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STORAGE AREA NETWORK (SAN)-IN-A-CAN™ EVALUATION REPORT

BY
MARK RHYNER

APRIL 2002

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TECHNOLOGY INTEGRATION CENTER

Product Certification
Signatures below indicate that this product does not develop a design or require a formal architectural review and complies with all USAISEC standards.

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EXECUTIVE SUMMARY

The Army Small Computer Program (ASCP), U.S. Army Communications Electronic Command (CECOM) tasked the U.S. Army Information Systems Engineering Command (USAISEC), Technology Integration Center (TIC) to evaluate the Removable Media Solutions, Inc. (RMSI) storage area network (SAN)-in-a-CAN™. TIC personnel evaluated this hardware/software for compliance to appropriate standards and its ability to interoperate with other Army sustaining base Information Technology (IT) equipment.

The RMSI SAN-in-a-CAN™ was developed to be an integrated, highly scalable hardware/software SAN system. It includes redundant array of inexpensive or independent disks (RAID) controllers, hard disk drives (HDDs), personal computer (PC) chassis, Windows NT 4.0, Internet Explorer, storage management software, and fiber channel (FC) switch in a single 5U-rackmount chassis.

TIC personnel found that the RMSI SAN-in-a-CAN™ is in compliance with the appropriate standards and protocols contained in the Joint Technical Architecture-Army (JTA-A). It is interoperable with IT equipment on current ASCP contracts and suitable from the technical review for inclusion on appropriate ASCP contract vehicles. This SAN device provides a useful tool to the Army system administrator in implementing and managing departmental or enterprise data storage requirements. By placing the SAN components in a 5U rackmount chassis RMSI has provided a solution which obviates the risk involved in implementing a SAN solution tying heterogeneous devices together and having to prove interoperability between those devices. TIC personnel recommend the addition of this product to server-focused indefinite delivery, indefinite quantity (IDIQ) contracts: Infrastructure Solutions (IS)-1 and Maxi-Minis and Databases (MMAD)-1.

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STORAGE AREA NETWORK (SAN)-IN-A-CAN™ EVALUATION REPORT

1.0 BACKGROUND

The Army Small Computer Program (ASCP), U.S. Army Communications Electronic Command (CECOM) tasked the U.S. Army Information Systems Engineering Command (USAISEC), Technology Integration Center (TIC) to evaluate the Removable Media Solutions, Inc. (RMSI) storage area network (SAN)-in-a-CAN™. TIC personnel evaluated this hardware/software for compliance to appropriate standards and its ability to interoperate with other Army sustaining base Information Technology (IT) equipment.

It is impossible to test any new product with the full suite of Information Technology (IT) equipment available on ASCP contract vehicles or with the plethora of servers and peripheral storage devices already fielded Army-wide. But, an evaluation of a subset can provide Army customers with a level of confidence that vendor claims of interoperability and manageability are accurate.

There are three major cost aspects of enterprise storage: non-availability of data, implementation, and management. A successful enterprise relies on the availability of information regardless of where in the enterprise the information is stored, the time of day, or access method. Although the Army doesn't depend on information assets to make money, the availability of information 24-7 allows decision-makers the data upon which to develop informed conclusions. According to the Meta Group, storage-related costs will constitute 70-80% of server costs by the end of 2002. Enterprise storage is doubling every 12-18 months, mirroring Moore's Law with respect to computing power. As storage hardware prices continue to decrease, emphasis will shift to storage software, SANs, services, and management costs. Various IT research groups peg the cost of enterprise storage in a centralized environment to be between a 17%-40% lower than storage in distributed environment. Storage is normally distributed throughout the organization. Efficiencies could be improved upon and costs reduced if this storage could be managed in a more centralized fashion. A SAN solution can assist in centralizing organizational or enterprise storage.

The current environment necessitates proactive attention to network and data survivability along with continuity of operations (COOP) requirements insuring the organization the ability to reconstitute IT assets after catastrophic events. Thus, consolidating storage assets into rack-mountable equipment, which are easily fielded and deployed, becomes more critical. One means to accomplish this is deployment of SAN solutions onsite and offsite to provide day-to-day data operations along with insuring COOP in the event of catastrophic failure onsite.

1.1 Network Attached Storage (NAS)

A NAS, shown in Figure 1, is a disk array that connects directly to a network via a local area network (LAN) interface that is usually Ethernet. It functions as a server in a client/server relationship with a processor, an operating system (OS), or a micro-kernel. It processes file input/output (I/O) protocols such as Server Message Block (SMB), Common Internet File

System (CIFS), and Network File System (NFS) and implements where data is stored. NAS provides solutions in four key areas.

