WHITEPAPER

CONTENTS

COMPAQ

High Availability

EXECUTIVE SUMMARY

Until the first half of this decade, critical applications primarily resided on proprietary mainframe and midrange computers. The high-availability requirements for system reliability and stability, security, fast processing power, large storage capacity, and systems management could only be realized on this class of system.

However, global business and economic changes have precipitated a need for new, more cost-effective information technology architectures that provide easier access to corporate information and that are more adaptable to rapid, ever-changing business needs worldwide. These demands have translated into a new computing paradigm that encompasses client/server technology and distributed, enterprise-wide computing systems.

Compaq has proven itself to be at the forefront of this technology. It has quickly established itself as the driving force of aggessively-priced, industry-standard solutions for critical applications previously only supported on larger, proprietary systems.

This white paper discusses the topic of high availability:

* How Compaq is at the forefront of the high-availability market

* The customer needs that are driving the demand for high availability client/server and distributed, enterprise-wide solutions

* A conceptual overview of how high availability is addressed

* How Compaq is addressing the customer needs for high availability

NOTICE

High Availability White Paper

AT THE FOREFRONT OF A NEW COMPUTING PARADIGM

Business needs are changing rapidly today and are impacting corporate information technology goals. Pressures for cost controls, globalization, and distribution of responsibility have served to shift computer resources from a corporate "glass house" IS environment to an enterprise-wide distributed-processing environment that includes client/server configurations. Critical applications that previously ran on large, expensive, proprietary systems are now migrating to lower-costing, industry-standard server platforms. And Compaq, as a trendsetter and world's leading supplier of computer systems, has spearheaded the market for these high-availability systems, delivering mainframe performance with x86 price:performance levels. Compaq's success can be attributed to its ability to keep abreast of the ever-changing industry trends and to proactively respond to customer needs.

Compaq's current client/server implementation has fast become a viable alternative to one where mainframes have historically been the backbone support for "critical" or high-availability applications. This is because Compaq's client/server system capabilities closely approach those of larger systems in terms of processing power, storage capacity, growth capacity, reliability, and systems management, but do so at a much lower price.

Earlier versions of client/server technology, which competed with the mainframe systems for business-critical applications, ran on proprietary, RISC-based, midrange systems running a version of a UNIX operating system. When Systempro and Systempro/XL servers entered the market in 1989, customers began migrating their critical applications on to these low-cost, industry-standard high-availability solutions. However, the performance of these x86-based systems had not yet matched that of the midrange systems. Thus, between 1990 and 1994, most critical applications still resided on midrange systems.

It was in 1994 that an x86-based client/server implementation was truly becoming an alternate solution to the proprietary, RISC-based midrange technology. The dilemma, however, was still whether the lower-costing, x86-based configuration could provide the same performance and reliability as the more expensive midrange system. Compaq's answer to this was the Compaq ProLiant 4500. Not only did the ProLiant 4500 offer similar performance and reliability but it did so at a better price:performance level; and with the flexibility of the industry-standard system, customers were not locked into proprietary technology.

Today, Compaq continues to challenge the more expensive, proprietary, RISC-based systems with its most recent entry in the market, the Compaq ProLiant 5000. With the evolution of the Pentium Pro processor and Windows NT Server, midrange capabilities have migrated down to the more cost-effective, industry-standard x86-based servers. In fact, the performance of a Pentium Pro processor (standard in the ProLiant 5000) actually exceeds that of many RISC processors. Windows NT Server has the equivalent power of UNIX with its multitasking capability and strong networking support. RISC-based client/server systems have met their match with Compaq's high-end ProLiant servers, especially the ProLiant 5000.

The demands for a highly-reliable system with maximum uptime are the same on an x86-based client/server system as they are on a larger system. Businesses are requiring just as much availability for their applications, regardless of what platform they use. Compaq is responding as the high-availability market leader to ensure that as the new computing paradigm continues to evolve, Compaq's systems will continue to address the growing needs of the market.

The following chart identifies the high-availability features that Compaq was first in introducing to the market, validating the company's position at the forefront of this new paradigm.

Year	Feature Introduced	Year	Feature Introduced
1989-1995	**Processor/Memory** • ECC memory • Automatic Server Recovery • Off-Line Backup Processor **Power** • Redundant Power Supply **Array Controller** • RAID 0, 1, 4, 5 • Hot-pluggable hard drives • On-line disk spare **System Management** • Server Manager/R • Insight Manager **Server Arrays** • Standby Recovery Server • On-Line Recovery Server	1996	**Processor/Memory** • ECC data bus **Power** • Redundant Processor Power Modules **Array Controller (SMART-2)** • ECC cache • Battery-backed cache • On-Line Capacity Expansion **System Management** • Remote Insight

CUSTOMER NEEDS

Due to the tremendous costs associated with downtime of their critical business applications, companies demand computer systems with high-availability features to run those applications. A study published by Gartner Group in September 1995, used a model of a 150-user LAN with two servers. The associated cost of downtime for this model was $209,790 per year, factoring in the following:

• an average 97% system uptime per year

• 12 hour/day, 5 day/week operation

• an average compensation package of $25.90 per hour per employee on a server

• a production server environment with 30% required access time.

Variables *not included* in this estimation, which would have made the downtime cost even higher, were transaction loss, loss of revenue, costs associated with customer dissatisfaction, service loss for data recovery and technical support costs.

Other studies that have revealed the significant impact cost of downtime can have on business include:

• a 1992 survey by the Strategic Research Division of Find/SVP of 450 Fortune 1000 companies indicated system downtime costs U. S. business approximately $4 billion per year.

• a report by Forrester Research identified executives who claimed that online system failures cost companies more than $3.8 billion in lost revenue and productivity in 1991.

• an article found in the April 1995 issue of Midrange Systems indicated that system downtime can cost up to $76,000 per hour.

However a company defines cost of downtime, the end result is the same—a negative impact on the company's bottom line.

Besides cost of system downtime, there are several other notable factors that affect customers' demands. The corporate culture is changing rapidly with the evolution of new technologies. Companies are becoming more "decentralized" as they begin to globalize. A more flattened corporate architecture distributes management responsibility to remote offices. Though this empowers individuals making decisions, it requires distributed computer resources located at these worldwide offices with easy access to corporate-wide data. It also dictates the need for sophisticated system management capabilities to monitor the entire network, ensuring its reliability and availability to its clients.

To "centralize" part of their information networks, companies are consolidating some of their servers and applications onto fewer servers. For example, a company may have four departmental file and print servers. By consolidating them onto one server, the company can gain more control over the network and can minimize the technical support required to manage the servers. However, this makes the single, consolidated server even *more* critical to business operations, since there is now one single point of failure.

Companies continue to streamline their operations while their business needs increase. Their attempts to run more efficient operations with fewer resources requires that they also downsize their personnel. Thus, the staffing requirements for operating and maintaining the computer systems critical to their business must be optimized.

It is crucial that high-availability solutions can accommodate these customer demands within this rapidly-changing business environment. By ensuring that these needs are met, Compaq is maintaining its world-class leadership as a total high-availability solution provider.

