involves:

1. Creating a new catalog entry
2. Importing the most recent backup copy of the catalog
3. Updating the catalog entries made since the backup copy.

Recovery may involve using volume table of contents (VTOCs), VSAM Volume Data Sets (VVDSs), and System Management Facility (SMF) records, and can take anywhere from hours to days. Use of a tool such as the Program Offering Integrated Catalog Forward Recovery Utility (program number 6798-DXQ) may substantially reduce the manual effort required.

Dual copy may be desirable where there is a need to reduce the number of catalog backups, or where even the reduced recovery time provided by the ICF Recovery Utility is not sufficient to satisfy user availability requirements.

Other Critical System Data Sets

There are a number of other critical system data sets, such as:

- Program libraries
- IMS ACBLIB
- IMS MFSLIB
- DFHSM control data sets (MCDS, BCDS, and OCDS)
- ISPF data sets
- LINKLIST data sets
- SMP data sets
- Other system data sets with low levels of update activity
- Other system data sets for which there are facilities in place to log changes or otherwise provide for backup copies.

All of these may still be candidates for dual copy because dual copy insulates the operating system or applications from the effects of a DASD hardware failure.

JES SPOOL Volumes

Both JES2 and JES3 SPOOL volumes are critical system data sets. Using dual copy with these volumes protects the system from loss of spooled data due to a DASD hardware failure.

Full Function IMS Data Bases

Without **dual copy**, an I/O error on an IMS data base volume may result in bringing the application down and invoking data base recovery procedures. Depending on the frequency of image copy and update activity, the recovery process could take several hours. The basic steps in IMS recovery include:

1. Locate the latest image copy tape(s)
2. Locate a spare volume
3. Restore all volumes of the data base
4. Find all log data sets
5. Generate JCL for the recovery
6. Run change accumulation (if appropriate)
7. Apply the log data sets or change accumulation data sets
8. Restart the application.

Data Base Recovery Control (DBRC) may be used to facilitate recovery. It can be used to identify the proper image copy tapes and log data sets, perform change accumulation, and generate the JCL for the recovery process.

Dual copy may be useful to reduce application outages caused by hardware failure and the resulting recovery activity.

CICS/DLI Data Bases

Considerations are very similar to full function IMS data bases.

CICS VSAM Data Sets

Without **dual copy**, considerations here are quite similar to IMS, with some differences in the recovery process:

1. Locate the backup tapes
2. Locate a spare volume
3. Import the backup tape
4. Find the log tapes
5. Generate JCL for the application's recovery routine
6. Run this recovery routine to apply the log tapes
7. Restart the application.

If there is no user-written recovery routine, then invoke those recovery procedures the installation has defined.

Dual copy may be useful to significantly reduce application outages caused by hardware failure and the resulting recovery activity.

Using Dual Copy with DB2 Data Base Volumes

Several data sets are essential to the availability of a DB2 system, including:

- Boot Strap Data Set (BSDS)
- Recovery Log
- DB2 Catalog
- DB2 Directory
- Database data sets.

DB2 provides facilities for duplexing the BSDS and the Recovery Log. In addition, in the event of a hardware failure, there are utility commands for creating a new BSDS and Recovery Log and copying the active data set without disrupting DB2 operation.

DB2 does not provide duplexing capability for any of the other data sets listed above. Recovery and Image Copy utility functions are provided. The DB2 Catalog and the DB2 Directory are data bases. The same utility command, RECOVER, is used to recover from a catalog or directory failure as for a data base failure.

DB2 installations use the Image Copy utility to create full or incremental copies of data bases on a regular basis. The RECOVER command uses these image copies and the Recovery Log to complete a data base recovery. Depending on the scope of the recovery action (page, data base, or table space), part of a data base, an entire data base, or multiple data bases will be unavailable while the RECOVER utility restores the data base.

Because of their importance to the DB2 system, the DB2 catalog and directory are very good candidates for dual copy. Dual copy may improve the availability of data

base, directory, and catalog data and reduce outages on this data resulting from hardware failures.

Other Data Base Applications

Evaluate each data base for applicability of dual copy. An analysis of data bases with high-availability requirements will identify data set or volume candidates and the value of using dual copy for those candidates.

User Volumes

User volumes are typically backed up on a regular schedule determined by operations and the end user groups. A hardware failure may result in the restore of the most recent backup tape. Recovery of updates or new data sets created after the most recent backup tape was created is typically an end user responsibility. The impact of such a failure varies greatly, depending on the user's capability to recreate the lost data.

Using an archival/backup system such as DFHSM can substantially reduce the recovery effort. Typically, the latest backup tapes are applied, and then the restore function is used to recover data sets created or updated since the last backup, up to the last DFHSM backup cycle. Again, further recovery action is typically up to the user.

Dual copy may be used routinely on frequently-updated user volumes, on volumes containing data that is very difficult to recreate, or on application volumes with high-availability requirements.

Use of DASD Fast Write in MVS/XA Environments

DASD fast write is used to improve the performance of data sets that have a significant amount of write activity. Good DASD fast write candidates include catalogs, DFHSM Control Data Sets, and most logging functions. Data bases or VSAM data sets may also be good candidates.

Typically, the write hit ratios observed have been very high for two reasons:

- Most applications read a record before updating it, so the number of truly random write misses is quite small.
- When writing a sequential output file, a format write is used for the entire track, which is considered a write hit by the 3990 Model 3 (no stage is required since the entire track will be rewritten).

Some applications may not show a performance improvement with DASD fast write. As in the case of normal caching, write updates where the transfer size is more than half a track may not benefit from DASD fast write because of the write miss stage activity. Data for which the write hit ratio is less than 70% might not benefit from DASD fast write. Also, applications such as very-high-activity logging functions that write half a track or more at a time with very high request rates might not perform better than noncached DASD. (This is true even if there is a high write hit ratio, that is, no staging activity.) Such applications must be individually evaluated.

Guidelines for Using Cache Fast Write with DFSORT Release 9 in MVS Environments

Cache fast write is supported for sort work files in DFSORT Release 9 in both MVS/370 and MVS/XA environments. We recommend that you use the following guidelines in implementing DFSORT Release 9 with cache fast write:

- Use cache fast write for small- to intermediate-size sorts. Large sorts (for example, sorts that will require more sort work space than is available in the cache) should be directed to DASD volumes that are not eligible for cache fast write because the volumes are:
  - Not attached to a 3990 Model 3
  - Attached to a 3990 Model 3 with device caching set off for the volume.
- Estimate approximate sort work space requirements by multiplying the input data set size by 1.7. See the *DFSORT Application Programming Guide* for details.
- Ensure that the estimated total concurrent sort work space in bytes does not exceed the available cache storage. If other data will also be cached, reduce the total concurrent sort work space appropriately. (See the recommended process below.) Be aware that larger sort jobs could cause temporary variations in the DASD subsystem response for other applications using the same cache. If possible, schedule larger sort runs at times when the cache workload is lighter.
- Follow the existing guidelines on placement of sort work file volumes:
  - Isolate the sort work volumes from other high activity system data sets
  - Place the sort work volumes on DASD strings dedicated to sort activity.
- Sort performance will probably not be improved by using more than three or four sort work files.
- Following are recommended guidelines for selecting and migrating data to a 3990 Model 3 that is expected to have a significant sort workload:
  - Migrate the sort volumes to the 3990 Model 3 before caching the other data
  - Measure the performance
  - Gradually add more caching volumes to the subsystem
  - Monitor both the performance of the sort volumes and the performance of the added volumes
  - Continue adding more workload as long as the subsystem performance is satisfactory.

3990 Performance Guidelines

Many 3990 Model 3 technological improvements significantly reduce the importance of a detailed analysis of caching data set candidates. These include:

- Larger cache capacities provide for higher read hit ratios or may reduce the need to remove data sets with lower hit ratios.
- Fast write capabilities add high write activity volumes to the list of caching candidates, removing the need to segregate high-write-activity data sets.

- More efficient internal processing reduces the control unit utilization thereby reducing the control unit overhead due to staging activity and allowing more data sets with a lower hit ratio.
- Improved cache utilization provides for higher read hit ratios.
- Improved caching algorithms provide for higher hit ratios, improving cache performance for high-activity sequential access files.
- DLSE mode reduces the impact of storage control internal path busy conditions.

Figure 20 and Figure 21 on page 53 give data selection guidelines for the 3990 Model 3 with and without DASD fast write. Data sets in the 'Best Cache Candidates' category require little analysis beyond ensuring that the I/O rate through the storage control is reasonable.

You can gradually add more data sets (and consequently more activity). As you do this, ensure that the DASD subsystem response times and system-level performance remain acceptable. A 3990 Model 3 requires less data set analysis than a 3880 Model 23. In most cases, you can install a 3990 Model 3 and receive a performance improvement with no analysis of the data sets behind the storage control.

MVS Cache and Cache Fast Write Data Selection Guidelines

Figure 20 shows data set candidates for basic caching and cache fast write operations. Data sets identified by an asterisk (*) are candidates for cache fast write operations.

Data Set Categories	System and General Data Sets	TSO	IMS	CICS
Best Cache Candidates	Partitioned data sets, PROCLIB, control data sets, SORTWK*, catalogs, RACF	Libraries, ISPF, TSO user data	ACB, MFS, ADF work data base, ADF rules, program libraries	Program libraries
Good Cache Candidates	Sequential input data sets		Data base indexes, moderate-sized data bases (primarily inquiry), IMS short message queue	
Potential Good Cache Candidates (See the following note)	Other System-type data sets, lookup tables or dictionaries, custom systems		Image copy, RECON data set, larger data bases (with larger cache sizes), Scratch Pad Area, long message queue, QBLKS	Application data sets

Figure 20. MVS Cache and * (Cache Fast Write) Data Selection Guidelines

Note: Custom-designed systems or other software might have good cache candidates that you can evaluate by the criteria given above. For example, data sets having a read hit ratio of 70% or better and a read-to-write ratio of 2:1 are good candidates for a 3990 Model 3.

MVS DASD Fast Write Data Selection Guidelines

Data Set Categories	System and General Data Sets	TSO	IMS	CICS
Good DASD Fast Write Candidates	Sequential data sets, work volumes		Moderate-sized data bases, IMS message queues, Scratch Pad Area, Image Copy, RECON, OLDS	System Log, Intra-partition transient data, Aux temporary storage, Aux trace
Potential Good Cache Candidates (See the following note)	Other System-type data sets, lookup tables or dictionaries, custom systems, data sets with high update activity		Larger data bases with high update activity (recommended with the larger cache sizes)	Larger application data bases with high update activity (recommended with the larger cache sizes)

Figure 21. MVS DASD Fast Write Data Selection Guidelines

Note: Custom-designed systems or other software might have good cache candidates that you can evaluate by the criteria given above. For example, data sets having read hit and DASD fast write hit ratios of 70% or better are good candidates for a 3990 Model 3.

The performance of DASD fast write in typical TSO and IMS data base applications have been modelled using data collected from representative large TSO and IMS data base systems. In such environments, DASD fast write performance is very good.

In many installations, it would be desirable to use DASD fast write for very active IMS logging applications, or for similar applications with very high levels of write activity. Such applications will require analysis, and probably testing on the 3990 Model 3. It is very difficult to develop guidelines for these, due to the varying load on the storage control and the I/O rate to the write data set. The suggested procedure is to place this high write activity application on the 3990 Model 3 first, and add more workload gradually. In general, the higher the hit ratio of the additional data, the more easily the additional load may be absorbed with a good response time.

Chapter 6. Optional Features

Features Available for 3990 Storage Controls

The following optional features are available on any model of the 3990:

- Four Channel Switch, Additional
- Remote Switch
- Remote Switch, Additional
- Local/Remote Switch
- Local/Remote Switch, Additional
- 3380 Model AA4 Support.

Figure 22 on page 56 summarizes the 3990 feature prerequisites.

Four Channel Switch, Additional

The Four Channel Switch, Additional feature 8172 permits four additional channels to be attached to each storage cluster.

Remote Switch

The Remote Switch feature 6149 removes the channel switches from the 3990 operator panel to a remote location, usually a switch panel at the host system.

Remote Switch, Additional

If remote switching is desired and the Four Channel Switch, Additional feature is installed, the Remote Switch, Additional feature 6150 is required to switch the additional channels from a remote location. This feature requires features 8172 and 6149.

Local/Remote Switch

The Local/Remote Switch feature 7149 permits the operator to enable or disable the channels either at the 3990 operator panel or at a remote switch panel.

Local/Remote Switch, Additional

The Local/Remote Switch, Additional feature 7150 permits the operator to enable or disable the additional channels either at the 3990 operator panel or at a remote switch panel. This feature requires features 8172 and 7149.