The first of these areas is high-performance file serving for NFS and CIFS. NAS solutions are generally higher performing than general all-purpose servers when executing block storage tasks due to being a dedicated and specialized file processor with a real-time proprietary OS. The NAS server is able to focus on a specific task, efficiently serving files to clients.

The second area involves applications with clients needing to access and share the same files such as computer-aided design (CAD)/ computer-aided manufacturing (CAM), or Geographic Information Systems (GIS). NAS servers have the capability of carrying security permissions across NFS and CIFS boundaries, allowing Windows clients access to Solaris-based files and vice versa.

Low-end and workgroup file serving is the third area where NAS servers simplify the administration and maintenance of storage, while maintaining low cost solutions for simple file-serving requirements.

The last area entails NAS servers as caching appliances. Caching of web, application, or page-server information in server farms provides for high performance in serving Hypertext Transfer Protocol (HTTP) requests. This area can provide caching of front-end database requests from HTTP clients. Front-end caching can increase overall end-to-end application performance but doesn't preclude the necessity of the front-end server to have high performance direct attached or fiber channel (FC) storage.

NAS solutions will continue to satisfy many of the file-serving requirements and some low-end database requirements but certification, reliability, and performance could be issues.

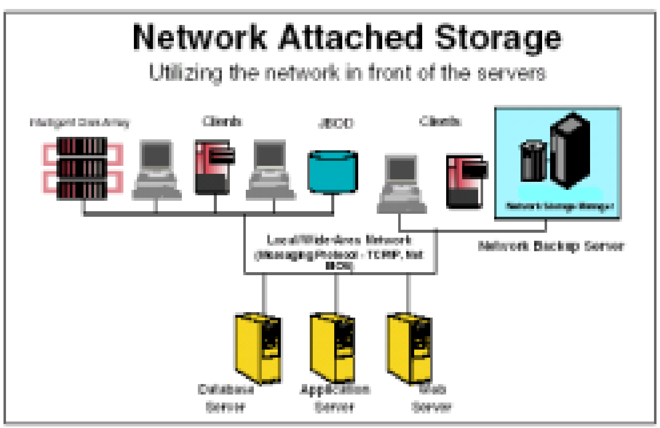

Figure 1. Typical Network Attached Storage

1.1.1 Advantages

NAS makes storage assets more available to clients/users and helps to alleviate some of the bottlenecks connected with access to those storage devices. NAS is less expensive and easier to implement and manage than a typical SAN solution.

1.1.2 Disadvantages

Network bandwidth places inherent throughput limitations on connected storage devices. Most NAS devices are still provided with fast Ethernet connectivity. Although some provide FC interconnects, the host interconnect is usually Internet Protocol (IP)- and file-based and therefore not suitable for large-scale Database Management System (DBMS) applications. There are some third-party file systems, such as Veritas File System, that can help overcome this limitation. But normally, when a DBMS update occurs on a NAS solution, the whole file is modified which can add significant overhead and latency to DBMS write requests and to application response times. Management of all the disk arrays and tape drives on the network can prove to be a daunting task; since most of the time they are separate devices and not logically tied together. NAS backup and recovery solutions suffer from problems in scalability and minimizing recovery time resulting in part from the network being the bottleneck in the data path.

1.2 Storage Area Network (SAN)

As data volume increases through the network, small computer system interface (SCSI)- and NAS-based models begin to breakdown.

A SAN, shown in Figure 2, is a centrally managed, dedicated, high-speed information system enabling any-to-any interconnections between servers and storage systems. The main purpose of a SAN is the transfer of data between computer systems and storage elements and between different storage elements. The SAN connects storage devices to servers with a high speed interconnect which is usually FC and uses similar technologies as those in LANs or wide area networks (WANs). These technologies include routers, hubs, switches, and gateways. A SAN can be local or remote; shared or dedicated. The SAN provides for alternative paths from server to storage device reducing unavailability. (FC is key to enabling an infrastructure for scalability (long term growth) and manageability. SCSI bus connections have been limited to 7 or 15 storage devices and as bandwidth is increased this limit is compressed to fewer devices per bus. In contrast FC supports up to 126 nodes per loop and by adding multiple loops scalability is almost limitless. SANs provide for port zoning/logical unit numbers (LUN) mapping that allows segregation of nodes by physical port, name, or address. Zoning can be broken down into hard, broadcast and virtual zoning.

Storage devices or LUNs are devised to communicate with a specific host or appliance. These LUNs are mapped with exclusive or shared paths against the network. This is similar to the way virtual local area networks (VLAN) defines device to dedicated paths in the network. Hard zoning is at the hardware layer and rigidly defines which port can access which device. Broadcast zoning provides multiple zones in overlapping SAN fabrics. This form of zoning limits traffic, prevents denial of service, and propagation of fabric knowledge and events. Virtual zoning occurs at the host level and is based upon the recognition between the FC switched fabric and the worldwide name associated with the host bus adapter (HBA).