ADDRESSING HIGH-AVAILABILITY NEEDS

What High Availability Is

Simply defined, availability is the measure of how well a computer system can continuously deliver services to clients. This is dependent upon the system's ability to prevent or recover from failures or "faults."

There are different classes of availability defined by a system's critical application requirements:

- applications that require 100% uptime where the system's operation is never interrupted by a failing component or subsystem, for example, the stock exchange trading floor or mission control in the aerospace industry

- applications that can tolerate minimal interruptions, for example, Electronic Fund Transfer (EFT) in the banking industry

The commonly-used terms that describe these different classes of availability are given in the table below. "High availability" and "fault tolerant" have been used interchangeably, incorrectly. The table identifies the true differences between the two in percentage of downtime.

% Uptime	Downtime	Class
99	3.5 days /year	Conventional
99.9	8.5 hours / year	High Availability
99.99	1 hour / year	Fault Resilient
99.999	5 minutes / year	Fault Tolerant

To distinguish between a high-availability and a fault-tolerant system in terms of their design, a high-availability system comprises *some* fault-tolerant features, whereas, *all* of a true fault-tolerant system's components are fault-tolerant. An application requiring 100% uptime will thus require a true fault-tolerant system, whereas an application requiring less than 100% uptime can reside on a high-availability system. Compaq's strategy is to provide the highest availability in its servers with a multitude of fault-tolerant features.

Key Elements to Providing a High-Availability Solution

There are several key elements to providing a high-availability solution for a critical application:

- System components that provide maximum system uptime (with the ability to prevent or recover from system failures with minimal, if any, interruption)

- Sophisticated system management capabilities to monitor the system and its environment, preventing potential problems or resolving problems with minimal, if any, system interruption

- Integration management capabilities that optimize the setup of new servers, and establish configuration consistency for all systems within a distributed network requiring high system availability

- Proactive service and support that ensures application availability

- Scalability to grow a system according to the growth of a company's business needs

System Components—Maintaining maximum uptime can be accomplished by eliminating critical system components as single points of failure, thus providing a system that provides both high availability and reliability. For example, system failures that occur either in memory or due to system hangs are eliminated with automatic recovery features that check for errors and then attempt to recover without interrupting operations. Failures occurring in storage or due to power failures are minimized with redundant hardware components that take over in the event of a failure.

Server Management—A system's availability can also be optimized by identifying and predicting faults before they actually occur. Sophisticated server management capabilities can monitor a system's components and environment, and keep the system administrator apprised of the status. This ensures that for any potential or actual problems, the appropriate action will be taken, whether it's preventive maintenance or problem resolution. Comprehensive server management also allows for an entire distributed network to be monitored from one central location, thus eliminating the need for additional on-site technical support at remote sites.

Integration Management—Setting up a server can be a complex process, considering the numerous hardware and software components that are typically configured. Additionally, companies with distributed-processing environments may demand consistency in how all their servers are set up and maintained. Integration management tools can simplify the implementation process and ensure that server configurations across a company's network are consistent and conform to any standards the company may have established for its hardware and software configuration.

Service and Support—In a high-availability environment, service and support is of the utmost importance, not just for a single server but for a company's network of servers distributed worldwide. Service offerings need to include around-the-clock technical support and on-site response, planning, server installation and integration, and the like to ensure maximum system and application availability.

Scalability—With the deployment of enterprise-wide distributed systems, a high-availability solution also needs to accommodate the ability to grow the system relative to the customer's growing business needs. This translates into *not only* being able to grow a single system with additional processor or storage capacity, but to also group systems into "clusters" that operate as a single system, providing support for virtually unlimited devices or connections.

Because Compaq is sensitive to customer needs and understands the importance of maximizing system availability for critical applications, the company's high-availability solutions encompass all elements:

- system components that provide optimum availability

- extensive server management tools

- comprehensive integration management capabilities

- company support structure committed to providing the most reliable support services to customers

- scalability to allow for growth

OVERVIEW OF COMPAQ'S HIGH-AVAILABILITY OFFERINGS

A Little History

In 1989, Compaq introduced the Systempro, the first industry-standard multiprocessing x86-based server system. With its innovative drive array system that provided several fault-tolerant storage options, the Systempro was a breakthrough for customers wishing to move their business-critical applications to a smaller, more cost-effective platform.

A follow-on to the Systempro was the Systempro/XL with its special bus structure that optimized system performance and included Automatic Server Recovery (ASR) and Error Checking and Correcting (ECC) memory, two other features providing high system availability. This architecture has evolved and is incorporated into present Compaq platforms.

Critical applications not only required performance and reliability from the system on which they resided, but also system management capability. Responding to customers' needs to be able to monitor the operation of the system, Compaq introduced, in 1991, Compaq Server Manager/R, the industry's first remote PC server management tool. Building upon the success of Server Manager/R, Compaq introduced another industry first—Full-Spectrum Fault Management in the Compaq ProSignia and ProLiant servers. Full-Spectrum Fault Management enabled fault prediction, prevention and recovery for Compaq servers.

To enable proactive monitoring and control of Full-Spectrum Fault Management capabilities, Compaq introduced Compaq Insight Manager, comprehensive, standards-based server management software that enable administrators to efficiently manage hundreds of servers. Finally, for a complete remote management solution that expanded the functionality of Insight Manager, Compaq introduced Remote Insight.

Compaq's Present and Future Offerings

Since the introduction of the Systempro and the system management tools, Compaq has continued its path of providing systems with more and more functionality to ensure maximum uptime in a high-availability environment. And with the demand for systems that can keep up with increasing business needs, Compaq has designed into its systems, upgrade paths that protect a customer's current investment while taking advantage of the latest technology.

High-availability features prevalent in today's client/server configurations include Error Checking and Correcting (ECC) memory, hot-pluggable hard drives, RAID support, redundant power supplies, and comprehensive system management tools. With its Full-Spectrum Fault Management technology, which includes these features and more, Compaq is fully committed to providing the ideal client/server solution for business-critical environments. This is carried into the future with the introduction of Compaq's Server Array products that are designed for distributed, enterprise-wide networks, thus providing the total high-availability solution.

The following chart illustrates the progression of high-availability features and systems offered by Compaq since the introduction of the Systempro in 1989. For a quick review of Compaq servers and all of their high-availability features, refer to the Appendix at the end of this paper.