3380 Model AA4 Support

The 3380 Model AA4 Support feature 9003 is required to attach each 3380 Model AA4 to a 3990. This is a *3990 feature* that provides 3990-related maintenance information for 3380 Model AA4s.

Summary of 3990 Feature Prerequisites

Figure 22 summarizes the 3990 feature prerequisites.

3990 Features	3990 Feature Prerequisites
Four Channel Switch, Additional (8172)	—
Remote Switch (6149)	—
Remote Switch, Additional (6150)	Remote Switch (6149) and Four Channel Switch, Additional (8172)
Local/Remote Switch (7149)	—
Local/Remote Switch, Additional (7150)	Local/Remote Switch (7149) Four Channel Switch, Additional (8172)
3380 Model AA4 Support (9003)	—

Figure 22. Summary of 3990 Feature Prerequisites

Features Available for 3380 Direct Access Storage Devices

One of two features is required on all 3380 Model AJ4/AK4 that attach to a 3990. These features specify whether the DASD string operates in 2-path or 4-path mode.

3990 AJ4/AK4 2-Path String Attachment

The 3990 AJ4/AK4 2-Path String Attachment feature 9432 must be installed on all 2-path 3380 Model AJ4 or AK4s before the strings are attached to a 3990 operating in DLS support mode. Feature 9432 allows the 3380 AJ4 or AK4 to operate in a 2-path string. DLS mode permits two single-path storage directors to access data in the DASD subsystem.

3990 AJ4/AK4 4-Path String Attachment

The 3990 AJ4/AK4 4-Path String Attachment feature 9433 must be installed on all 3380 Models AJ4 or AK4 before the strings are attached to a 3990 Model 2 or 3 operating in DLSE support mode. Feature 9433 allows the 3380 AJ4 or AK4 to operate as a 4-path string. DLSE mode permits two multipath storage directors to access data in the DASD subsystem.

3380 Models AD4 and AE4

The 3380 Models AD4 and AE4 do not require any features to attach to a 3990.

Chapter 7. Performance Characteristics

DASD Subsystem Performance Overview

IBM systems, both hardware and software, provide a number of ways to improve storage subsystem performance.

Among the ways to improve storage subsystem performance are:

- **Increase the channel speed:** Several channel speeds are available. Currently the fastest IBM channel speed is 4.5 megabytes per second for subsystems using cache. Assuming all other performance variables remain the same, an increase of about five to 10 percent can be obtained by changing from a channel speed of 3.0 megabytes per second to 4.5 megabytes per second for cache operations.
- **Add additional data paths and devices:** Enhancements in processor architecture and MVS/XA permit the effective use of more paths and devices, which can improve performance by reducing both path and device contention. Furthermore, the 3990's DLSE mode provides four independent and concurrent data transfer paths to and from the DASD string resulting in improved response times.
- **Increase the data path utilization:** The Dynamic Path Reconnect feature of MVS/XA and the concurrent data transfer over any of four paths in the 3990 in DLSE mode allow higher channel and storage path utilization. However, when using this capability to improve performance, the mechanical nature of the device is still a factor.
- **Increase the device speed:** Because of the increased track density of the IBM 3380 Models AE4/BE4 and AK4/BK4, access times per tracks accessed have improved. Minimum seek times of the 3380 Models AJ4/BJ4 and AK4/BK4 are improved by one-third over previous 3380 models.
- **Improve the storage control efficiency, particularly by using those storage controls with cache:** Storage Controls such as the IBM 3990 use cache to aid performance by allowing frequently-accessed data to transfer at near-channel speeds. For example, when an I/O request can be completed with a cache access (either a read or a write operation) the 3990 Model 3 immediately satisfies that request. The device's electromechanical motion is eliminated by the cache. I/O operations with cache can be done essentially at channel speed. Subsystem response time, an important measure of performance, and user satisfaction, can often significantly improve by using a cached storage control.

  New capabilities, such as the 3990 Model 3s **DASD fast write, cache fast write**, and **dual copy** give an installation added flexibility resulting in an optimum of subsystem performance and availability.

All of the above methods do work in different environments to improve storage subsystem performance (depending on the environment, some methods work better than others). However, in most installations, perhaps the most dramatic performance improvement can occur with the use of more efficient storage controls, such as the IBM 3990 Model 3 Storage Control.

Modeling Assumptions

This chapter shows performance characteristics of 3880 Model 3s, 3880 Model 23s and 3990 Models 2 and 3. The performance values in this chapter were obtained from mathematical models and should not be considered actual obtainable results in a specific environment. The different operating environments and processing workloads used with the models were obtained through studies of representative production systems. The performance values should be taken as indications of relative performances characteristics. In an attempt to ensure fair and accurate comparisons, the mathematical models are based on fixed sets of assumptions. The model for DASD fast write and dual copy is preliminary in nature and is based on product specifications. It has not yet been validated against 3990 Model 3s running in a production environment. It is important to realize that some of the specified assumptions may not apply to a given operating environment.

When evaluating DASD subsystem performance characteristics, it is also important to realize that improvements in DASD subsystem performance may not necessarily result in improvements in system performance. Other variables such as the processor cycle speeds, the main storage size, the operating system, and the communications network may limit the potential system performance even if the DASD subsystem performance has been improved. **Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.**

The purpose of this chapter is to show the performance characteristics of the 3990 models compared to those of the 3880 Models 3 and 23. A cross-configured 3880 Model 3, a dual-frame 3880 Model 23, each attached to 3380 AE4/BE4, and a single 3990 Model 2 in DLSE mode and a single 3990 Model 3 in DLSE mode, each attached to 3380 Models AK4/BK4 are used in the comparisons. For simplicity of presentation, the 3990 Model 3 uses its caching ability alone in one comparison, the **fast dual copy** capability in one comparison, and the **DASD fast write** capability in the final comparison. In these comparisons, the 3880 Model 3s, 3880 Model 23s, and the 3990 Model 2 transfer data at the 3.0 megabytes per second channel speed. The 3990 Model 3 transfers data at the 4.5 megabytes per second channel speed.

Figure 23 shows the various models and the assumptions used in the mathematical models to generate the storage control performance characteristics used in this chapter.

Each configuration has 32 actuators, and each of the configurations that has cache, uses 32 megabytes in the TSO environment and 64 megabytes in the IMS environment. (The 3990 Model 3 configuration using **fast dual copy** uses 64 actuators with 32 duplex pairs as all data is duplexed.)

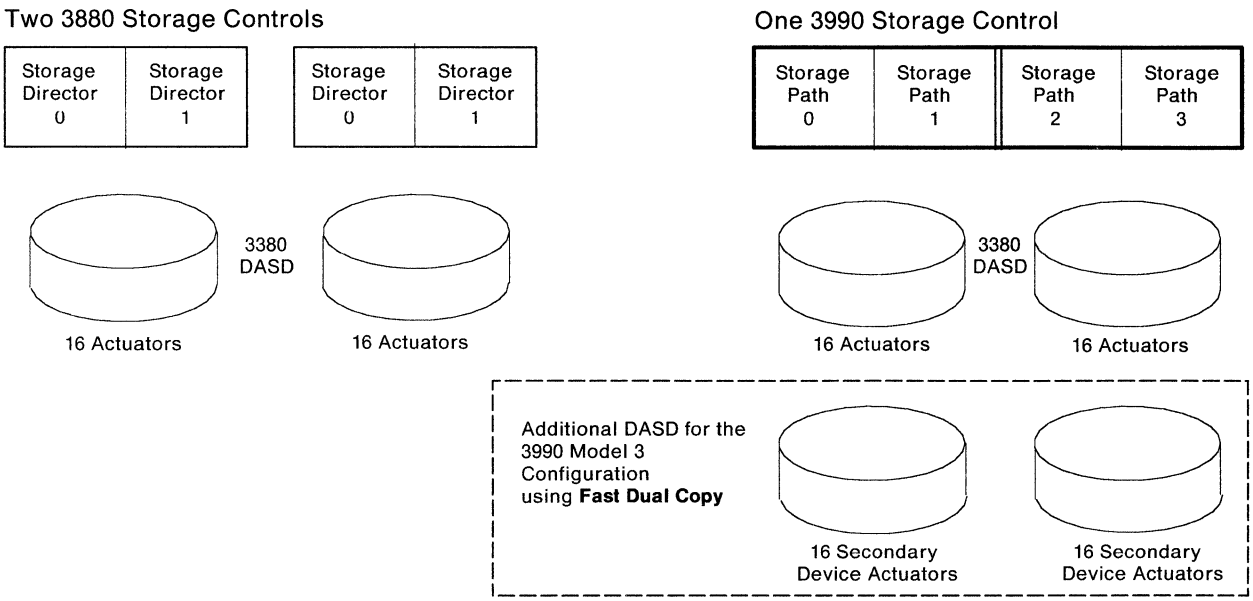
The performance of the 3880 models and the 3990 models is compared in two operating environments:

- TSO
- IMS.

For consistency of interpretation, all performance comparisons are made at two values:

- A constant 22 millisecond response time
- A constant 150 accesses per second.

Modeling Assumptions



	TSO	IMS
Block Size	5496	7936
Read-To-Write-Ratio	4.8/1	7.2/1
Cache Size	32 Mb	64 Mb
Read Hit Ratio	91%	82%
Write Hit Ratio	98%	99%
Data Defined To Be Cached	100%	100%
Data Defined To Be DASD Fast Write Data	100%	100%
Data Defined To Be Fast Dual Copy Data	100%	100%

slvc0tm7

Figure 23. Modeling Assumptions

Performance Comparisons in a TSO Environment

Overall Performance Comparisons in a TSO Environment

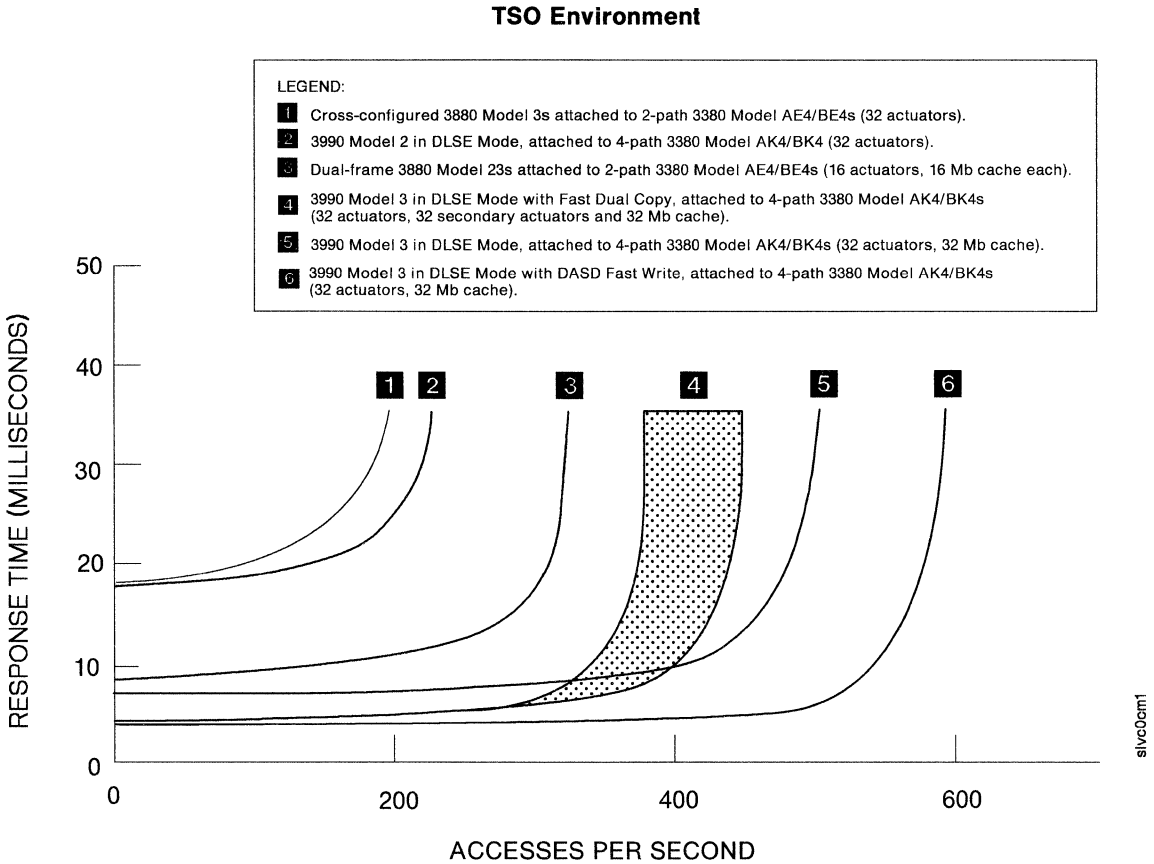
The performance of two cross-configured 3880 Model 3s, attached to 3380 Model AE4/BE4s, using 3.0M byte channels **1** and two 3880 Model 23s in a dual-frame configuration (with a total of 32 megabytes of cache) attached to 3380 Model AE4/BE4s, using 3.0M byte channels **3** are compared to the performance of:

2 One 3990 Model 2 in DLSE mode attached to 3380 Model AK4/BK4s, using 3.0M byte channels

4 One 3990 Model 3 in DLSE mode (with a total of 32 megabytes of cache) using **fast dual copy** attached to 3380 Model AK4/BK4s, using 4.5M byte channels

5 One 3990 Model 3 in DLSE mode using 32 megabytes of cache attached to 3380 Model AK4/BK4s, using 4.5M byte channels

6 One 3990 Model 3 in DLSE mode (with a total of 32 megabytes of cache) using **DASD fast write** attached to 3380 Model AK4/BK4s, using 4.5M byte channels.



Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 24. TSO Overall Performance of Storage Controls Compared

General Observations on Performance in a TSO Environment

- The configurations that use cache (configurations 3, 4, 5, and 6) show a response time half of that of those configurations that do not use cache 1 and 2. Furthermore, those configurations that use cache sustain their faster response times for a much greater rate of accesses per second. This significant improvement in response times at higher request rates means that installations using cache have the ability to sustain a much higher throughput of data without affecting, and in most cases lowering, their system response times.
- Configurations 1 and 2 show the performance improvement of a 3990 Model 2 DLSE DASD subsystem compared to that of two 3880 Model 3 – 2-path DASD subsystems.

  Configurations 3 and 5 show the performance improvement of a 3990 Model 3 DLSE DASD subsystem using its 32 megabytes of cache for basic caching (no fast writes) compared to that of two 3880 Model 23 – 2-path DASD subsystems using 32 megabytes of cache.

  It is interesting to see that, because of the various improvements of the 3990 cache model over the 3880 cache model, the 3990 Model 3 DLSE DASD subsystem sustains more than one-half greater rate of accesses per second than the 3880 Model 23 – 2-path DASD subsystem.
- Configurations 5 and 6 show the performance improvement of a 3990 Model 3 DLSE DASD subsystem using **DASD fast write** compared to that of a 3990 Model 3 subsystem using only basic caching.
- For **fast dual copy**, the performance is shown as a range rather than as a single curve. This range is shown because to date the dual copy model reflects a limited set of environments. As the dual copy model is validated across a broader range of production environments, IBM may update this range of performance values.

  Configurations 4 and 5 show the relative performance of a 3990 Model 3 using **fast dual copy** and a 3990 Model 3 using 32 megabytes for basic caching. Figure 24 shows that the performance of **fast dual copy** is approximately the same as a 3990 Model 3 using basic caching at lower access rates. At higher access rates, the additional overhead of **fast dual copy** begins to affect response time. While **fast dual copy** performance is better than two 3880 Model 23's 3, a 3990 Model 3 using basic caching will probably have better performance at higher access rates.
- A 3990 Model 3 in DLSE mode, attached to 4-path 3380 Model AK4/BK4s 5 compared to two 3880 Model 3s cross-configured with 2-path 3380 Model AE4/BE4s 1 results in a data throughput improvement of more than 200% at a constant 22 millisecond response time.

  Or, in a comparison between those storage controls with cache, and using **DASD fast write**, the performance improvements can again be seen and quantified. A 3990 Model 3 with 32 megabytes of cache in DLSE mode, using **DASD fast write** attached to 4-path 3380 Model AK4/BK4s 6 compared to a dual-frame 3880 Model 23, each storage control having 16 megabytes of cache attached to 2-path 3380 Model AE4/BE4s 3 results in a data throughput improvement of more than 90% at a constant 22 millisecond response time.

Examining a 3990 Model 3 with 32 megabytes of cache in DLSE mode, using **fast dual copy** (all volumes dual copied) attached to 4-path 3380 Model AK4/BK4s 4 compared to a dual-frame 3880 Model 23, each storage control having 16 megabytes of cache attached to 2-path 3380 Model AE4/BE4s 3 results in a data throughput improvement of more than 20% at a constant 22 millisecond response time.

Accesses Per Second Comparisons in a TSO Environment

Figure 24 shows the overall performance characteristics of the storage controls in the TSO environment. At a constant response time of 22 milliseconds, the 3880 Model 3 cross-configuration 1 produces **150** accesses per second. This performance of the 3880 Model 3 cross-configuration can be compared to:

2 A 30% increase in data throughput for the 3990 Model 2/3380 Model AK4/BK4 configuration

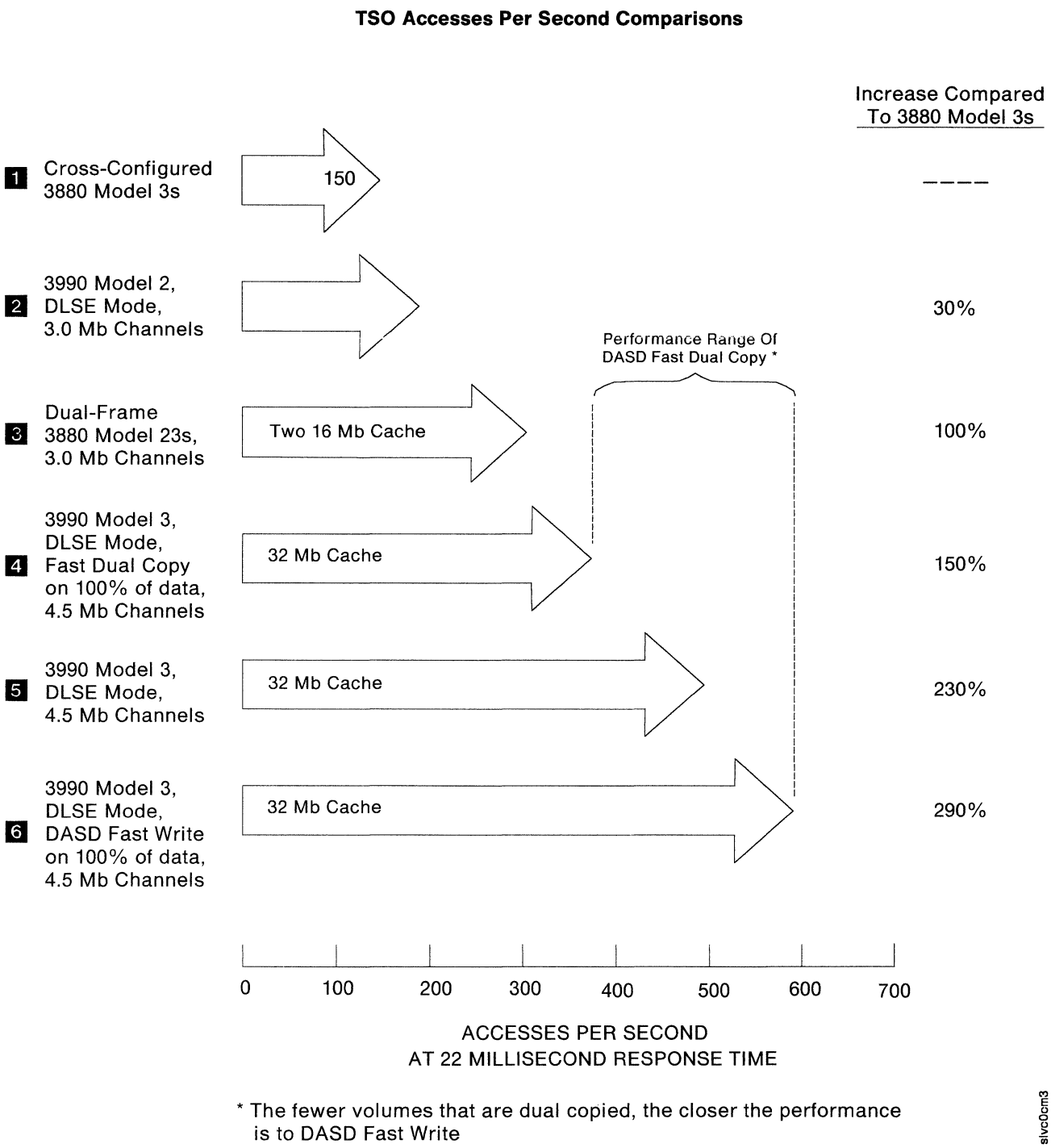
3 A 100% increase in data throughput for the dual-frame 3880 Model 23/3380 Model AE4/BE4 configuration

4 A 150% increase in data throughput for the 3990 with **fast dual copy**/3380 Model AK4/BK4 configuration

5 A 230% increase in data throughput for the 3990 with 32 megabytes of cache/3380 Model AK4/BK4 configuration

6 A 290% increase in data throughput for the 3990 with **DASD fast write**/3380 Model AK4/BK4 configuration.

The performance range shown in Figure 25 applies to individual installations. Configuration 4, the **fast dual copy** configuration, depicts the performance of a fully configured 3990 Model 3/3380 AK4/BK4 subsystem, with 32 dual copy pairs, for a total of 64 devices. With the modelled workload, performance could vary from that shown here—to something approaching the performance of the **fast write** configuration 6, depending on the number of volumes being dual copied.



Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 25. TSO Accesses Per Second at 22 Millisecond Response Time and the Performance Range of DASD Fast Write and Fast Dual Copy

Response Time Comparisons in a TSO Environment

Figure 26 examines the same set of TSO data as the previous two figures but shows the data in a different manner: the sensitivity of response time at a fixed 150 accesses per second. Examining the fixed 150 accesses per second allows a comparison of the different hardware configurations of 3880s and 3990s.

At a constant 150 accesses per second, the 3880 Model 3 cross-configuration **1** produces a **22** millisecond response time. This performance of the 3880 Model 3 cross-configuration can be compared to:

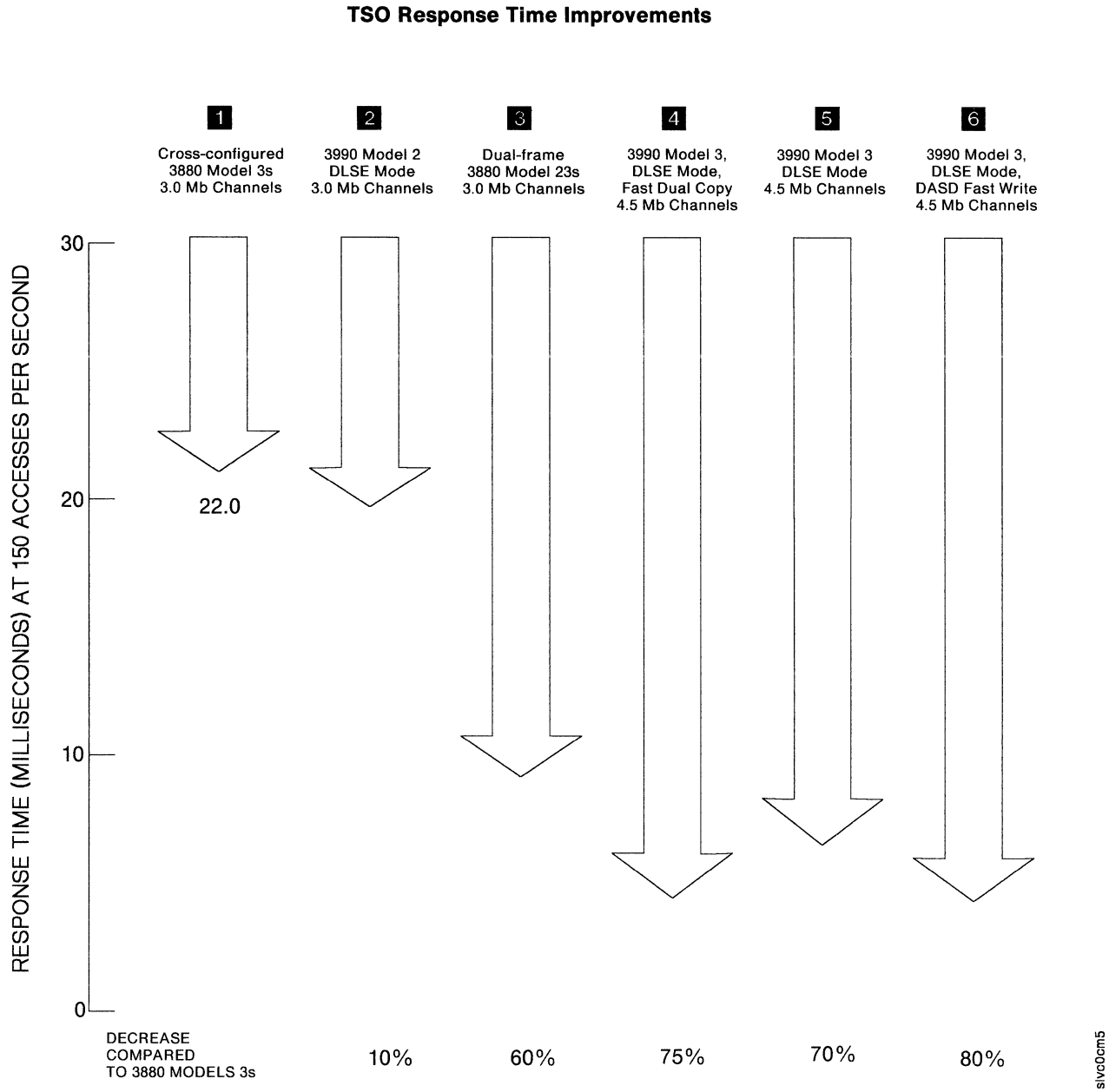
2 A 10% decrease in response time for the 3990 Model 2/3380 Model AK4/BK4 configuration