While NAS solutions are based on file systems, SANs are based on block formatting. If a DBMS is updated under a file system, the whole file is rewritten during the update. Under a block data system, only the blocks that were modified are rewritten during updates. This significantly reduces the overhead and latency involved in operating on block data rather than files. While there has been much written on NAS vs. SAN, the bottom line is that both will continue to co-exist as applications may have requirements for both file and block data.

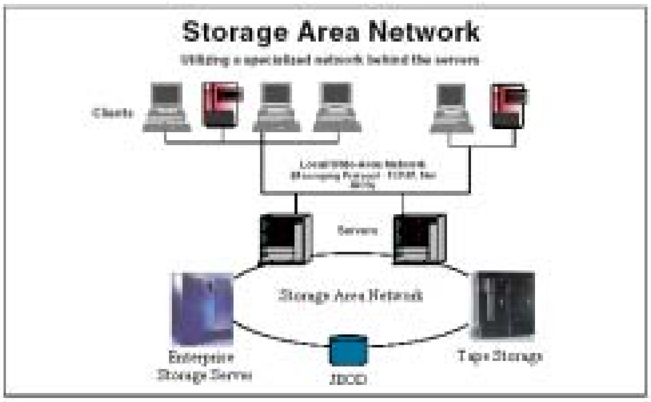

Figure 2. Typical Storage Area Network

1.2.1 Advantages

Some of the advantages of consolidating storage assets are to improve asset allocation, lower operating costs by centralizing assets and personnel, and automatically reallocate storage assets as business requirements dictate. Block reads and writes reduce the overhead and latency involved in the DBMS writes that occur under most NAS solutions.

1.2.2 Disadvantages

Zoning and LUN masking which are traditional methods used to allow multiple operating systems to share storage assets impede scalability. There is cost and risk associated with proving interoperability of heterogeneous IT components resulting in delays in deployment.

1.3 SAN-in-a-CAN™

SAN-in-a-CAN™ (SIAC) is a fully integrated, hardware/software SAN system that includes dual hot swappable RAID controllers, storage management software, and a FC switch contained in a 5U-rackmount enclosure. The unit TIC personnel evaluated had four 18-gigabyte (GB) FC hard disk drives (HDDs) enabling testing of both internal and external storage devices.

The SIAC provides for a highly scalable SAN implementation allowing growth in storage capacity, I/O performance and bandwidth and storage domain hierarchies. This allows system administrators to construct very large SAN configurations encompassing most storage requirements. The SIAC provides striping across RAID arrays and just a bunch of disks (JBOD), which increases total storage performance. The SIAC supports differing configurations based on customer requirements. It supports multiple protocols while complying with those standards governing those protocols and transport systems; it allows SCSI-based storage devices along with FC-based storage; and supports fiber-based FC transport along with copper-based FC transport.

The SIAC switch software automatically detects and discovers HBAs and FC Management Integration Block (MIB) (Fiber Alliance MIB)-compliant switches, hubs, routers, bridges, disks, and arrays in the SAN for management. The switch software collects and interprets management data and allows the user to launch alternate management tools such as Telnet or Web-based tools. The software integrates with and reports events to enterprise management applications such as CA Unicenter. The switch software proactively monitors status and detects problems at all levels, notifying administrators via email when failure-marked events occur. The health of all SAN devices is continually monitored and displayed.

The SIAC SAN Volume Manger (SVM) is the graphical user interface (GUI) for storage applications, and comes preinstalled on the device along with Windows NT 4.0 in the current configuration. The SVM is responsible for monitoring physical devices, volume definitions, and storage allocations. The SVM also enables new SAN-oriented technologies (e.g., multi-node clusters, shared file systems, serverless backup and storage applications) to be supported for all the hosts attached to the SAN. The problem of scalability restraint through sharing storage assets via zoning and LUN masking is ameliorated by virtualizing physical storage devices. Virtualization is not new. It first appeared as a means to enable an OS to "see" a larger hard drive than it could normally. For example, if an OS could only access a 2-GB space but a 10-GB HDD was available, a volume manager allowed the OS to see the 10-GB drive as five 2-GB logical disks. The current virtualization iteration is external to both servers and storage devices allowing utilization of all storage devices by the servers on the network. SAN management is accomplished via the web-enabled GUI from a local or a remote location using a standard browser. Some of the features provided by the SVM are denoted in Appendix A. The SVM coexists with and can be managed by other host-based SAN management software such as those provided by Veritas, Legato, and CA.