1997

Server Arrays
- Multi-Node Clusters

1996

Processor (Pentium Pro)
- ECC processor bus
- ECC cache
- parity address bus

Power
- Redundant Processor Power Modules

Array Controller (SMART-2)
- ECC read/write cache
- Modular, battery-backed cache
- On-Line Capacity Expansion

Storage Management
- DLT Array

Network Interface Controller
- Redundant NICs

System Management
- Remote Insight

1989-1995

Processor/Memory
- ECC memory
- Automatic Server Recovery
- Off-Line Backup Processor

Array Controller (SMART)
- RAID 0, 1, 4, 5
- Hot-pluggable hard drives
- On-line disk spare

Power
- Redundant Power Supply

System Management
- Server Manager/R
- Insight Manager

Server Arrays
- Standby Recovery Server
- On-Line Recovery Server

GETTING DOWN TO THE SPECIFICS

Compaq's understanding of how to design a system for critical applications is seen in the impressive set of high-availability features implemented in its servers:

- systems that have been designed with a multitude of fault-tolerant subsystems and rapid recovery features

- server management tools that are standard on all servers, monitoring both stand-alone and networked systems

- Compaq SmartStart that allows full integration management of software and hardware components of servers across an enterprise-wide network

- vast number of service and support offerings to ensure the highest system availability

- Compaq Server Array products that combine the need for high system availability with scalability for growth

Fault-Tolerant System Components

There are several possible causes of a system failure, including a memory error, hard drive failure, system lock-up, or power outage. Any of these can disrupt system operations if not corrected immediately. In a high-availability system, failures such as these are minimized with either built-in error-correcting functionality or with redundunt components.

As a minimum, all Compaq servers come standard with ECC memory and Rapid Recovery features which include Automatic Server Recovery-2 (ASR-2) and Server Health Logs. Other fault-management features offered as an integral part of Compaq's server hardware include:

- Additional built-in hardware fault-protection capabilities

  - Server Parameter Tracking

  - Disk System Tracking

  - Dynamic Sector Repairing

  - ECC system bus (ProLiant 5000)

- Storage management

  - Hot-Pluggable Hard Drives

  - SMART-2 Array technology with RAID support and On-Line Capacity Expansion

  - ProLiant Storage System

  - DLT Tape Array

- Redundant power capabilities

  - Redundant Power Supplies (ProLiant 1500, 4500, 5000)

  - Redundant Processor Power Modules (ProLiant 5000)

  - Uninterruptible Power Supply

- Other Redundant Features

  - Offline Backup Processors (multi-processor systems only)

  - Redundant Compaq Netelligent 10/100 TX Network Interface Controllers (NICs)

Basic Fault-management Components

ECC (Error Checking and Correcting) Memory—With today's increasing need for uninterrupted server operations in complex networking environments, memory system integrity is critical. A company's productivity can be significantly impacted if a memory subsystem fails. Applications such as databases are extremely memory-intensive and on a network, a memory failure can affect a great number of users.

Memory failures can be either soft errors, which cause data to be stored incorrectly in a memory location, or hard errors, which are a result of a failure within a DRAM device causing the inability of data to be stored reliably.

To improve the data integrity of its servers, and therefore prevent data from being corrupted or lost while being processed in memory, Compaq has incorporated ECC memory into all of its servers. ECC memory detects and corrects memory errors without system operation interruption.

Rapid Recovery—The failure of a business-critical server can be devastating to a company's operation. The failure could be due to any one of the system's key subsystems including its software, memory, processor, or even its environment. To minimize the impact of a failure, Compaq has implemented in all of its servers, Rapid Recovery features which include Automatic Server Recovery-2 (ASR-2) and Server Health Logs. When an error occurs, ASR-2 records it in the Server Health Logs. For example, in the case of a memory error, after rebooting the system, ASR-2 will test and de-allocate bad memory to avoid subsequent faults. In many cases, the server restarts successfully. This is ideal for a remote location that is unattended by service personnel.

If the system fails to reboot, ASR-2 can make multiple attempts to reset the system. If the server continues to experience hardware or software errors and ASR-2 makes more recovery attempts than a pre-defined number, it will log the error in the Server Health Log, reboot the Compaq utilities to identify the problem, and if configured to do so, will page an administrator to make a diagnosis and return the system back to pre-error condition as soon as possible.

Automatic Server Recovery—2
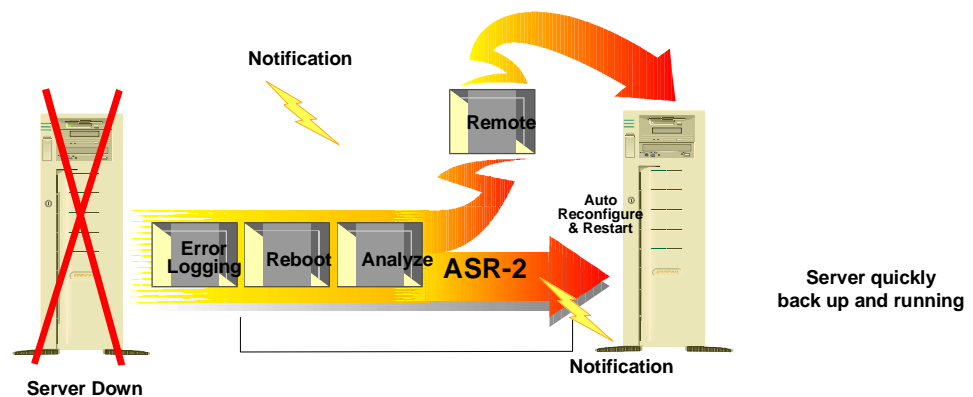
Additional Built-in Hardware Fault Prevention—All Compaq servers have several other built-in fault prevention features (in addition to those described in this paper) that work in conjunction with Insight Manager to ensure the highest availability of server subsystems.

For example, Server Parameter Tracking is a data collection agent that monitors and records over 800 system parameters, including those for memory, storage, the environment, the processors and the network. This real-time information is then managed by Insight Manager to alert the administrators of the status so that preventive maintenance can be performed and faults can be avoided.

Disk System Tracking performs preventive maintainance on disk subsystems. By monitoring conditions such as read/write/seek errors and running tests against seek times, care can be taken to prevent any failures from occurring.

Dynamic Sector Repairing occurs within Compaq hard drives as they automatically map bad sectors and move the data to safe areas.

Not only does the Compaq ProLiant 5000 include ECC memory as standard, but it also provides single-bit ECC protection for data errors between internal data buses between processors, memory, cache and the I/O subsystems.

Storage Management

Fault management is a must in a storage subsystem since storage is one of the most critical elements in a high-availability network server. To address business-critical storage requirements, Compaq offers, internal to its ProLiant servers, hot-pluggable hard drives and SMART-2 Array technology with RAID support and On-Line Capacity Expansion. For external storage requirements, there are the ProLiant Storage System and the DLT Tape Array.

Hot-Pluggable Hard Drives—With hot-pluggable hard drives, a customer can remove, install and replace one or several drives within a server while the system is powered on. This minimizes interruption of the network.