3 A 60% decrease in response time for the dual-frame 3880 Model 23/3380 Model AE4/BE4 configuration

4 An 75% decrease in response time for the 3990 with **fast dual copy**/3380 Model AK4/BK4 configuration

5 A 70% decrease in response time for the 3990 with 32 megabytes of cache/3380 Model AK4/BK4 configuration

6 An 80% decrease in response time for the 3990 with **DASD fast write**/3380 Model AK4/BK4 configuration.



Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 26. TSO Response Time at 150 Accesses Per Second

Performance Comparisons in an IMS Environment

Overall Performance Comparisons in an IMS Environment

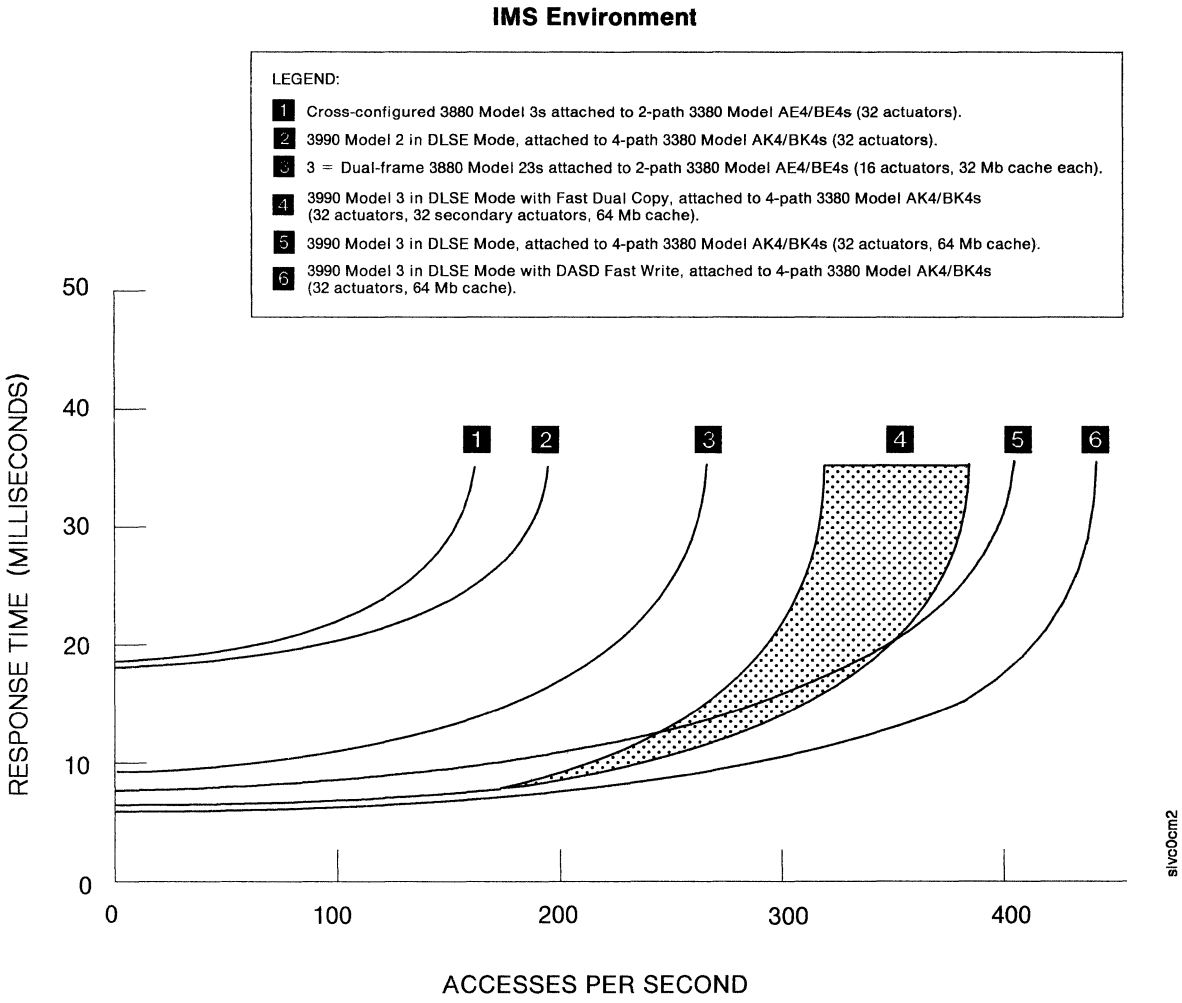
The performance of two cross-configured 3880 Model 3s, attached to 3380 Model AE4/BE4s, using 3.0M byte channels **1** and two 3880 Model 23s in a dual-frame configuration (with a total of 64 megabytes of cache) attached to 3380 Model AE4/BE4s, using 3.0M byte channels **3** are compared to the performance of:

2 One 3990 Model 2 in DLSE mode attached to 3380 Model AK4/BK4s, using 3.0M byte channels

4 One 3990 Model 3 in DLSE mode (with a total of 64 megabytes of cache) using **fast dual copy** attached to 3380 Model AK4/BK4s, using 4.5M byte channels

5 One 3990 Model 3 in DLSE mode using 64 megabytes of cache attached to 3380 Model AK4/BK4s, using 4.5M byte channels

6 One 3990 Model 3 in DLSE mode (with a total of 64 megabytes of cache) using **DASD fast write** attached to 3380 Model AK4/BK4s, using 4.5M byte channels.



Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 27. IMS Overall Performance of Storage Controls Compared

General Observations on Performance in an IMS Environment

- The configurations that use cache (configurations 3, 4, 5, and 6) show a response time half of that of those configurations that do not use cache 1 and 2). Furthermore, those configurations that use cache sustain their faster response times for a much greater rate of accesses per second. This significant improvement in response times at higher request rates means that installations using cache have the ability to sustain a much higher throughput of data without affecting, and in most cases lowering, their system response times.
- Configurations 1 and 2 show the performance improvement of a 3990 Model 2 DLSE DASD subsystem compared to that of two 3880 Model 3 – 2-path DASD subsystems.

  Configurations 3 and 5 show the performance improvement of a 3990 Model 3 DLSE DASD subsystem using its 64 megabytes of cache for basic caching (no fast writes) compared to that of two 3880 Model 23 – 2-path DASD subsystems using 64 megabytes of cache.

It is interesting to see that, because of the various improvements of the 3990 cache model over the 3880 cache model, the 3990 Model 3 DLSE DASD subsystem sustains more than a one-half greater rate of accesses per second than the 3880 Model 23 – 2-path DASD subsystem.

- Configurations 5 and 6 show the performance improvement of a 3990 Model 3 DLSE DASD subsystem using **DASD fast write** compared to that of a 3990 Model 3 subsystem using only basic caching.
- For **fast dual copy**, the performance is shown as a range rather than as a single curve. This range is shown because to date the dual copy model reflects a limited set of environments. As the dual copy model is validated across a broader range of production environments, IBM may update this range of performance values.

  Configurations 4 and 5 show the relative performance of a 3990 Model 3 using **fast dual copy** and a 3990 Model 3 using 64 megabytes for basic caching. Figure 27 shows that the performance of **fast dual copy** is approximately the same as a 3990 Model 3 using basic caching at lower access rates. At higher access rates, the additional overhead of **fast dual copy** begins to affect response time. While **fast dual copy** performance is better than two 3880 Model 23's 3, a 3990 Model 3 using basic caching will probably have better performance at higher access rates.
- A 3990 Model 3 in DLSE mode, attached to 4-path 3380 Model AK4/BK4s 5 compared to two 3880 Model 3s cross-configured with 2-path 3380 Model AE4/BE4s 1 results in a data throughput improvement of more than 320% at a constant 22 millisecond response time.

  Or, in a comparison between those storage controls with cache, and using **DASD fast write**, the performance improvements can again be seen and quantified. A 3990 Model 3 with 64 megabytes of cache in DLSE mode, using **DASD fast write** attached to 4-path 3380 Model AK4/BK4s 6 compared to a dual-frame 3880 Model 23, each storage control having 32 megabytes of cache attached to 2-path 3380 Model AE4/BE4s 3 results in a data throughput improvement of more than 50% at a constant 22 millisecond response time.

  Examining a 3990 Model 3 with 64 megabytes of cache in DLSE mode, using **fast dual copy** (all volumes dual copied) attached to 4-path 3380 Model AK4/BK4s 4 compared to a dual-frame 3880 Model 23, each storage control having 32 megabytes of cache attached to 2-path 3380 Model AE4/BE4s 3 results in a data throughput improvement of more than 20% at a constant 22 millisecond response time.

Accesses Per Second Comparisons in an IMS Environment

Figure 27 shows the overall performance characteristics of the storage controls in the IMS environment. At a constant response time of 22 milliseconds, the 3880 Model 3 cross-configuration 1 produces **90** accesses per second. This performance of the 3880 Model 3 cross-configuration can be compared to:

2 A 30% increase in data throughput for the 3990 Model 2/3380 Model AK4/BK4 configuration

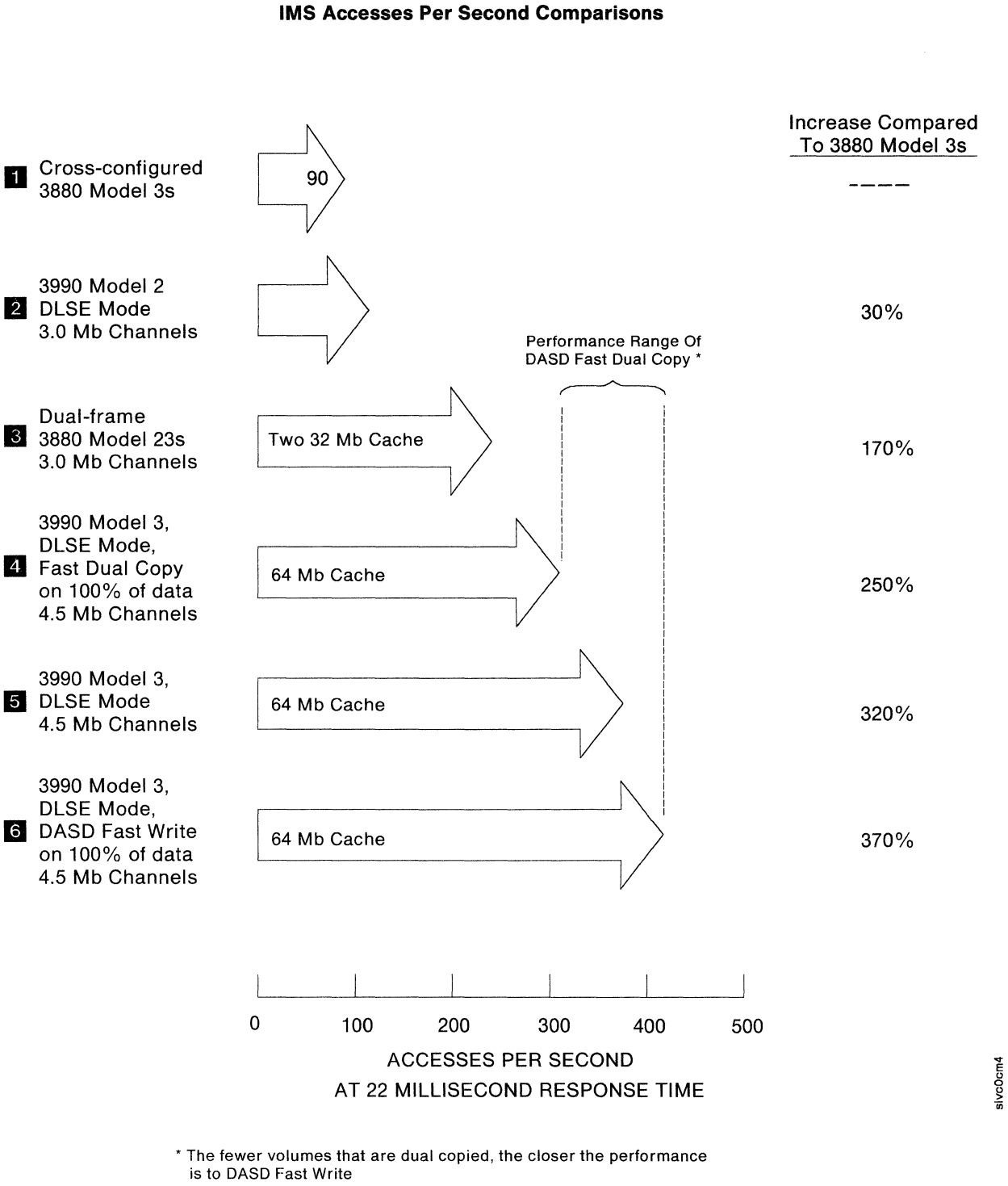
3 A 170% increase in data throughput for the dual-frame 3880 Model 23/3380 Model AE4/BE4 configuration

4 A 250% increase in data throughput for the 3990 with **fast dual copy**/3380 Model AK4/BK4 configuration

5 A 320% increase in data throughput for the 3990 with 64 megabytes of cache/3380 Model AK4/BK4 configuration

6 A 370% increase in data throughput for the 3990 with **DASD fast write**/3380 Model AK4/BK4 configuration.

The performance range shown in Figure 28 applies to individual installations. Configuration 4, the **fast dual copy** configuration, depicts the performance of a fully configured 3990 Model 3/3380 AK4/BK4 subsystem, with 32 dual copy pairs, for a total of 64 devices. With the modelled workload, performance could vary from that shown here—to something approaching the performance of the **fast write** configuration 6, depending on the number of volumes being dual copied.