SIAC incorporates a hybrid of physical or hard zoning with virtual zoning. This two-tier approach requires the switch to communicate only with specific hosts for specific acquisitions of storage pools. To date, the only known methods to make malicious attempts to acquire volumes are the following: a) physical introduction of a host with appropriately configured HBA cards, connected to the SIAC appliance via FC, with the virtual driver installed into the specific device or b) the shared volume acts like any other attached storage device and is subject to the same security scrutiny as all other data assets on the network. Once the data is shared over the LAN, the onus is upon the existing security mechanisms of the network environment to ensure data integrity

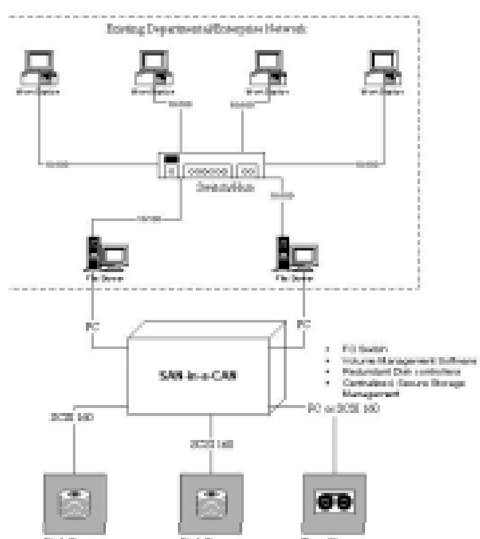

Figure 3. Typical SAN in a CAN Configuration

2.0 OBJECTIVE

TIC personnel performed this evaluation to answer the following questions posed by the customer:

- Is SAN-in-a-CAN™ interoperable with existing equipment procured from ASCP contracts?
- Does SAN-in-a-CAN™ comply with the appropriate standards applicable to IT/network storage equipment?

3.0 METHOD

Only a subset of fielded equipment and software were available in the evaluation timeframe. In order to answer the two questions listed in paragraph 2.0, the test setup consisted of a server using NT 4.0 as the OS, the SIAC, internal storage of the SIAC using an FC interface, and an external storage tower using a SCSI interface. This provides a means to determine interoperability and manageability of the storage devices attached to the system under test. There was no attempt to measure any performance parameters. The product was also evaluated to insure that it meets the appropriate standards as a part of integral IT systems that are compatible with the Joint Technical Architecture-Army (JTA-A).

3.1 NT Server using Fiber Channel Interface to and Storage Internal to SAN-in-a-CAN™

In this configuration, shown in Figure 3, the NT server (a digital Venturis FX 5133s) was hooked to the SIAC via an Emulex FC HBA. The storage media used in this setup were four 18-GB HDD internal to the SIAC.

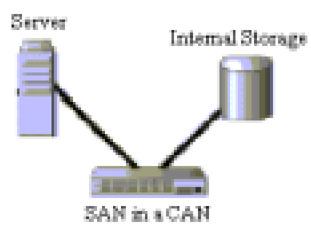

Figure 4. Test Setup 1

3.1.1 Setup

- The SVM was executed on the SIAC.
- The Emulex FC HBA card was installed in the server along with a driver for Windows NT 4.0.
- The HBA was connected via fiber optic cable to the left top SC connector in the row of 16 panel openings for the FC switch matrix at the bottom of the panel shown in Figure 5.
- The SVM driver was installed on the server.
- Three virtual volumes were established across the four HDDs.
- The Server was assigned access permissions to the created volumes.
- Files were transferred to and from the created volumes.

Figure 5. Rear Panel of SAN in a CAN

3.2 External Storage Tower Interface to SIAC using SCSI 160 Interface

- Fortra Storage Towers containing five 18-GB HDD with SCSI 160 interfaces were used for the second test scenario.
- The Fortra Storage towers were interfaced to the existing configuration of test setup #1 via SCSI 160 into the SIAC by removing the terminating block on the SIAC rear panel shown in Figure 5 and attaching the SCSI cable from the Fortra to the connector.
- The Fortra Towers are self-terminating.
- Device identifications (IDs) and channels were initiated.
- From the RMSI, a rescan was done for all new devices.
- New volumes were assigned.
- Files were transferred to and from the new volumes to test operations and management on the new volumes.

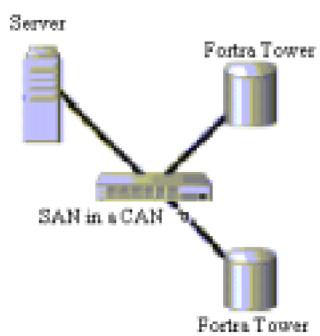

Figure 6. Test Setup 2

4.0 RESULTS

The SIAC proved to be easy and intuitive to setup and install. The user manuals are easy to understand as long as the user has an understanding of Windows OS, Internet Explorer, the file systems involved, and how storage and volumes are allocated. This is a very easy storage allocation and management system to implement and manage.