SMART-2 Array Controller Technology—SMART-2 Array Controller technology was developed to address today's network data storage requirements of performance, growth, and high availability. Compaq's SMART-2 Array Controller technology is a culmination of the company's intelligent array architectural design that supports RAID functionality. This technology provides the ability to monitor I/O activity, predict potential problems, take appropriate measures, and perform automatic data recovery in the event of a hard drive failure.
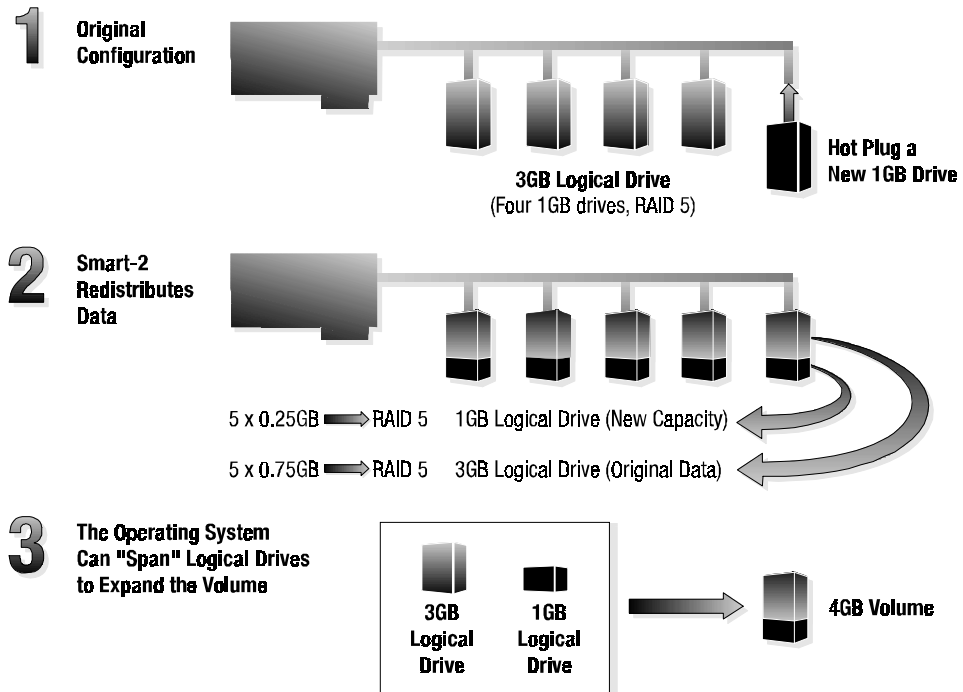
To maximize system uptime, the SMART-2 Array Controller offers On-Line Capacity Expansion which allows additional pluggable hard drives to be added to a configuration without having to go through the time-consuming backup/reconfigure/restore cycle. A drive is added, the On-Line Capacity Expansion feature of the controller is invoked, and the data is distributed across the newly-expanded storage capacity, all without having to power down the server and disrupt operation.

During the expansion operation, memory failures and power outages are protected against by ECC memory and battery backup of the enhanced array accelerator, a removeable cache module that provides significant performance improvements for I/O operations, as well as maximum data availability. ECC technology is used to protect the data in cache DRAM on the module. It can detect and correct DRAM bit errors, DRAM chip failures, and memory bus errors on the array accelerator connector. Rechargeable batteries integrated into the array accelerator provide backup power to the cache DRAM, if the system power is lost.

In the event that the array accelerator fails or is removed, the SMART-2 Controller can continue operating. If the controller fails, the ECC memory and battery backup on the array accelerator will keep posted-write data secure. The accelerator could then be removed and attached to a replacement controller, and all data maintained in the cache would be rewritten to the hard drives.

With these features, customers get full RAID protection for their data during the operation.

On-Line Capacity Expansion

1 Original Configuration

3GB Logical Drive
(Four 1GB drives, RAID 5)

Hot Plug a
New 1GB Drive

2 Smart-2 Redistributes Data

5 x 0.25GB ➡ RAID 5   1GB Logical Drive (New Capacity)

5 x 0.75GB ➡ RAID 5   3GB Logical Drive (Original Data)

3 The Operating System Can "Span" Logical Drives to Expand the Volume

3GB Logical Drive   1GB Logical Drive ➡ 4GB Volume

The SMART-2 Array Controller also allows additional drives to be designated as on-line spares in the event of an active drive failing. The spares are powered on but are in standby mode. If an active drive fails, the controller automatically rebuilds the data onto one of the spares without any administrator intervention. Once the rebuilding process is complete, the system is in full fault-tolerant operation once again and the failed drive can be replaced when convenient.

For more information on SMART-2 Array Controller technology, refer to the Compaq SMART-2 Array Controller Technology White Paper, Document Number 028A/0296.

Compaq ProLiant Storage System—In a high availability environment where external storage with fault-tolerant capability and expandibility is required, such as in a multi-array server configuration, the Compaq ProLiant Storage System is the solution. With its support of hot-pluggable drives, the SMART-2 Array Controller, and its temperature sensing capability, the storage subsystem provides various levels of fault tolerance with a maximum capacity of up to 30.1 GB per unit.

As with the hot-pluggable hard drives internal to Compaq's servers, removing, installing, and replacing one or more drives in the external storage subsystem can be done while the system is powered on, virtually eliminating any operational interruption.

SMART-2 Array technology delivers full fault-management capabilities to ensure maximum uptime of the external storage subsystem.

The ProLiant Storage System also has temperature sensing capabilities built into it that monitor the temperature of the cabinet. If the temperature exceeds the factory-set value, the system administrator is warned through Insight Manager so that appropriate action can be taken before critical data is corrupted or lost.

DLT Tape Array—Loss of corporate records and data can be disastrous for a company. Backing up this information is crucial to the security of one of a company's most important assets. But even the backup procedures are time consuming and costly, and in a critical environment, time is of the essence. With the DLT Tape Array, which can back up over 200 GB in less than 5 hours, Compaq has set the stage for a backup system that provides not only high accuracy and high performance rates, but it incorporates the same RAID technology of the disk arrays for high levels of fault tolerance and recovery, and is modularly designed for growth. A tape or tape drive can fail without the system's operation being interrupted.

Redundant Power Components

Redundant Power Supply—In the event a power supply failure, the flow of the life blood of your server, the power, comes to a screeching halt. To prevent this from happening, Compaq offers the Redundant Power Supply, an option on some ProLiant servers. By duplicating the power of the internal power supply, the redundant power supply minimizes your risk of interrupted operation even if a power supply failure occurs and removes the power supply as a single point of failure.

Redundant Processor Power Modules—Pentium Pro processors require very tightly-controlled power for proper operation.Thus, processor power modules must be placed physically close to the processors. But if one of the processor power module fails, the system goes down. Therefore, Compaq offers a redundancy scheme in the ProLiant 5000 that supports up to three Redundant Processor Power Modules for every two processors. If one of the power module fails, a redundant module takes over operation without interrupting system uptime.

Uninterruptible Power Supply—Where the Redundant Power Supply protects a server from a power supply failure, the Uninterruptible Power Supply (UPS), available for all Compaq servers, guards against an external AC power failure. Regardless of power disturbances, this power supply provides an enhanced level of protection. Its Enhanced Battery Management (EBM) prolongs the life of the battery while monitoring the battery's condition to identify when it may need to be replaced, before a failure. If there is a power failure and the battery's life falls below a predetermined threshold, the server will close open files, log off users and gracefully shut the system down.