* The fewer volumes that are dual copied, the closer the performance is to DASD Fast Write

Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 28. IMS Accesses Per Second at 22 Millisecond Response Time and the Performance Range of DASD Fast Write and Fast Dual Copy

Response Time Comparisons in an IMS Environment

Figure 29 examines the same set of IMS data as the previous two figures but shows the data in a different manner: the sensitivity of response time at a fixed 150 accesses per second. Examining the fixed 150 accesses per second allows a comparison of the different hardware configurations of 3880s and 3990s.

At a constant 150 accesses per second, the 3880 Model 3 cross-configuration **1** produces a **30** millisecond response time. This performance of the 3880 Model 3 cross-configuration can be compared to:

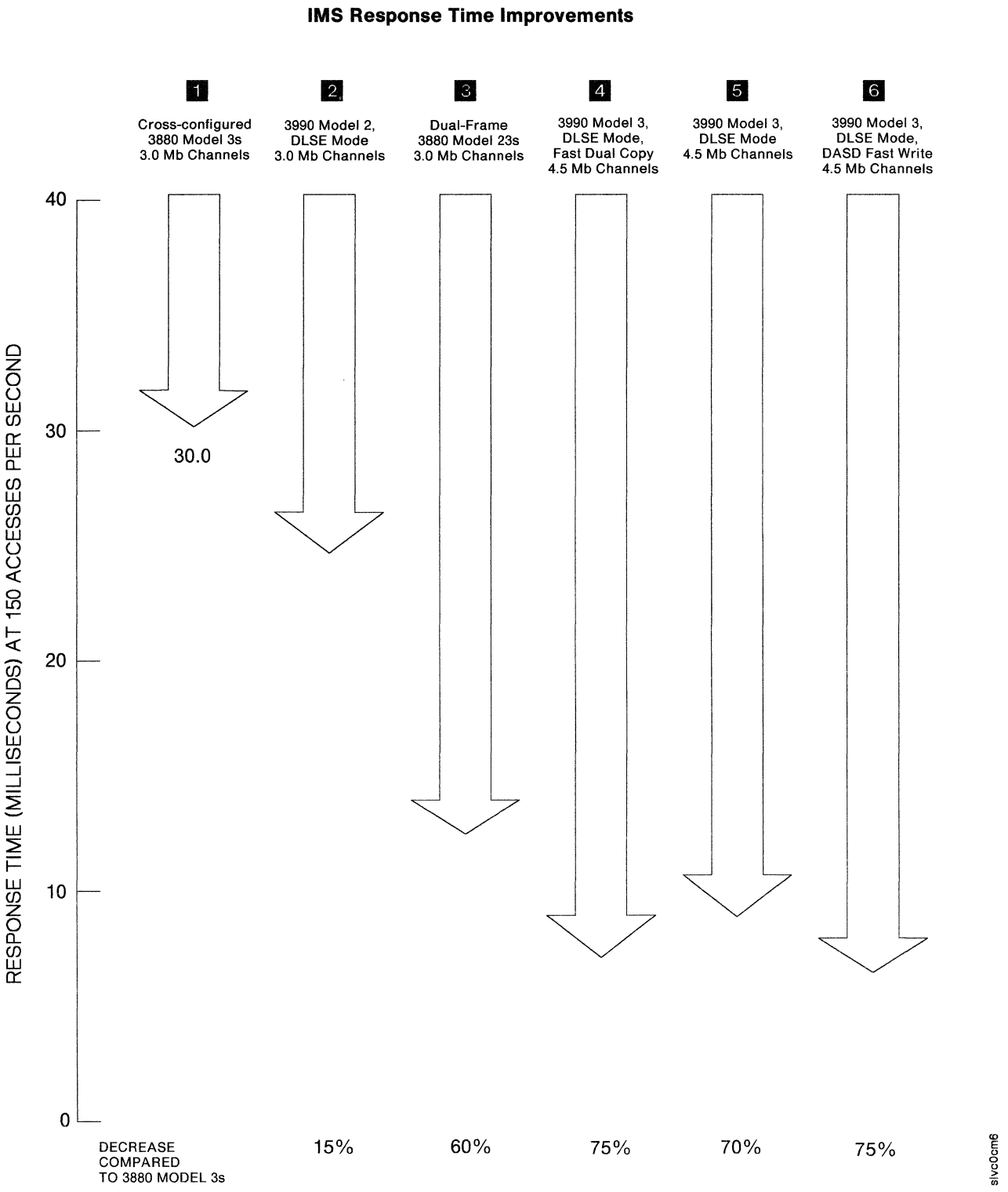
2 A 15% decrease in response time for the 3990 Model 2/3380 Model AK4/BK4 configuration

3 A 60% decrease in response time for the dual-frame 3880 Model 23/3380 Model AE4/BE4 configuration

4 A 75% decrease in response time for the 3990 with **fast dual copy**/3380 Model AK4/BK4 configuration

5 A 70% decrease in response time for the 3990 with 64 megabytes of cache/3380 Model AK4/BK4 configuration

6 An 75% decrease in response time for the 3990 with **DASD fast write**/3380 Model AK4/BK4 configuration.



Modeling Data - For Reference Only. These results are from an analytic model using specific workloads and specific predefined parameters. Other environments, configurations, and processors will experience different levels of performance. Accordingly, these figures do not constitute a performance guarantee or warranty.

Figure 29. IMS Response Time at 150 Accesses Per Second

Glossary

This glossary contains disk storage subsystem terms that are used in the various manuals in the Storage Subsystem Library. Each of the terms included here is not necessarily used in *this specific* manual. To help explain some of the terms related to configuration of storage subsystems, several illustrations are included at the end of this glossary. The definitions of certain terms include references to these illustrations.

A

A-unit. The direct access storage unit that contains the controller functions to attach to the storage control. An A-unit controls the B-units that are attached to it and is often referred to as a head of string.

access mechanism. See actuator.

actuator. A set of access arms and their attached read/write heads, which move as an independent component within a head and disk assembly (HDA). For example, the 3380 Model AK4 has two HDAs, each containing two actuators. See also device and volume.

alternate track. On a direct access storage device, a track designated to contain data in place of a defective primary track.

B

B-unit. A direct access storage unit that attaches to the subsystem through an A-unit. A B-unit has no controller functions.

C

C-unit. A direct channel attach 3380 Model CJ2 direct access storage unit that contains both the storage control functions and the DASD controller functions. A 3380 C-unit functions as a head of string and controls the B-units that are attached to it.

cache storage. A random access electronic storage in selected storage controls used to retain frequently used data for faster access by the channel. For example, 3880 Model 23 and 3990 Model 3 contain cache.

cache fast write. A form of fast write where the data is written directly to cache storage without using nonvolatile storage and is available for later destaging. This 3990 Model 3 Storage Control function should be used for data of a temporary nature, or data that is readily recreated, such as the sort work files created by the appropriate release of DFSORT.

channel interface (CHL-I). The circuitry of a storage control that attaches storage paths to a host channel.

check-1 error. In the storage control and DASD, an error that does not allow the use of normal machine functions to report details of the error condition.

check-2 error. In the storage control and DASD, an error that can be reported using the normal machine functions.

concurrent maintenance. A 3990 Model 2 and 3 capability that permits a service representative to perform a service action on one storage cluster while normal DASD access operations continue on the other cluster.

On the 3990 Model 3, a service representative can perform most service actions on nonvolatile storage while caching and DASD access operations continue through both the storage clusters.

On the 3990 Model 3, a service representative can perform most service actions on cache storage while DASD access operations continue through both the storage clusters. During a cache service action, cache fast write and DASD fast write operations are not performed and dual copy operations are performed directly with the DASD.

connection check alert. The electronic signal used by the 3380 to indicate a check-1 error condition to the storage control. See check-1 error.

control interface (CTL-I). The hardware connection between the storage control function and the DASD controller function.

controller. The hardware component of a DASD head of string unit that provides the path control and data transfer functions. For example, there are two controllers in a 3380 Model AE4 or AK4.

count-key-data (CKD). A DASD data recording format employing self-defining record formats in which each record is represented by a count area, that identifies the record and specifies its format, an optional key area that may be used to identify the data area contents, and a data area that contains the user data for

the record. CKD is also used to refer to the set of channel commands that are accepted by a device that employs the CKD recording format.

D

DASD. Direct access storage device; for example, a 3380.

DASD fast write. A form of fast write to cache storage where the data is written concurrently to cache storage and nonvolatile storage and is automatically scheduled for destaging to the DASD. Both copies are retained in the 3990 Model 3 until the data is completely written to the DASD, providing data integrity equivalent to writing directly to the DASD. DASD fast write can be active with dual copy, resulting in a 'fast dual copy'.

DASD subsystem. One or more DASD strings and the storage control(s) to which the DASD are attached.

demotion. The process of removing the image of one or more records from cache storage. A set of one or more DASD records is demoted either by being selected for replacement (overlay) by another set of DASD records or by being marked invalid. Compare to promotion.

destage. The asynchronous write of new or updated data from cache storage or nonvolatile storage to DASD. This is used only for the fast write and dual copy functions of 3990 Model 3. See also fast write and write hit.

device. A uniquely addressable part of a DASD unit that consists of a set of access arms, the associated disk surfaces, and the electronic circuitry required to locate, read, and write data. See also volume.

device address. Three or four hexadecimal digits that uniquely define a physical I/O device on a channel path in System/370 mode. The one or two left-most digits are the address of the channel to which the device is attached. The two right-most digits represent the unit address.

device ID. An 8-bit identifier that uniquely identifies a physical I/O device.

device level selection (DLS). A DASD function available with 3380 Models AD4, BD4, AE4, BE4, AJ4, BJ4, AK4, BK4, and CJ2. With DLS, each of the two controllers in the DASD string has an independent path to all devices in the string (as many as 14 addresses for a CJ2 or 16 addresses for other string types), and any two devices in the 2-path DASD string can read or write data simultaneously. See DLS support mode.

device level selection enhanced (DLSE). A DASD function available with 3380 Models AJ4, BJ4, AK4, and BK4. With DLSE, each of the four controllers in the 4-path DASD string (as a result of interconnecting two A-units), has an independent path to all devices in the string (as many as 32 addresses), and any four devices in the 4-path DASD string can read or write data simultaneously. See DLSE support mode.

device number. Four hexadecimal digits that logically identify an I/O device in a System 370/Extended Architecture system.

device release. A command that terminates the reservation of the device from the channel issuing the command or from all channels on the interface path group.

device reserve. A command that reserves the device for the channel issuing the command, or for all channels in the same interface path group.

device support facilities program (ICKDSF). A program used to initialize DASD at installation and provide media maintenance.

diagnostic tracks. Tracks used by the diagnostic programs for testing the read/write function.

diskette drive. A direct access storage device that uses diskettes as the storage medium. A 3880 uses a read-only diskette drive for microcode storage; a 3990 and a 3380 Model CJ2 use a read/write diskette drive for microcode storage and storage control error logs.