Hooking up the HBA of the server to the rear panel connector of the SIAC before installing the SVM driver caused one problem experienced during setup of the initial test scenario.

This resulted in a duplicate volume showing up in the volume tables and the inability of the server to access the volume. This problem was resolved by removing the volumes, re-establishing the volumes, insuring that the SVM driver was installed and configured properly and then hooking the FC cable from the HBA to the SIAC back panel SC connector. No other problems were encountered in establishing new volumes for storage purposes.

The SIAC has the appropriate agency approvals such as Class A approvals for electromagnetic emissions from US, Canada, Australia and Japan along with CE approval and IEC60950, CISPR22, and CISPR24. SIAC uses standard protocols (e.g., IP, SCSI) and transport (e.g., FC, Ethernet) supporting SMB, NFS, and CIFS. Device drivers for Windows NT 4.0; Win2K; Solaris 2.51, 2.6, 2.7 and 7; HPUX 11.0; and Linux. Drivers for other operating systems are in development.

5.0 CONCLUSION

The SIAC provides a modular, highly scalable, high availability, SAN solution that provides multiple OS support and coexists with and can be managed by other host-based SAN management software. The product is easy to set up, add storage hardware to and then create virtual volumes that can be accessed by those users with the appropriate access permissions. Security concerns are those associated with all other IT equipment existing in a Windows NT Domain. Proper attention should be paid to setting up the appropriate administration and user access rights. The combination of hard zoning with virtual zoning reduces exposure to unauthorized access. The SIAC, in most cases, will exist behind the firewall of the organization implementing a SAN. The SVM can monitor all the physical devices attached to it and send device event messages to SNMP consoles. Researching the standards, protocols, and architecture of the switch in the device demonstrates that the SIAC complies with the appropriate protocols and standards in the JTA-A, and interoperates with other Army sustaining-base IT equipment. By placing the SAN components in a 5U-rackmount chassis RMSI has provided a solution which obviates most of the risk involved in implementing a SAN solution tying heterogeneous devices together and proving interoperability. The SIAC can provide another tool in the Army IT manager's suite to initiate COOP practices while enhancing the manager's ability to satisfy the ever-increasing storage requirements brought about by the expanding use of video, images, and multi-media applications in the day-to-day business of Army units. Recommend addition of this product to server-focused IDIQ contracts, IS-1, and MMAD-1.

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APPENDIX A. RMSI SVM FEATURES

The following is a list of key features of the RMSI SAN Volume Manager.

- Volumes are a list of physical storage areas concatenated and presented to the host as a single virtual device.
- Volumes can be expanded instantly (without re-striping) by adding a new storage area to the list. No limit of the number of storage areas that compose a Volume.
- Volumes are assigned (by the management function) to specific hosts and are not “seen” by other hosts. This feature, which could be termed “Volume Masking,” enables the sharing of the same physical device by several hosts with different OS (instead of “LUN masking”).
- Volumes can be moved from host to host. This in contrast with host-based Volume Managers where the Volume is an entity of the server rather than of the SAN.
- Volumes are OS and file system independent. Any OS can use a Volume as a standard drive.
- Multiple hosts can access the same Volume, enabling an easy implementation of multi-node clusters as well as shared file systems.
- Data is transferred from the physical device directly to the host memory enabling the full utilization of the SAN bandwidth. The fact that the host accesses the data directly from the physical devices drastically increases the number of hosts that could be connected without creating bottlenecks. The underlying switched fabric becomes the only limiting factor.
- Unlimited number of Volumes of any size can be created.
- Volumes are allocated from the storage pool. Volumes can be created, expanded, moved, and deleted by users or by other applications. This feature enables the allocation of storage by software applications for their internal use.
- Volume size can be from 1 MB to multiple Terabytes (64 bit addressing mode). It is possible to create a giant Volume by concatenating many RAID subsystems breaking the barrier of 2 Terabytes. Many hosts can share this giant Volume by adding a shared file system on top of the Volume Manager.
- A Volume can be accessed from the same host via multiple “access paths” with load balancing and automatic failover. A server may have many HBAs connected through different FC switches to the same storage devices. If one access path fails, the server continues to work from other access paths.
- A Volume can be used by a Storage Application that creates new Volumes. Storage Applications like Volume Mirror, Snapshot, Hierarchical Storage Volume and others can be sold as “add-ons” to the Volume Manager providing enterprise class functionality.
- Volume can be striped across many storage devices. By composing a Volume from a Stripe of Multiple Storage systems, a very high performance can be achieved for the specific Volume.
- Multiple Storage Pools can be defined allowing control from where the Volumes are allocated. (e.g., The total storage can be divided into different storage pools according to the protection level, performance, or other criteria).
- Performance statistics, per Volume, HBA, and storage devices allow the administrator to quickly discover and resolve SAN bottlenecks.