Other Redundant Components

Off-Line Backup Processor—System downtime can also be caused by a processor failure. In servers with multiprocessor architecture, such as the ProLiant 1500, 4500, and 5000 models, this can be alleviated with the Off-Line Backup Processor feature. In the event of a failed processor, a system automatically can be powered down, reconfigured, and rebooted from a second processor. Operation can continue with minimal interruption. In the Compaq ProLiant 5000, if the operating system supports multiprocessing, all processors can be used; the Off-Line Backup Processor is not used solely for backup purposes.

Redundant Compaq Netelligent 10/100 TX Network Interface Controllers (NICs)—Networks are just as vulnerable to system downtime due to failed network controllers as with any other failed subsystem within the configuration. Within a Compaq server, a second controller can be installed to act as a standby network controller if the active controller fails. The redundant controller assumes operation without any loss of service. This eliminates the network controller from being a single point of failure.

Server Management Tools

Effective systems management software can identify and even predict faults before they can cause a disruption. And tools that manage remote sites from a central location can reduce the need for additional on-site personnel. Compaq's response to these systems management needs is Compaq Insight Manager, comprehensive server management software for monitoring and controlling Compaq servers, in addition to Compaq Remote Insight, which extends the remote management capability of Insight Manager, and Compaq Survey Utility, a service tool that can be used without taking the server off-line.

Compaq Insight Manager—comes standard with all Compaq servers. It is a key component of an overall systems and network management approach. Compaq Insight Manager is a device or element manager that provides in-depth fault, configuration and performance monitoring of Compaq hardware. Supporting leading network operating systems such as NetWare, Windows NT Server, SCO Open Server, SCO Unixware, and OS/2 Warp, it allows customers to manage hundreds of Compaq servers and network nodes from a single management console. The monitoring and delivery of server alerts and information is provided by Insight Management Agents software that operates on Compaq servers. The agents monitor more than 1,000 parameters that describe the status of all key server components including memory, hard drives, power supplies, NICs, processors and the server's operating environment. These monitored data allow Compaq Insight Manager to:

- predict component failures so that preventative maintenance can be performed—in the event of a potential failure, Insight Manager notifies the administrator of the problem so that immediate action can be taken to prevent the failure from occurring.

- identify faults when they do occur and provide problem resolution information to administrators—Insight Manager provides a visual representation of the fault location and provides detailed information about the problem and recommended corrective action.

Because it's also critical that high-availability systems maintain peak performance, Insight Manager assists administrators with performance management of all major subsystems within each server. With the ability to set performance thresholds on such things as bus utilization, NIC throughput, and disk capacity, and to monitor these thresholds for potential performance degradation, administrators can take the necessary action to keep the systems running at top levels.

With its extensive remote management capabilities, Compaq Insight Manager can also run server diagnostics to isolate faults, carry out server reconfiguration and restart the server as needed.

Insight Manager is but one essential component of an enterprise-wide network environment. As an element manager managing Compaq servers or *elements* within a departmental LAN, Insight Manager integrates nicely with:

- LAN managers such as Microsoft Systems Management Server (SMS), which typically monitors and controls a local area network at a business unit level.

- Enterprise managers such as HP OpenView and IBM Netview, which monitor and control entire networks, typically at a corporate IM level.

Compaq Remote Insight—The Compaq Remote Insight board is fully integrated with Insight Manager to provide a complete remote management solution. Total host server independence allows Remote Insight to deliver robust functionality, simplifying remote server administration and increasing server availability.

Remote Insight provides seamless remote access and control by offering:

- complete hardware independence from the managed server, including an on-board modem that allows out-of-band network communication.

- a remote console and remote reset that allows viewing and control of all phases of server operation. A server can also be reset remotely without any loss of connection, regardless of the server's state.

Remote Insight also captures and stores critical troubleshooting information using the following mechanisms:

- video sequence replay that allows storage and replay of reset and failure sequences, giving the administrator vital information to solve problems efficiently and reduce server downtime.

- access to the Remote Insight event log as well as the host server critical error log. This information is available for review at all times.

To ensure that a network administrator is notified of critical conditions of a remote server, Remote Insight offers:

- alphanumeric paging and out-of-band delivery of Compaq Insight Manager-generated SNMP alerts. These enable quick response times for protection of critical applications and data.

- full battery back-up on the board to ensure that the alerts are delivered even in the case of server power outage.

An extra measure of security for remotely-located servers is provided through:

- password protection, variable user access rights, unauthorized user detection, and optional dialback support.

Compaq Survey Utility—Compaq Survey Utility is a serviceability tool available for Windows NT and Novell NetWare, that delivers on-line configuration capture and comparison to maximize server availability. When making a service call about a server running business-critical applications, being able to collect critical information about the system without bringing the system down is of great benefit. With the Compaq Survey Utility, an administrator can obtain detailed information about a server's hardware and software configuration to handle issues and resolve potential problems, without taking the server off-line.

Compaq Survey Utility can also maintain a record of recent configuration changes. The changes are compared to the baseline configuration and stored in a file on the server. Oftentimes a recent configuration change is the cause of a problem that has occurred on the server. In this case, being able to make a comparison between the baseline and changed configuration can greatly reduce the time it takes to resolve the problem.

For more information on server management tools, refer to the Compaq Insight Manager White Paper, Document Number 170A/0696 and the Compaq Remote Insight White Paper, Document Number 078A/0496.

Service and Support for Compaq Systems

Service and support is a key element in providing high availability. To ensure that critical applications and data remain available to users, customers must manage activities ranging from planning for additional components, installation and integration of those new components, ongoing routine maintenance of the hardware and software, and the maximization and optimization of the computing environment.

Compaq offer customers the choice to perform these activities themselves or to outsource system management activities. The integration of Compaq Service and Support Offerings (CSSO) with Compaq product features ensures high availability of customers' applications.

CSSO Integration and Implementation Services—help customers focus on getting their IT environments up and going.

- **Installation Services**—ensure the most efficient and cost-effective implementation of a customer's Compaq systems. Compaq experts that understand their IT environment install and ensure proper integration of their Compaq hardware, software, and networking solutions. Installation provides all associated planning and site preparation work prior to an installation.

- **Interoperability Services**—offered by Compaq provide distributed enterprise customers error-free integration of Compaq systems in a multivendor hardware and software environment. Customers benefit by identifying issues before implementing a new LAN or adding LAN components and can take advantage of Compaq's state-of-the-art technology and tools.

- **Technical Consulting Services**—are available to customers to complement their internal knowledge and expertise with specialized information as they integrate and implement new Compaq systems into their IT environment. A range of offerings (e.g., requirements assessment, capacity planning, applications integration) are available to help customers plan for, design and implement Compaq products into the distributed environment.

CSSO Maintenance Services—are focused on traditional hardware and software remedial services to ensure the IT environment stays up.

- **Onsite Hardware Maintenance**—offers custom-tailored service agreements that meet customers' specific availability requirements. Customers can select from a range of flexible service coverage, response time and delivery methods. Options include 2 or 4 hour response, 7x24 coverage including holidays, and a resident engineer. Standard features include service activity reports, configuration reports, Field Change Order installations, diagnosis, parts, and repair.