DLS support mode. A mode of operation in a 3990 Storage Control that supports 3380 2-path strings, including 3380 AA4 strings and 3380 AD4, AE4, AJ4, and AK4 2-path strings. DLS support mode must be specified by the IBM service representative during the 3990 installation. See single-path storage director.

DLSE support mode. A mode of operation in a 3990 Model 2 or 3 Storage Control that supports 3380 AJ4 and AK4 4-path strings. DLSE support mode must be specified by the IBM service representative during the 3990 installation. See multipath storage director.

dual copy. A high availability function made possible by the nonvolatile storage in a 3990 Model 3 and its programming support. Dual copy maintains two logically identical copies of designated DASD volumes in the logical 3990 Model 3 subsystem, and automatically updates both copies every time a write operation is issued to the dual copy logical volume. When DASD fast write is active for the dual copy logical volume, the capability is called fast dual copy.

dual copy logical volume. A logical volume comprised of two physical devices with all data recorded twice, once on each device. The 3990 Model 3 Storage

Control with nonvolatile storage automatically ensures that both devices are updated with each write operation to the dual copy volume. Also called a duplex pair.

dual-frame configuration. Consists of two like storage controls physically interconnected. Pairs of 3880 Model 13 and 23 and 3990 Models 2 and 3 Storage Controls can be dual-framed. In a dual-frame configuration, each storage director in a logical DASD subsystem is in a different storage control. When a 3990 Storage Control is in DLS support mode, each DASD string has one path to a single-path storage director in each of the 3990 Storage Controls. When a 3990 Storage Control is in DLSE support mode, each DASD string has two paths to a multipath storage director in each of the 3990 Storage Controls.

duplex mode. Two devices in a 3990 Model 3 subsystem are in duplex mode when they have been made into a dual copy logical volume.

duplex pair. See dual copy logical volume.

dynamic path reconnect. A function of dynamic path selection (DPS) that allows disconnected DASD operations to reconnect over any available channel path rather than being limited to the one on which the I/O operation was started. It is available only on System 370/Extended Architecture systems. For example, when a 3990 Storage Control (in DLSE support mode) having four host channels is connected to a 3380 Model AJ4 or AK4 4-path string, any device can reconnect on any one of four completely independent data paths, providing improved performance and availability.

dynamic path selection (DPS). DASD subsystem functions available with all 3380 heads of string except Model A04. These functions include:

- Two controllers providing data paths from the 3380 strings to the storage directors
- Simultaneous transfer of data over two paths to two devices, providing the two devices are on separate internal paths within the string
- Sharing DASD volumes by using System-Related Reserve and Release
- Providing dynamic path reconnect to the first available path (with System 370/Extended Architecture hosts only).

E

error burst. A sequence of bit errors counted as one unit, or burst.

error correcting code (ECC). A code designed to detect and correct error bursts by the use of check bytes.

extended count-key-data (ECKD) architecture. A set of channel commands that use the CKD track format. This architecture employs the Define Extent and Locate Record commands to describe the nature and scope of a data transfer operation to the storage control to optimize the data transfer operation. The 3990 Storage Control supports the ECKD architecture.

F

fast dual copy. A dual copy capability where DASD fast write and dual copy are active concurrently to provide a significant dual copy performance enhancement.

fast write. In a 3990 Model 3 Storage Control, a write operation at cache speed that does not require immediate transfer of data to a DASD. Fast write reduces the time an application must wait for the I/O operation to complete. Also see DASD fast write, cache fast write, destage, and fast dual copy.

fence. To separate one or more paths or elements from the remainder of the logical DASD subsystem. The separation is by logical boundaries rather than power boundaries. This separation allows isolation of failing components so that they do not affect customer operation.

G

gigabyte (Gb). 10^9 bytes.

H

head and disk assembly (HDA). A field replaceable unit in a direct access storage device containing the disks and actuators. A 3380 Model AK4 has two HDAs.

head of string. The unit in a DASD string that contains controller functions. For example, a 3380 Model AA4, AD4, AE4, AJ4, AK4, or CJ2.

home address (HA). The first field on a CKD track that identifies the track and defines its operational status. The home address is written after the index point on each track.

I

ICKDSF. See Device Support Facilities program.

IDCAMS. A Data Facility Product program for MVS that is also referred to as access method services.

identifier (ID). A sequence of bits or characters that identifies a program, device, controller or system.

index point. The reference point on a disk surface that determines the start of a track.

initial microcode load (IML). The act of loading microcode.

I/O device. An addressable input/output unit, such as a direct access storage device, magnetic tape device, or printer.

invalidation. The process of removing records from cache storage because of a change in status of a subsystem facility or function, or because of an error while processing the cache image of the set of records. When such a cache image is invalidated, the corresponding records cannot be accessed in cache and the assigned cache space is available for allocation.

L

least recently used algorithm (LRU). The algorithm used to identify and make available the cache space that contains the least recently used data.

logical DASD subsystem. Two storage directors attached to the same DASD strings together with those DASD strings.

M

maintenance analysis procedure (MAP). A step-by-step procedure for tracing a symptom to the cause of a failure.

megabyte (Mb). 10^6 bytes.

multipath storage director. A storage director in a 3990 Storage Control operating in DLSE support mode. Each multipath storage director in a storage control is associated with two storage paths. All storage paths in a multipath storage director respond to the same range of control unit addresses on a channel.

N

nondisruptive install. Provides for the physical installation of additional Enhanced Subsystem B-units to an existing 4-path DASD string or an additional 4-path DASD string, concurrently with customer operations, providing access to existing data when DASD unit installation activity is occurring. Nondisruptive install uses the quiesce path and resume path functions and is available when only 4-path Enhanced Subsystem DASD are attached to a 3990 Model 2 or 3 Storage Control.

nonvolatile storage (NVS). Additional random access electronic storage with a backup battery power source to retain data during a power failure, available with a 3990 Model 3. Nonvolatile storage, accessible from all storage directors, stores data during DASD fast write and dual copy operations.

O

orientation. A control state within a storage path that indicates the type of area (home address, count, key, or data field) that has just passed under the read/write head of the device.

P

physical ID. A unique designation to identify specific components in a data processing complex.

predictable write. A fast write operation that formats, in cache storage only, the entire user area of the track and creates a track image. This full track image is available for later destaging to a DASD.

primary device. One device of a dual copy volume. All channel commands to the dual copy logical volume are directed to the primary device. The data on the primary device is duplicated on the secondary device. See also secondary device.

primary track. On a direct access storage device, the original track on which data is stored. See also alternate track.

promotion. The process of moving a track image from a DASD to cache.

R

read hit. When data requested by the read operation are in the cache.

read miss. When data requested by the read operation are not in the cache.

rotational position sensing (RPS). A function that permits a DASD to reconnect to a block multiplexer channel when a specified sector has been reached. This allows the channel to service other devices on the channel during positional delay.

S

secondary device. One of the devices in a dual copy logical volume that contains a duplicate of the data on the primary device. Unlike the primary device, a limited subset of channel commands may be directed to the secondary device. See also primary device.

service information message (SIM). A message, generated by the host processor upon receipt of sense information from a 3990 or a 3380 Model CJ2, that contains notification of a need for repair or customer action. The SIM identifies the affected area of the storage control and the effect of the expected service action. A host Error Recovery Procedure (ERP) causes a SIM Alert to be sent to the operator console.

SIM Alert. An operator console message that alerts the operator that an action requiring attention has occurred. The service information message (SIM) can be obtained from the EREP exception report.

simplex mode. A volume is in simplex mode if it is not part of a dual copy logical volume. Terminating a dual copy logical volume returns the two devices to simplex mode. In this case, there is no longer any capability for either automatic updates of the secondary or for logging changes.

single-frame configuration. In a single-frame configuration, the storage directors of a logical DASD subsystem are located inside one storage control.

single-path storage director. A storage director in a 3990 or 3380 Model CJ2 operating in DLS support mode. Each single-path storage director in the storage cluster is associated with one storage path. A storage path on a single-path storage director responds to a unique control unit address on the channel. A single-path storage director in a 3990 is like a storage director in a 3880.

storage cluster. In the 3990 Storage Control and 3380 Model CJ2, a power and service region containing two independent transfer paths and either one multipath storage director or two single-path storage directors. It is designed so that should a failure or maintenance action occur, it will be independent of the other storage cluster in a 3990 Model 2 or 3 Storage Control. The 3990 Model 1 and the 3380 Model CJ2 each have a single storage cluster; the 3990 Models 2 and 3 each have two storage clusters.

In the 3990 Model 3, cache storage and nonvolatile storage are shared by the storage paths, but are logically and physically separate from the storage clusters. See also storage director, single-path storage director, and multipath storage director.

storage control. The component in a DASD subsystem that connects the DASD to the host channels. It performs channel commands and controls the DASD devices. For example, the 3990 Models 1, 2, and 3 are storage controls.

storage director. In a 3990 storage control, a logical entity consisting of one or more physical storage paths in the same storage cluster. In a 3880, a storage director is equivalent to a storage path. See also storage path, single-path storage director, and multipath storage director.

storage director ID. For 3880 Storage Control configurations, an 8-bit designation that uniquely identifies the storage director regardless of its selection address. It identifies to the service representative, by means of EREP output, a failing subsystem component (storage director) to prevent the need to translate a selection address (which may have little relation to a physical address) to a physical component. The storage director ID is the number shown on the operator panels of 3880s and the attached DASD units.

storage facility. See 4-path string.

storage path. The hardware within the 3990 Storage Control that transfers data between the DASD and a channel. See also storage director.

storage subsystem. One or more storage controls and their attached storage devices.

string. A series of connected DASD units sharing one or more controllers (or heads of string). For example, a 3380 Model AE4 and its attached B-units is a 2-path string. In a 4-path J and/or K configuration, the 3380 Model AJ4 or AK4 units and their attached B-units comprise a 4-path string.

string address. The 1-bit address used by the storage control to direct commands to the correct DASD string on the CTL-I.

substring. In a 4-path Enhanced Subsystem configuration, one of the two A-units and the physically adjacent B-units (as many as three B-units).

subsystem identifier (SSID). In a 3990 Storage Control configuration, a number that identifies the physical components of a logical DASD subsystem. This number is set by the service representative at time of installation, and is included in the vital product data in the support facility. This number is identified on the 3380 Enhanced Subsystem models and 3990 operator panels.

subsystem storage. A term used for cache storage. See cache storage.

support facility (SF). A component of each 3990 and 3380 Model C2 storage cluster that provides initial microcode load, error logging, maintenance panel, MAPs, and microdiagnostic functions for that cluster.

U

unit address. The last two hexadecimal digits of a DAS device address. This identifies the storage control and DAS string, controller, and device to the channel subsystem. Often used interchangeably with channel unit address and device address in System/370 mode.

V

volume. The DASD space that is accessible by a single device. A 3380 Model AK4 contains four volumes, each with 1.89 gigabytes of space.

W

write hit. When data requested by the write operation are in the cache.

write miss. When data requested by the write operation are not in the cache.

Numeric

2-path string. A series of physically connected DASD units in which the head of string unit provides two data transfer paths that can operate simultaneously.

4-path string. A series of physically connected DASD units in which the heads of string provide four data transfer paths that can operate simultaneously. A 4-path string requires two 3380 Enhanced Subsystem model A-units.

Bibliography

The manuals listed in the table below contain more detailed information on the subjects discussed in this book. For each manual, the table shows the short and expanded title with the manual's order number, and a short description of its contents.

For information on how to order these manuals, contact your local IBM branch office.