- The SAN Volume Manager does not require that all the devices and servers connected to the SAN will use it. This enables the upgrade of existing SANs with the SVM without the need to reconfigure servers and storage devices.
- The SVM can coexist with and be managed by other host-based SAN management software like those provided by Veritas, Legato, CA and others.
- The SVM is capable of monitoring all the SAN's physical devices and of sending "events" (email, pagers, SNMP console) through the LAN when a physical device fails.

APPENDIX B. INTEROPERABILITY MATRIX

RMSI Interoperability Matrix										
							Tested Operating Systems			
	X = Tested & Interoperable ns = Not supported				nt = Not tested				na = Not applicable	
Tested FC Components	BIOS	Driver Rev* / OS / FW	Public/ Private +	Fabric mode+	Auto Stealth loop	NT 4.0	WIN 2K	Solaris 2.5.1, 2.6, 2.7	Solaris 7	HP-UX 11.0
Host Bus Adapters										
Agilent 5121A		V2.02 NT	X	X	X	X	X	na	na	na
Agilent 5101A		V2.02 NT	X	X	X	X	X	na	na	na
Agilent 5101A		SR03 (Solaris)	X	X	X	na	na	na	X	na
Agilent 5121A		SR03 (Solaris)	X	X	X	na	na	na	X	na
Atto Express PCI FC		1.13 NT	X ns	X ns	X ns	X	ns	na	na	na
Cambex MC 1000 Fiber Quick		AIX 4.3.3	nt	nt	X	na	na	na	na	na
Compaq Host Bus Adapter		V4.20.02.60 NT	X	X	X	X	na	na	na	na
Emulex PCI LP 6000	1.4	3.03a NT	ns	ns	ns	X	X	na	na	na
Emulex PCI LP 7000	1.4	3.03a NT / Win 2K	X	X	X	X	X	na	na	na
Emulex PCI LP 7000	1.4	4.02d-COMBO (Solaris)	X	X	X	na	na	na	X	na
Emulex PCI LP 8000	1.4	3.03a NT / Win 2K	X	X	X	X	X	na	na	na
Emulex PCI LP 8000	1.4	4.02d-COMBO (Solaris)	X	X	X	na	na	na	X	na
Emulex PCI LP 850	1.4	3.03a NT	X	X	X	X	X	na	na	na
HP 3740A-6001 PCI		HP-UX 11.0	nt	nt	nt	na	na	na	na	X
Interphase 5540		LINUX S100056-A04	X	X	X	X	X	nt	nt	nt
Interphase 5526		V2.4 build 132	nt	nt	X	X	na	na	na	na
JNI FCE-3210	latest	3.0.3 NT / Win 2K	X	X	X	X	X	na	na	na
JNI FCE-6410	latest	3.0.3 NT / Win 2K	X	X	X	X	X	na	na	na
JNI FCE2-6412	latest	3.0.3 NT / Win 2K	X	X	X	X	X	nt	nt	nt
JNI SBUS		Sun Ultra 2 - Solaris 2.7	nt	nt	X	na	na	X	na	na
JNI FCI-1063-N		V2.11 NT	nt	nt	nt	X	ns	na	na	na
JNI FCI-1063-N		Solaris 7 V2.2 1.12	nt	nt	nt	na	na	na	X	na
JNI FiberStar PCI	V1.47	V2.2.01LSI NT	ns	ns	ns	X	ns	X	na	na
JNI FiberStar PCI	V1.47	V2.11 NT	ns	ns	ns	X	ns	na	na	na
qLogic QLA2100	V1.37	V7.04.02 NT	X	X	X	X	X	na	na	na
qLogic QLA2100	V1.37	V2.26 Solaris 7	X	X	X	na	na	na	X	na
qLogic QLA2200	V1.54	V7.04.02 NT / WIN 2K	X	X	X	X	X	nt	nt	nt
qLogic QLA2200	V1.54	V1.09 Solaris 7	X	X	X	na	na	na	X	na
qLogic QLA2200	V1.54	2.11-Beta (Linux)	nt	nt	X	na	na	na	na	na
qLogic QLA2202	latest	V7.04.02 NT / WIN 2K	X	X	X	X	X	nt	nt	nt
Sun 6730A S-Bus HBA		Solaris 2.5.1	nt	nt	nt	na	na	X	na	na
Sun 6730A S-Bus HBA		Solaris 2.6	nt	nt	X	na	na	X	na	na
Sun 6730A S-Bus HBA		Solaris 2.7	nt	nt	nt	na	na	X	na	na
Unisys IntelliFiber		1.000.187 NT	nt	nt	X	X	X	na	na	na
Fiber Channel Hubs & Switches										
Vixel 7100/7200 Auto Stealth		V1.02 (43) FW	X	na	X					
Vixel 7100/7200 Auto Stealth		V2.0 (89) FW	ns	na	ns					
Vixel 7100/7200 Public Private		V2.0 (89) FW	X	na	na					
Vixel 7100/7200 Fabric		V2.0 (89) FW	na	X	na					
Vixel 7100/7200 Classic Stealth		V2.0 (89) or 1.02 (43) FW	X	na	ns					
Vixel 8100 Switch Classic Stealth Mode		FW 01.01.01v	X	na	X**					
Vixel 8100 Switch Fabric mode		FW 01.01.01v	na	X	na					
Vixel 2100		V1.2 FW	X	na	X					
Vixel 2000/2006		V1.2 agent FW	X	na	X					
Vixel 1000		na	X	na	x					
Brocade Silkworm 2800		2.21A	na	X	na					
Brocade Silkworm 2400		2.21A	na	X	na					
Gadzoox Slingshot 4218		SW2	na	X	na					