- **Enhanced Software Support**—provides up to 7x24 comprehensive remote support to customers who require assistance in resolving complex problems as they apply to CSSO supported Network Operating Systems, Database Management Systems products (installation, configuration, and setup only), Application Server products, and Network Management products.

CSSO Maximization and Optimization Services—assist customers in managing their Information Technology environments and ensuring they perform at optimal levels.

- **LAN Management Support**—allows customers to cost-effectively augment their internal resources by having Compaq experts assist with LAN monitoring and administration support. Customers maximize their network's efficiency by identifying potential trouble spots before they affect availability. Other benefits include improved LAN response times and capacity utilization as well as increased productivity of internal staff and end-users.

- **Remote System Management**—Customers benefit by the monitoring of day-to-day system management activities which helps spot any potential problem areas. Some of the features include: an assigned team of specialists, logging and validation of SM related service calls, remote guidance to assist on-site SM resources and routine tasks such as: user account administration, system backups, management of print queues and disk resources, and modification of system parameters.

- **System Management Support**—helps not only monitor and manage day-to-day activities, but also helps focus on operations review, performance analysis and tuning, security assessment, and implementation of System Healthcheck recommendations. Specialists experienced in optimizing networks, operating systems, and applications perform an in-depth assessment and work with the customer to fine-tune their computing environment for maximum return on their investment.

- **System Healthcheck**—services help customers uncover potential trouble spots before they cause any performance degradation. Compaq will provide expert recommendations for addressing problems and optimizing performance. These recommendations can by implemented by the customer or by Compaq as part of its System Management Services.

Compaq will continue to expand its service and support offerings to ensure customers access to their applications and data. Consistent with the company's clustering strategy, future offerings from Compaq will be designed to deliver guaranteed application availability.

Integration Management Tools

In today's burgeoning distributed-processing environment, there is a growing demand for simplified and consistent deployment and maintenance of servers throughout the network. The effort of this complex task can be immense without the use of integration management tools, particularly when software and hardware are from multiple vendors and require optimum coordination for top-level performance, reliability and stability.

In a high-availability environment, it is crucial that integration issues that might result from the assembly and configuration of the multiple system software and hardware are absolutely minimized. There is little if any room for problems that bring down a system running critical applications.

In 1991, Compaq recognizing the complexity of system setup, began providing customers with tools to assist them in setting up their systems. These tools evolved into SmartStart, Compaq's integration tool developed and based on the experience and knowledge the company gained from the working relationships with its software partners.

Key Components of SmartStart

SmartStart comprises all key components needed for consistent and reliable deployment and maintenance of systems distributed throughout a company's enterprise-wide network:

- the SmartStart installation program that guides the customer through server configuration and software installation

- system software which includes supported operating systems, database management, networking and backup software

- Compaq system utilities and operating system support software to maximize the installation and maintenance of the software and hardware of the system

- other items required to access the supported software products that reside on the SmartStart CDs—the Program License Diskette and Activation Key Order Forms that in combination allow a customer to activate a code that unlocks the software for which he has purchased licenses

- various other items that assist the customer in his use of SmartStart—all user and installation guides; a System Reference Library CD that provides reference information on Compaq servers and Insight Manager, and on other Compaq products; and the materials to register the server with Compaq through SmartStart

Integration Management

With SmartStart, a company can set up an Integration Server to establish a centralized, network-based repository for approved system software to be deployed across a distributed network. Any Compaq server running Windows NT Server 3.51 , NetWare 3.12 or 4.1 can be used as an Integration Server.

With the Integration Server Maintenance function of Insight Manager, a customer can then keep track of what software resides on the Integration Server and what updated software is available from Compaq so that he can acquire the necessary updates. For systems running Windows NT and NetWare, once the customer has implemented an Integration Server, he can then deploy production servers with the system software by using SmartStart Integration Maintenance Utilities.

Optimized Setup

SmartStart offers an *Assisted Integration* setup path that allows the system to be configured for maximum integration and performance. When installing and configuring the hardware, operating system and database software at the same time, SmartStart will recommend default parameter settings that are based on Compaq's understanding and experience of how the various components work together. Parameters are selected to best match the customer's requirements based on the selected operating system and database management software, for example, number of users, number of NICs, and number of users accessing the database.

SmartStart also installs all appropriate drivers for the selected operating system and the appropriate Insight Management Agents.

For more information on Compaq SmartStart, refer to the Compaq SmartStart Positioning Paper, Document Number 057A/0496.

Server Array Strategy for Scalability

Compaq has positioned itself as the market leader of the business-critical client/server network solution, where high availability is realized through redundant server configurations with high-performance components. However, the increasing globalization of companies and the distribution of responsibility to remote sites such as branch offices have dictated the need for enterprise-wide network solutions.

To accommodate this evolving business requirement, Compaq has developed a multi-server or clustering strategy that allows a customer to obtain high levels of system availability while having the flexibility to grow their computing platforms in the most cost-effective way. Compaq calls this family of high-availability, high-performance clustering solutions Server Arrays. Through the company's alliances with Microsoft and Tandem, these solutions are setting a new industry standard for Windows NT Server clustering. And through the support of other key industry players, the market will begin seeing new cluster-aware applications taking advantage of the Windows NT Server clustering platform.

Compaq's goal has been to implement its clustering strategy in phases, the first one having begun with the introduction of the Recovery Server Option in the second quarter of 1995. This solution is discussed in this section. Compaq expects the second phase to move forward with the roll-out of its new Server Array products beginning in the fall of 1996. These will include a two-node "Branch Office" Server Array and, in the first half of 1997, a Multi-node "Data Center" Server Array, which are discussed in the section, *Where Compaq is Headed* (on page 21).

Before further discussion about these high-availability Compaq solutions that address the company's clustering strategy, a brief overview of the clustering models on which the company has based its strategy might be helpful.

Clustering Models

Clustering is defined as grouping systems together so that they work as a single system, providing fast, uninterrupted operation with the ability to increase processing capacity and I/O bandwidth. There are two clustering models—Failover and Distributed Processing—for which Compaq has targeted its server array solutions:

- A Failover is one in which a pre-designated recovery server is available in the event that a primary server fails. If this occurs, applications will automatically be switched to the secondary server, which will reboot and resume operation within minutes. This type of model's primary focus is high availability of critical data. Compaq's Recovery Server Option and two-node Server Array solutions address this model.

- A Distributed application, on the other hand, is concerned not only with high availability but also performance and capacity expansion. This model allows multiple instances of an application to reside on multiple servers across an enterprise. Compaq's multi-node Server Array solution will address this model. Much like a hard disk array, which by striping data across multiple hard disk drives, receives both availability and performance gains, so too a server array gets these same benefits by distributing multiple instances of an application across two or more servers.

Standby Recovery Server

Though Standby Recovery Server is the first of the Recovery Server Options, introduced in May 1995, it is not a true component of Compaq's clustering strategy. However, because it has set the stage for Compaq's commitment to produce high-availability solutions, it is discussed here. It is available for both Microsoft Windows NT and NetWare environments and is ideal for a single-server, branch office application, in which there is little, if any, on-site technical support.