Short Title	Full Title	Order Number	Contents
Storage Subsystem Hardware Manuals			
IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide	*IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*	GA32-0100	Detailed information on installation and use of the 3990 storage control
IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference	*IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference*	GC26-4497	Overview of functions and reference information for 3380 Model CJ2
IBM 3990 Storage Control Introduction	*IBM 3990 Storage Control Introduction*	GA32-0098	Overview of 3990 storage control unit functions
IBM 3990 Storage Control Reference	*IBM 3990 Storage Control Reference*	GA32-0099	Information on the 3990 channel interface (channel commands and sense bytes)
3380 Direct Access Storage Reference Summary	*3380 Direct Access Storage Reference Summary*	GX26-1678	Summary card containing 3380 device characteristics
IBM 3380 Direct Access Storage Introduction	*IBM 3380 Direct Access Storage Introduction*	GC26-4491	Overview of all 3380 models
Maintaining IBM Storage Subsystem Media	*Maintaining IBM Storage Subsystem Media*	GC26-4495	Description of DASD media maintenance and error handling
Storage Subsystem Library Master Index	*Storage Subsystem Library Master Index*	GC26-4496	Index to information in 3380 and 3990 manuals
Using the IBM 3380 Direct Access Storage in a VM Environment	*Using the IBM 3380 Direct Access Storage in a VM Environment*	GC26-4493	Discussion of 3380 use under VM
Using the IBM 3380 Direct Access Storage in a VSE Environment	*Using the IBM 3380 Direct Access Storage in a VSE Environment*	GC26-4494	Discussion of 3380 use under VSE
3380 DASD Features, Installation and Conversion	*3380 DASD Features, Installation and Conversion*	GG22-9308	Describes standard 3380 hardware features, how to prepare for installation of 3380 and migration of data
IBM 3031, 3032, 3033 Processor Complex Channel Configuration Guidelines	*IBM 3031, 3032, 3033 Processor Complex Channel Configuration Guidelines*	GG22-9020	Provides guidance on configuring 303X processor channels
Introduction to IBM Direct Access Storage Devices	*Introduction to IBM Direct Access Storage Devices*	SR20-4738	Textbook describing large IBM early DASD and data storage theory and methods
Using the IBM 3380 Direct Access Storage in an MVS Environment	*Using the IBM 3380 Direct Access Storage in an MVS Environment*	GC26-4492	Discussion of 3380 use under MVS/XA and MVS/370
Early Experiences with 3880-23	*Early Experiences with 3880-23*	GG66-0200	Describes initial experiences with cache
IBM 3880 Storage Control Model 13 and Model 23 New Perspectives and Experiences	*IBM 3880 Storage Control Model 13 and Model 23 New Perspectives and Experiences*	GD26-7000	Describes early experiences and uses of cache storage directors
IBM International Systems Centers/Washington Systems Center Guide to the IBM 3880 Storage Control Model 23	*IBM International Systems Centers/Washington Systems Center Guide to the IBM 3880 Storage Control Model 23*	GG24-1642	Describes usage of the 3880 Model 23
IBM 3880 Storage Control Models 1, 2, 3, and 4 Description	*IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual*	GA26-1661	Overview of 3880 Models 1, 2, 3, and 4 functions
Introduction to IBM 3880 Storage Control Model 13	*Introduction to IBM 3880 Storage Control Model 13*	GA32-0062	Overview of 3880 Model 13 functions

Short Title	Full Title	Order Number	Contents
IBM 3880 Storage Control Model 13 Description	*IBM 3880 Storage Control Model 13 Description*	GA32-0067	Reference manual for 3880 Model 13 functions
IBM 3880 Storage Control Model 23 Description	*IBM 3880 Storage Control Model 23 Description*	GA32-0083	Reference manual for 3880 Model 23 functions
IBM 3880 Storage Control Model 23 Installation and Administration Guide	*IBM 3880 Storage Control Model 23 Installation and Administration Guide*	GA32-0085	Describes how to install and use the 3880 Model 23 effectively
IBM 3880 Storage Control Model 23 Introduction	*IBM 3880 Storage Control Model 23 Introduction*	GA32-0082	Overview of 3880 Model 23 functions
IBM 3880 Storage Control Model 23 with RPQ #8B0035 Description	*IBM 3880 Storage Control Model 23 with RPQ #8B0035 Description*	GA32-0087	Reference manual for 3880 Model 23 functions
Introduction to IBM 3880 Storage Control Model 23 with RPQ #8B0035	*Introduction to IBM 3880 Storage Control Model 23 with RPQ #8B0035*	GA32-0086	Overview of 3880 Model 23 functions
Storage Management Library			
EREP User Guide and Reference	*Environmental Record Editing and Printing (EREP) User's Guide and Reference*	GC28-1378	Description of EREP functions and commands for DASD media reporting
ICKDSF Primer	*Device Support Facilities: Primer for the User of IBM 3380 Direct Access Storage*	GC26-4498	Describes how to use ICKDSF with the 3380
ICKDSF User's Guide and Reference	*Device Support Facilities User's Guide and Reference*	GC35-0033	Description of ICKDSF functions and commands for DASD initialization and maintenance
MVS/XA SML: Configuring Storage Subsystems	*MVS/Extended Architecture Storage Management Library: Configuring Storage Subsystems*	GC26-4262	Describes evaluating hardware configurations, developing capacity plans, and performance, availability and space utilization considerations
MVS/XA SML: Managing Data Sets	*MVS/Extended Architecture Storage Management Library: Managing Data Sets*	GC26-4263	Describes managing data sets, catalogs and control data sets. establishing and enforcing data set policy, and data set security
MVS/XA SML: Managing Storage Pools	*MVS/Extended Architecture Storage Management Library: Managing Storage Pools*	GC26-4264	Describes storage requirements for groups of data sets, designing storage pools, making transition to pooled storage, and maintaining and monitoring storage pools
TPF2 General Information Manual	*Transaction Processing Facility Version 2 General Information Manual*	GH20-6200	Provides on overview of TPF with a description of supported hardware
Physical Planning and Reference Information			
IBM Input/Output Equipment: Installation - Physical Planning for System/360, System/370, and 4300 Processors	*IBM Input/Output Equipment: Installation - Physical Planning for System/360, System/370, and 4300 Processors*	GC22-7064	Description of physical planning for I/O hardware
IBM Input/Output Equipment: Installation Reference - Physical Planning for System/360, System/370, and 4300 Processors	*IBM Input/Output Equipment: Installation Reference - Physical Planning for System/360, System/370, and 4300 Processors*	GC22-7069	Description of physical planning for I/O hardware
9370 Information System Installation Manual – Physical Planning	*9370 Information System Installation Manual – Physical Planning*	GA24-4031	Contains physical planning information for the 9370 family of processors
IOCP User's Guide and Reference	*Input/Output Configuration Program User's Guide and Reference*	GC28-1027	Shows how to define the I/O configuration data required by the processor complex to control I/O requests, describing the MVS version, the VM version, and the standalone version of IOCP
Installation	*VM/SP Installation Guide*	SC24-5237	Discussion of VM/SP installation tools, including the DISKMAP exec
	VM/SP HPO Installation Guide	SC38-0107	Discussion of VM/SP HPO installation tools, including the DISKMAP exec

Short Title	Full Title	Order Number	Contents
	VM/XA SF Installation, Administration, and Service	GC19-6217	Discussion of VM/XA SF installation tools, including the DISKMAP exec
MVS/370 Planning and Reference Information			
Access Method Services Reference	*MVS/370 Integrated Catalog Administration: Access Method Services Reference*	GC26-4051	Describes the access method services commands used with VSAM and integrated catalog facility catalogs
Access Method Services Reference	*MVS/370 VSAM Catalog Administration: Access Method Services Reference*	GC26-4059	Describes the access method services commands used with VSAM
Cache Device Administration	*Cache Device Administration*	GC35-0101	Describes the AMS cache utility commands necessary to manage cache and to obtain information about cache status and performance
MVS Initialization and Tuning Guide	*OS/VS2 MVS System Programming Library: Initialization and Tuning Guide*	GC28-1029	Describes how to initialize the system and improve system performance, includes information on GTF
MVS/370 Data Administration Guide	*MVS/370 Data Administration Guide*	GC26-4058	Contains information on using access methods to do input and output
MVS/370 Data Administration Macro Instruction Reference	*MVS/370 Data Administration: Macro Instruction Reference*	GC26-4057	Describes how to use macros to do input and output
MVS/370 Data Administration: Utilities	*MVS/370 Data Administration: Utilities*	GC26-4065	Describes how to use IEHLIST to maintain VTOC, IEHMOVE to maintain OS CVOLS, and IEHPROM to protect data sets
MVS/370 JCL User's Guide	*MVS/370 JCL User's Guide*	GC28-1349	Describes syntax of JCL statements, JES2 and JES3 control statements
MVS/370 System: Data Administration	*MVS/370 System: Data Administration*	GC26-4056	Describes MVS/370 DFP, and how to modify and extend the data management capabilities of the operating system
MVS/370 System Generation Reference	*MVS/370 System Generation Reference*	GC26-4063	Describes how to do a sysgen, iogen, or edtgen
MVS/370 VSAM Administration: Macro Instruction Reference	*MVS/370 VSAM Administration: Macro Instruction Reference*	GC26-4074	Describes using VSAM macro instructions for VSAM data sets
MVS/SP Version 1 General Information Manual	*MVS/System Product Version 1 General Information Manual*	GC28-1025	Contains overview and planning information for JES3 and JES2 for MVS/370
MVS/SP Version 1 Release 3 Installation Considerations	*MVS/System Product Version 1 Release 3 Installation Considerations*	GG22-9250	Installation planning considerations for MVS/370
Operator's Library: OS/VS2 MVS System Commands	*Operator's Library: OS/VS2 MVS System Commands*	GC28-1031	Describes syntax and use of MVS/370 commands
MVS/XA Planning and Reference Information			
Cache Device Administration	*Cache Device Administration*	GC35-0101	Describes the AMS cache utility commands necessary to manage cache and to obtain information about cache status and performance
An MVS Tuning Perspective	*An MVS Tuning Perspective*	GG22-9023	Describes the effects of tuning an MVS system
MVS/XA Catalog Administration Guide	*MVS Extended Architecture Catalog Administration Guide*	GC26-4046	Describes how to use the integrated catalog facility
MVS/XA Data Administration Guide	*MVS Extended Architecture Data Administration Guide*	GC26-4140	Describes how to use access methods (except VSAM) to process data sets
MVS/XA Data Administration: Macro Instruction Reference	*MVS Extended Architecture Data Administration: Macro Instruction Reference*	GC26-4014	Describes how to code macro instructions for access methods
MVS/XA Installation: System Generation	*MVS/Extended Architecture Installation: System Generation*	GC26-4009	Describes how to do a complete sysgen, iogen, or edtgen in MVS/XA
MVS/XA Integrated Catalog Administration: Access Method Services Reference	*MVS Extended Architecture Integrated Catalog Administration: Access Method Services Reference*	GC26-4135	Describes access method services commands used to manipulate integrated catalog facility catalogs and VSAM data sets
MVS/XA I/O Performance Considerations	*MVS/XA I/O Performance Considerations*	GG22-9346	Describes the effect of the MVS/XA I/O subsystem on device performance. Tuning considerations are discussed

Short Title	Full Title	Order Number	Contents
MVS/XA JCL	*MVS/Extended Architecture Job Control Language (JCL)*	GC28-1148	Describes syntax and use of JCL in MVS/XA
MVS/XA Message Library: System Messages Volume 1	*MVS/Extended Architecture Message Library: System Messages Volume 1*	GC28-1376	Lists MVS/XA system messages and responses
MVS/XA Message Library: System Messages Volume 2	*MVS/Extended Architecture Message Library: System Messages Volume 2*	GC28-1377	Lists MVS/XA system messages and responses
MVS/XA: MVS Configuration Program Guide and Reference	*MVS/Extended Architecture MVS Configuration Program Guide and Reference*	GC28-1335	Describes use of MVSCP to define the I/O configuration to MVS/XA
MVS/XA Operations: System Commands	*MVS/Extended Architecture Operations: System Commands*	GC28-1206	Describes syntax and use of MVS/XA system commands
MVS/XA System – Data Administration	*MVS Extended Architecture System – Data Administration*	GC26-4149	Overview of IBM access methods
MVS/XA System Programming Library: Service Aids	*MVS/Extended Architecture System Programming Library: Service Aids*	GC28-1159	Describes how to use GTF, LIST, PRDMP, SADMP, and SPZAP
MVS/XA VSAM Administration Guide	*MVS Extended Architecture VSAM Administration Guide*	GC26-4015	Describes how to create VSAM data sets
MVS/XA VSAM Catalog Administration: Access Method Services Reference	*MVS Extended Architecture VSAM Catalog Administration: Access Method Services Reference*	GC26-4136	Describes access method services commands used to manipulate VSAM data sets
Performance, Availability, and Tuning Information			
Component Failure Impact Analysis—An Availability Management Technique	*Component Failure Impact Analysis—An Availability Management Technique*	GC20-1865	Planning for hardware availability through configuration
MVS/XA: JES3 User Modifications and Macros	*MVS/Extended Architecture: JES3 User Modifications and Macros*	SC23-0060	Describes tailoring JES3 exits and macros
Cache RMF Program Description and Operation	*Cache RMF Reporter Program Description/Operation*	SH20-6295	Provides detailed information on Cache RMF Reporter
MVS/XA RMF Reference and User's Guide	*MVS/XA Resource Measurement Facility Reference and User's Guide*	LC28-1138	Provides detailed information to operate RMF under MVS/XA
MVS/XA SMF	*MVS Extended Architecture System Management Facilities*	GC28-1153	Describes how to plan for, install and use SMF to manage the MVS/XA system
OS/VS2 MVS Performance Notebook	*OS/VS2 MVS Performance Notebook*	GC28-0886	Describes tuning your system to meet performance expectations and optimizing use of your system
OS/VS2 MVS Planning: Global Resource Serialization	*OS/VS2 MVS Planning: Global Resource Serialization*	GC28-1062	Contains information on how to serialize access to data sets on shared DASD volumes
RACF General Information Manual	*Resource Access Control Facility (RACF) General Information Manual*	GC28-0722	Provides overview and planning information for the RACF program
OS/VS2 MVS RMF Reference and User's Guide, Version 2	*OS/VS2 MVS RMF Reference and User's Guide, Version 2*	SC28-0922	Provides detailed information to operate RMF under MVS/370
OS/VS2 System Programming Library System Management Facilities	*OS/VS2 System Programming Library System Management Facilities*	GC28-1030	Describes how to plan for, install and use SMF to manage the MVS/370 system
OS/VS2 MVS RMF, Version 2, General Information	*OS/VS2 MVS Resource Measurement Facility, Version 2, General Information*	GC28-0921	Describes capabilities, functions, and usage of RMF (Version 2 runs on an MVS/370 system)
RMF, Version 3, General Information	*Resource Measurement Facility, Version 3, General Information*	GC28-1115	Describes capabilities, functions, and usage of RMF (Version 3 runs on an MVS/XA system)
SLR User's Guide	*Service Level Reporter User's Guide*	SH19-6215	Describes how generate reports using SLR
SLR, Version 2, General Information	*Service Level Reporter, Version 2, General Information*	GH19-6213	Overview of SLR functions
SPL: JES2 Installation, Initialization, and Tuning	*System Programming Library: JES2 Installation, Initialization, and Tuning*	SC23-0046	Describes requirements for and activities of JES2 installation, initialization, and tuning