Gadzoox Capellix 3000			nt	nt	X					
Gadzoox Capellix 2000 Series			nt	nt	X					
Gadzoox Gibraltar GS			X	na	X					
Gadzoox Gibraltar GL			X	na	X					
McData ES-3016		SW2	nt	X	nt					
McData ES-1000			nt	X	nt					
qLogic SANbox-8		SW2	nt	X	nt					
qLogic SANbox-16		SW2	nt	X	nt					
qLogic SANbox-16HA		SW2	nt	X	nt					
RAID Controllers & Enclosures										
Clariion 5500/5700 DPE		203	nt	na	X					
Clariion FC4500		NT	X	X	X					
Chaparral CHAPTEC K7413		K2.0	nt	nt	X					
Data Direct Raid (Symbios)		Controller V3.00.01	nt	nt	nt					
EMC Symmetrics 3330		NT	na	X	X					
EMC Symmetrics 3430		NT	na	X	X					
Hitachi HDS 7700E		NT / Solaris	na	X	X					
Hitachi HDS DF400		Solaris 7 FW B14 / 229.01	na	X	X					
Mylex DAC0960 ffx			na	X	X					
Mylex DACSF		FW 5.0, HW 52-550-212-03	na	X	X					
Lucent Optistar fc100r		256	na	X	X					
LSI MetaStor S-Class (3702)		NT	na	X	X					
LSI MetaStor E3300 (4766)		NT Controller V3.00.01	na	X	X					
LSI MetaStor S-Class (3702)		Solaris 2.5.1, 2.6	na	X	X					
LSI MetaStor E3300 (4766)		Solaris 2.5.1, 2.6	na	X	X					
RaidTec Fiber array 12		4.3 P NT / Solaris / LINUX	na	X	X					
XioTech Magnitude (Fport)		LINUX / NT	X	X	X					
XioTech Magnitude		NT	X	X	X					
JBODs and disk drives / Enclosures										
BoxHill with Seagate (ST34371FC)		0934	X	na	X					
Clariion 5000 (Seagate ST34371FC)		203	X	na	X					
Eurologic Voyager XL400 Fiber		NT	nt	nt	nt					
Eurologic Voyager 18FS		LINUX / NT	na	X	X					
Fujitsu MAA3182FC 18GB		E601 NT Solaris 2.5.1, 2.7 & 7	nt	nt	X					
IBM 09L, Type; DRVL		4148 NT Solaris 2.5.1, 2.7 & 7	X	X	X					
IBM 18L, Type; DRVL		4148 NT Solaris 2.5.1, 2.7 & 7	X	X	X					
IBM Model DNEF-318350		F70E NT Solaris 2.5.1, 2.7 & 7	X	X	X					
IBM Ultrastar 9LP, 18XP		NT Solaris 2.5.1, 2.7 & 7	X	X	X					
IBM Ultrastar 9LZX, 18ZX		NT Solaris 2.5.1, 2.7 & 7	X	X	X					
IBM Ultrastar model DDYF-T09170		F60J NT Solaris 2.5.1, 2.7 & 7	X	X	X					
nStor JBOD CR8F		NT	nt	nt	nt					
Quantum Atlas 10K		UJ21	X	X	X					
Sun A5000 (Seagate ST19171FC)		147E NT Solaris 2.5.1, 2.7 & 7	X	na	X					
Quantum Atlas FC 10KRPM 9GB		751 NT Solaris 2.5.1, 2.7 & 7	X	X	X					
Seagate Barracuda 9GB, ST34371FC		676 NT Solaris 2.5.1, 2.7 & 7	X	nt	X					
Seagate Cheetah ST318203FC		0004 NT Solaris 2.5.1, 2.7 & 7	X	X	X					
Seagate Cheetah ST39102FC		0007 NT Solaris 2.5.1, 2.7 & 7	X	X	X					
Routers and Bridges										
ATTO Fiber Bridge 3200R		NT / Solaris	na	X	X					
ATTO Fiber Bridge 2200R		NT / Solaris	na	X	X					
Chaparral FS1310R Intelligent Router		NT / Solaris	na	X	X					