In a Standby Recovery Server configuration, two Compaq ProSignia or ProLiant servers are attached to a common set of ProLiant Storage Systems with a single copy of the operating system, applications and data. It is crucial that both servers have identical hardware configurations because they boot from the same storage subsystem. All disk storage must be located in the storage subsystem and attached to the SMART and SMART-2 Array Controllers in order to allow for automatic switchover from the primary server to the secondary server. The primary server sends a heartbeat message to the secondary server. If the secondary server does not receive the message after a predetermined amount of time, then it assumes that the primary server has failed and a switchover is initiated. In this case, all disk storage connected to the failed server will automatically be switched to the secondary server, which will reboot, bringing the system back on-line within minutes. This automated process provides time-critical recovery without administrative intervention and the ability to service a failed server when it is most convenient.
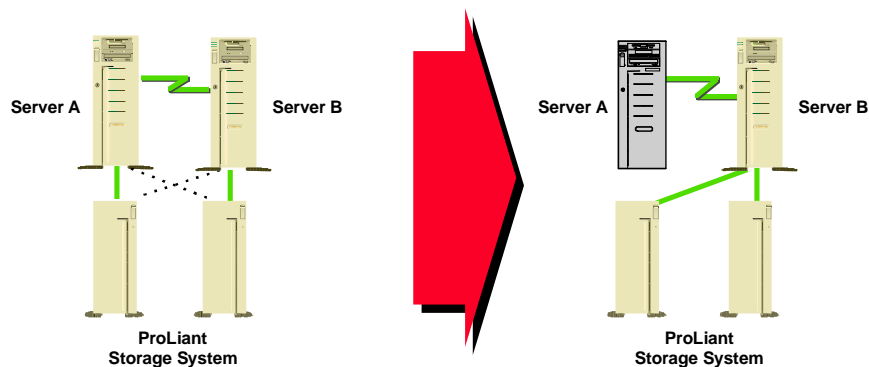
Standby Recovery Server
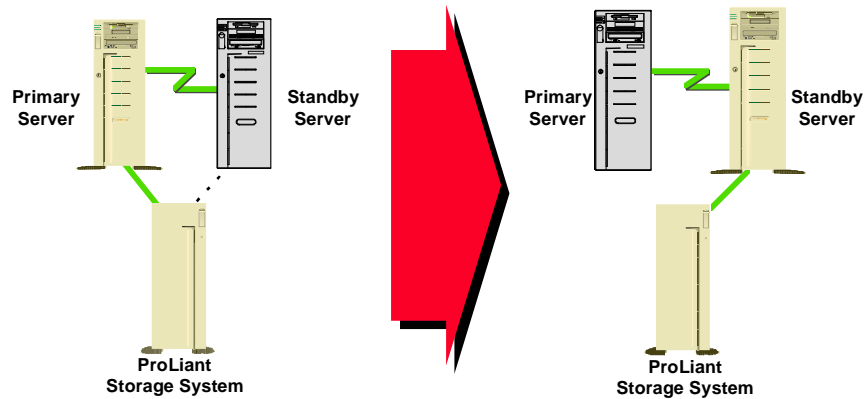
On-line Recovery Server

On-Line Recovery Server, the second of the Recovery Server Options, is Compaq's first clustering solution that allows customers to set up a branch office or replicated-site configuration for their business-critical applications. Operating under Microsoft Windows NT Server, this failover implementation pairs two interconnected Compaq ProSignia or ProLiant servers to provide backup services for each other. The servers don't need to have identical hardware configurations since during normal operation, they work independently and typically have ProLiant Storage Systems that are not shared between them. However, in the event of a server failure, the surviving server must be able to accommodate the load of the failed server in additon to its own work load. The storage system attached to the failed server must also be accessible by the client. This switchover is done automatically without administrator intervention.

Collaborative efforts with Oracle and Microsoft have produced seamless failover for Oracle7 Workgroup Server 7.3 and Microsoft SQL Server 6.5. These database applications have been designed specifically to take advantage of Compaq's On-Line Recovery Server solution. Essentially, the design ensures that when the database fails over, the database tables map correctly to the appropriate drives.

On-Line Recovery Server

Where Compaq is Headed

Compaq established several key requirements when it started exploring clustering architecture:

- Availability

- Scalability

- High performance

- Reliability

With the delivery of On-Line Recovery Server, Compaq paved the way for the implementation of ensuing clustering solutions that would address *all* of these needs.

While the first phase of the Compaq strategy has focused on a high-availability, failover model, the emphasis of the second phase is on the distributed processing model that meets the high availability, scalability, high-performance and reliability criteria. The company's thorough investigation of clustering technologies that would meet these specifications culminated with the selection of Tandem's ServerNet technology for the standard server interconnect and Fibre Channel for communication between clusters and shared storage devices.

ServerNet—ServerNet meets Compaq's core requirements with the following features:

- Availability—transparent client re-connect, hardware failure recovery, and preservation of transaction state where any data in transit at the time a server fails will be preserved

- Scalability—support for multiple I/O data paths to allow for a scalable bandwidth as more connections are added

- Performance—high bandwidth (aggregate of 100 MB/s) and low latency

- Reliability—fault resiliency that includes error checking and redundant connection

ServerNet's design philosophy emphasizes improving performance by adding processors, permitting a customer to "add as they grow" with low entry and incremental costs. With its support for as many as 1,000,000 devices and aggregate throughput of up to 400 terabytes per second, ServerNet provides an unlimited growth path.

Fibre Channel—The Fibre Channel technology, an IEEE standard for providing high-speed data transfer among computer devices, removes the limitations of today's server-to-storage interconnect solutions: insufficient capacity per server, limited interconnect redundancy and shared storage capabilities, and inability to hot-plug boxes.

With Fibre Channel, a customer has vast storage capabilities which meet the high-availability criteria as well:

- Greater connectivity

- Full redundancy and sharing

- Dynamic storage attachment

- High performance (100 MB/s interconnect)

Because of their unlimited growth and performance capabilities and their high levels of fault tolerance, ServerNet and Fibre Channel technologies will ride the crest of the wave for distributed processing in business-critical, enterprise-wide environments.

In the fourth quarter of 1996, Compaq will forge ahead with its clustering implementation of these technologies and expects to introduce its two-node "Branch Office" Server Array, a configuration similar to On-Line Recovery Server that can provide recovery solutions for any NT applications, but optimally for an environment in which a company's database is replicated across nodes. In the first half of 1997, Compaq expects to unveil its answer to distributed processing environments, the "Data Center" Server Array.

"Branch Office" Server Array—The Branch Office Server Array is the first of Compaq's new line of clustered Server Array products. It is an extension of On-Line Recovery Server whereby it can be used for "branch office" or replicated-site applications. The primary differences between the two solutions are the use of storage and the ServerNet components in the Server Array. The Branch Office Server Array has 4-20 GB of mirrored internal storage whereas On-Line Recovery Server is connected to a ProLiant Storage System with a capacity of up to 30.1 GB per unit to satisfy its storage requirements. A typical Branch Office Server Array configuration consists of two Compaq servers, each containing up to 20 GB of mirrored internal storage, connected by a ServerNet. Mirrored hard drives add an extra level of fault tolerance by providing alternate access to data in the event of a hard drive failure.