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SPL: JES3 Installation, Initialization, and Tuning	*System Programming Library: JES3 Installation, Initialization, and Tuning*	SC23-0041	Describes requirements for and activities of JES3 installation, initialization, and tuning
DATABASE 2 (DB2) Information			
DB2 Release 2 Data Portability	*DB2 Release 2 Data Portability*	WSCF-8642	Describes moving DB2 data sets and volumes between DASD or systems
IBM DB2 General Information	*IBM DATABASE 2 General Information*	GC26-4073	Overview of DB2 operation and functions
IBM DB2 Installation	*IBM DATABASE 2 Installation*	SC26-4084	Describes installation requirements of DB2
IBM DB2 System Planning and Administration Guide	*IBM DATABASE 2 System Planning and Administration Guide*	SC26-4085	Describes planning activities for installing or migrating to DB2 Release 2 and managing system resources once installed
Data Facility Device Support (DFDS) Information			
Data Facility Device Support, General Information	*Data Facility Device Support, General Information*	GC26-3954	Overview of capabilities and requirements
Data Facility Device Support: User's Guide and Reference	*Data Facility Device Support: User's Guide and Reference*	SC26-3952	Describes syntax and usage of commands
Using Data Facility Device Support Exits for DASD Space Management Assistance	*Using Data Facility Device Support Exits for DASD Space Management Assistance*	GG22-9306	Describes use of DADSM and OPEN exits to assist in DASD space management
Data Facility Data Set Services (DFDSS) Information			
DFDSS: General Information (Version 2)	*Data Facility Data Set Services: General Information* (Version 2)	GC26-4123	Overview of capabilities and requirements
DFDSS: User's Guide and Reference (Version 2)	*Data Facility Data Set Services: User's Guide and Reference* (Version 2)	SC26-4125	Describes syntax and usage of DFDSS commands
Data Facility SORT (DFSORT) Information			
DFSORT General Information	*DFSORT General Information*	GC33-4033	Contains introductory material for planners, system support people, managers, or programmers
DFSORT Application Programming Guide	*DFSORT Application Programming Guide*	GC33-4035	Provides detailed programming information to enable programmers to prepare sort, merge or copy applications
Data Facility Hierarchical Storage Manager (DFHSM) Information			
DFHSM: Installation and Customization Guide	*Data Facility Hierarchical Storage Manager: Installation and Customization Guide*	SH35-0084	Describes how to install and tailor DFHSM to your needs
DFHSM: System Programmer's Guide	*Data Facility Hierarchical Storage Manager: System Programmer's Guide*	GH35-0085	Describes the concepts of DFHSM
DFHSM: System Programmer's Reference	*Data Facility Hierarchical Storage Manager: System Programmer's Reference*	GH35-0083	Describes and explains how to use the DFHSM system programmer, space manager, and operator commands
DFHSM: Planning Guide	*Data Facility Hierarchical Storage Manager: Planning Guide*	GC35-0109	Describes planning for incorporating DFHSM into your current environment.
Data Facility Product (DFP) Information			
MVS/370 DFP: General Information	*MVS/370 Data Facility Product: General Information*	GC26-4050	Overview of capabilities and requirements of MVS/370 DFP
MVS/370 DFP: Planning Guide	*MVS/370 Data Facility Product: Planning Guide*	GC26-4052	Describes installation of DFP, conversion to integrated catalogs, and conversion to indexed VTOCs in MVS/370
MVS/XA DFP Version 2: General Information	*MVS Extended Architecture Data Facility Product Version 2: General Information*	GC26-4142	Overview of capabilities and requirements of MVS/XA DFP
MVS/XA DFP Version 2: Planning Guide	*MVS Extended Architecture Data Facility Product Version 2: Planning Guide*	GC26-4147	Describes installation of DFP, conversion to integrated catalogs, and conversion to indexed VTOCs in MVS/XA

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IMS/VS Version 1, Data Base Administration Guide	*IMS/VS Version 1, Data Base Administration Guide*	SH20-9025	Describes design, implementation and maintenance of IMS data base
IMS/VS Version 1, General Information Manual	*IMS/VS Version 1, General Information Manual*	GH20-1260	Overview of capabilities and requirements
IMS/VS Version 1, Utilities Reference Manual	*IMS/VS Version 1, Utilities Reference Manual*	SH26-4173	Provides detailed information on utilities and how to run them
VM Reference Information			
Alternate Pathing under VM	*Alternate Pathing under VM*	GG22-9381	Description of how VM/SP uses alternate paths in the storage subsystem
CMS Reference	*VM/SP CMS Command and Macro Reference* (Release 4) *VM/SP CMS Command Reference* (Release 5)	SC19-6209	Discussion of CMS commands, including FORMAT and COPYFILE for the VM/SP and VM/SP HPO environments
	VM/XA SF CMS Command and Macro Reference	GC19-6231	Discussion of CMS commands, including FORMAT and COPYFILE
Comparison of IBM 3380s and IBM 3350s Used for VM/CMS Minidisks	*Comparison of IBM 3380s and IBM 3350s Used for VM/CMS Minidisks.*	GG22-9347	Evaluates 3380 disk capacity and performance in VM/SP HPO
CP for System Programming	*VM/SP CP for System Programming* (Release 5)	SC24-5285	Discussion of system programming tasks and commands, including CP INDICATE, SYSOWN, MONITOR
	VM/SP HPO CP for System Programming (Release 5)	SC19-6224	Discussion of system programming tasks and commands, including CP INDICATE, SYSOWN, MONITOR
CP Reference	*VM/SP CP Command Reference*	SC19-6211	Discussion of CP commands for both general and non-general users
	VM/SP HPO CP Command Reference	SC19-6227	Discussion of CP commands for both general and non-general users
	VM/XA SF CP Command and Diagnosis Reference	GC19-6215	Discussion of CP commands for both general and non-general users
DASD Sharing under VM	*DASD Sharing under VM*	GG22-9380	Description of how DASD can be shared among guest systems
VM/SP AJ4,BJ4,AK4,BK4 User's Guide	*VM/SP IBM 3380 AJ4/BJ4/AK4/BK4 User's Guide*	GC24-5371	Contains general description of VM/SP software support (within CP and CMS) for the Enhanced Subsystem 3380s.
3380 VM Performance Analysis	*IBM 3380 Extended Capability DASD VM Benchmark Performance Analysis*	GG66-0262	Helps plan migration from 3380 standard models to 3380 extended capability models, providing migration execs
System Operations and Planning Information			
Operations	*VM/SP Operator's Guide*	SC19-6202	Discussion of VM/SP operator commands and facilities, including DDR, MONITOR, VARY, and DMKFMT
	VM/SP HPO Operator's Guide (Release 4.2)	ST00-1898	Discussion of VM/SP HPO operator commands and facilities, including DDR, MONITOR, VARY, and DMKFMT
	VM/XA SF Real System Operation	GC23-0139	Discussion of VM/XA SF operator commands and facilities, including DDR, MONITOR, VARY, and DMKFMT
	VM/XA SF Virtual Machine Operation	GC23-0138	Discussion of VM/XA SF operator commands and facilities

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Planning	*VM/SP Planning Guide and Reference*	SC19-6201	Discussion of VM/SP hardware and software planning, system design, and system definition
	VM/SP HPO Planning Guide and Reference	SC19-6223	Discussion of VM/SP HPO hardware and software planning, system design, and system definition
	VM/XA SF Virtual Machine Planning	SC23-0167	Discussion of VM/XA SF hardware and software planning, system design, and system definition
	VM/XA Systems Facility Planning Guide	GG24-1709	Provides advanced installation and planning information for VM/XA SF, and includes planning information on MVS/370, MVS/XA, VSE and VM guests under VM/XA SF
VM Performance and Monitor Information			
VM/RTM Program Description/Operations Manual	*VM Real Time Monitor Program Description/Operations Manual*	SH20-2337	Description of RTM functions, commands, and reports for performance monitoring
RTM/SF Program Description/Operations Manual	*VM/XA Realtime Monitor/Systems Facility Program Description/Operations Manual*	SH26-7000	Description of RTM/SF functions, commands, and reports for performance monitoring
System Facilities for Programming	*Virtual Machine System Facilities for Programming* (Release 5)	ST24-5288	Discussion of system programming tasks and commands, including DDR for both the VM/SP and VM/SP HPO environments
System Logic and Problem Determination Guide Volume 2—CMS	*VM/SP System Logic and Problem Determination Guide Volume 2—CMS*	LY20-0893	Discussion of CMS file storage logic in the VM/SP and VM/SP HPO environments
System Programmer's Guide	*VM/SP System Programmer's Guide* (Release 4)	SC19-6203	Discussion of system programming tasks and commands, including CP INDICATE, SYSOWN, MONITOR
	VM/SP HPO System Programmer's Guide (Release 4.2)	ST00-1897	Discussion of system programming tasks and commands, including CP INDICATE, SYSOWN, MONITOR
VMBACKUP Management System General Information	*VMBACKUP Management System General Information*	GH20-6248	Overview of VMBACKUP and VMArchive functions for data backup and archival
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VM/Directory Maintenance Installation and System Administrator's Guide	*VM/Directory Maintenance Installation and System Administrator's Guide*	SC20-1840	Description of DIRMAINT administrator commands
VM/ISF General Information	VM/Intersystems Facility General Information	GC23-0397	Provides an overview of using VM/ISF for sharing minidisks
VM/ISF Planning and Installation	VM/Intersystems Facility Planning and Installation	SC23-0399	Provides guidance and reference information for those planning system resources' usage for VM/ISF and for installers of VM/ISF
VM/ISF Operation and Use	VM/Intersystems Facility Operation and Use	SC23-0400	Describes operation of VM/ISF functions, and contains CP and CMS command syntax and messages and codes for CP, CMS, and VM/Pass-Through Facility
VMMAP General Information	*VM Monitor Analysis Program General Information*	GC34-2164	Overview of VMMAP functions for performance monitoring
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VM/IS Planning For Your System	*VM/Integrated System Planning For Your System*	SC24-5337	Provides pre-installation planning instructions for VM/IS and should be read before *VM/IS Installing Your System*
VM/IS Installing Your System	*VM/Integrated System Installing Your System*	SC24-5341	Provides step-by-step instructions for installing VM/IS; use this book in conjunction with *VM/IS Planning For Your System*

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VM/IS Reporting System Problems	*VM/Integrated System Reporting System Problems*	SC24-5339	Provides problem reporting instructions for VM/IS and is based on VM/Interactive Productivity Facility's Problem Control Facility
VM/IS Learning to Use Your System: Error and Information Messages	*VM/Integrated System Learning to Use Your System: Error and Information Messages*	SC24-5351	Describes error and information messages produced by VM/IS; includes cross-reference table to help locate messages produced by other products and functions included in VM/IS
VSE System Information			
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VSE/AF Operation	*VSE/Advanced Functions Operation*	SC33-6194	Various operational considerations including the PRINTLOG function
VSE/POWER Application Programming	*VSE/POWER Application Programming*	SC33-6276	Information on using the system's accounting function
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