Just as with On-Line Recovery Server, the Branch Office Server Array's failover capability eliminates the need for immediate service. This makes it ideal for sites where there is little or no on-site support staff.

Branch Office Server Array
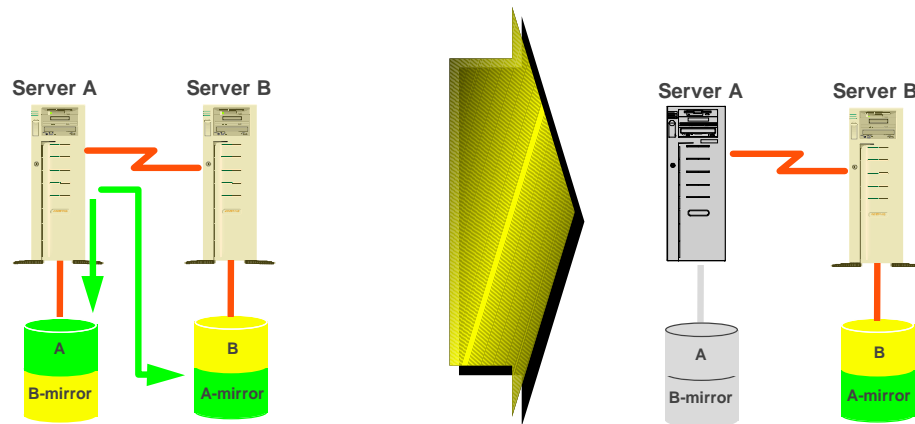
"Data Center" Server Array—The Data Center Server Array is designed to address the needs of the distributed enterprise in which both failover and distributed-processing environments exist. It derives its name from Compaq's commitment to provide MIS departments with a clustering solution for server consolidation in their data centers. The typical cluster implementation will consist of multiple Compaq ProLiant servers (or nodes) connected to one another by a ServerNet cross-bar switch. All nodes will have access to all resources within the cluster. Shared storage will be connected to the nodes through a Fibre-Channel Arbitrated Loop but will appear local to all nodes in the cluster.

Each node will maintain a private memory space, with a private copy of Windows NT Server and a private copy of a "cluster-aware" application (e.g., a database management system). All instances of the application will rely on Windows NT Server to provide globally-consistent arbitration to all shared resources.

In the event of a node failure, shared storage still remains accessible to all remaining nodes.

Data Center Server Array
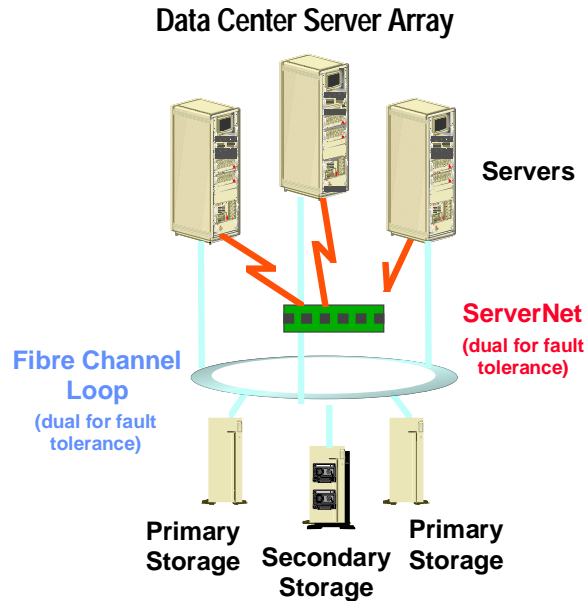
Partnerships for a Fully Integrated Clustering Solution

To provide the market with fully-integrated clustering solutions for both the branch office and the enterprise-wide, distributed processing environments, Compaq has forged alliances with a multitude of key industry players. The partnership Compaq has established with Microsoft and Tandem has laid the foundation for positioning Compaq as the market leader of the industry-standard Windows NT clustering solution. As the trio works with other industry partners, there will be a proliferation of cluster-aware applications developed.

As previously mentioned, Microsoft and Oracle have committed to delivering database management (DBMS) applications for both the failover and distributed environments. Today, with On-Line Recovery Server, both Microsoft SQL Server 6.5 and Oracle7 WorkGroup Server running under Microsoft NT 3.5x will automatically failover to a surviving server and be restarted without administrative intervention. An Oracle database will automatically be reconfigured and recovered with Oracle "FailSafe" installed, as will a MicroSoft SQL database using "FallBack." And Oracle Parallel Server is an enterprise-class DBMS that takes advantage of clustering within a distributed environment. Other potential partners on the roadmap for future clustering products might include Informix, Netscape, Novell, SAP, SCO, and Sybase.

SUMMARY

Expensive mid-range systems have met their match with lower-cost, industry-standard systems for providing high-availability solutions. Since 1989, Compaq's products for critical applications have evolved from the industry's first multiprocessing system with redundant components to its currently-available failover configuration. And with today's strong emphasis on enterprise-wide, distributed processing systems, Compaq continues with its clustering strategy that will carry over well into the future, providing the highest availability and scalability of system solutions that can grow as a customer's business needs grow.

APPENDIX

The following table identifies Compaq's high-availability offerings for its servers.

HIGH AVAILABILITY FEATURES

	ProSignia 300	ProSignia 500	ProLiant 1500	ProLiant 4500	ProLiant 5000
ECC memory	Y	Y	Y	Y	Y
Rapid Recovery	Y	Y	Y	Y	Y
Insight Manager	Y	Y	Y	Y	Y
Automatic Server Recovery	Y	Y	ASR-2	ASR-2	ASR-2
Hot-pluggable drive capability	Optional	Optional	Standard	Standard	Standard
SMART-2 Array Technology	Optional	Optional	Standard on some models	Standard on some models	Standard on some models
Redundant Power Supply	N	N	Optional	Optional	Optional
Off-Line Backup Processor	N	N	Optional	Optional	Optional
Redundant NICs *	Optional	Optional	Optional	Optional	Optional
Redundant Processor Power Modules	N	N	N	N	Optional
ECC bus	N	N	N	N	Y
Uninterruptible Power Supplies	Optional	Optional	Optional	Optional	Optional
DLT Tape Array	Optional	Optional	Optional	Optional	Optional
Standby Recovery Server	Optional	Optional	Optional	Optional	Optional
On-Line Recovery Server	Optional	Optional	Optional	Optional	Optional
Pre-Failure Warranty (memory, hard drives)	Y	Y	Y	Y	Y
Pre-Failure Warranty (processor)	N	N	N	N	Y
CompaqCare for Servers	Y	Y	Y	Y	Y
Global Service and Support Offerings	Y	Y	Y	Y	Y
Disaster Recovery	Y	Y	Y	Y	Y

* Compaq Netelligent 10/100 TX Network Interface Controller