Crossroads 2250 Router (Fport)		NT / Solaris	na	X	X					
Crossroads 4100/4200		NT / Solaris	na	X	X					
Pathlight SAN Gateway		NT / Solaris	na	X	X					
Smartsan SR 2001		V21D	na	nt	X					
Tape libraries, Drives and Filer subsystems										
ADIC Scaler 1000		NT / Solaris	na	X	X					
ADIC Scaler 1000		NT / Solaris	na	X	X					
Exabyte Mammoth 2		NT / Solaris	na	X	X					
Quantum DLT 7000		NT / Solaris	na	nt	X					
Spectra Logic 64000F Gator	1.20.03	NT HPUX11 LINUX	na	nt	X					
Spectra Logic 12000F Gator	1.20.03	NT HPUX11 LINUX	na	nt	X					
Spectra Logic 10000F Bullfrog	1.20.03	NT SOL HPUX10.X LINUX	na	X	X					
Spectra Logic 2000 Treefrog		NT	na	X	X					
Spectra Logic SANtape 100&200		NT	na	X	X					
StorageTek L180		NT / Solaris / UNIX	na	X	X					
Network Appliance F740 Filer		NT	na	na	X					
*The driver and firmware revision numbers listed indicate code levels at time of initial test. We recommend checking with the										
device manufacturer for the latest revisions.										
Operating Systems: NT - NT 4.0 SP5										
RMSI reserves the right to make changs to this Interoperability Matrix and the equipment described herein without notice. RMSI has made all reasonable effort to ensure that the information in this										
Interoperabiltiy Matrix is accurate and complete.										

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GLOSSARY. ACRONYMS, ABBREVIATIONS, AND TERMS

Section I. Acronyms and Abbreviations

ASCP	Army Small Computer Program
CAD	computer-aided design
CAM	computer-aided manufacturing
CECOM	U.S. Army Communications Electronic Command
CIFS	Common Internet File System
COOP	continuity of operations
DBMS	Database Management System
FC	fiber channel
FCP	Fiber Channel Protocol
GB	gigabyte
GIS	Geographic Information System
GUI	graphical user interface
HBA	host bus adapter
HDD	hard disk drive
HTTP	Hypertext Transfer Protocol
I/O	input/output
ID	identification
IDIQ	indefinite delivery, indefinite quantity
IP	Internet Protocol
IS	Infrastructure Solutions
IT	Information Technology
JBOD	just a bunch of disks
JTA-A	Joint Technical Architecture-Army
LAN	local area network
LUN	logical unit numbers
MIB	Management Integration Block
MMAD	Maxi-Minis and Databases
NAS	network attached storage
NFS	Network File System
OS	operating system
PC	personal computer
RAID	redundant array of independent disks
RMSI	Removable Media Solutions, Inc.
SAN	storage area network
SCP	Small Computer Program
SCSI	small computer system interface
SIAC	SAN-in-a-CAN™
SMB	Server Message Block
SVM	SAN Volume Manger
TCP/IP	Transmission Control Protocol/Internet Protocol
TIC	Technology Integration Center
USAISEC	U.S. Army Information Systems Engineering Command
VLAN	virtual local area network

WAN wide area network

Section II. Terms

Adapter: Hardware unit that aggregates other I/O units, devices or communications links to a system bus.

Backup: Copy of computer data that is used to recreate data that has been lost, mislaid, corrupted, or erased. The act of creating a copy of computer data that can be used to recreate data that has been lost, mislaid, corrupted or erased.

Bandwidth: Measure of the information capacity of a transmission channel.

Bridge: Component used to attach more than one I/O unit to a port. (2) A data communications device that connects two or more networks and forwards packets between them. The bridge may use similar or dissimilar media and signaling systems. It operates at the data link level of the OSI model. Bridges read and filter data packets and frames.

Bridge/Router: Device that can provide the functions of a bridge, router or both concurrently. A bridge/router can route one or more protocols, such as TCP/IP, and bridge all other traffic.

Channel: Point-to-point link, the main task of which is to transport data from one point to another.

Channel I/O: Form of I/O where request and response correlation is maintained through some form of source, destination and request identification.

Client: Software program used to contact and obtain data from a server software program on another computer -- often across a great distance. Each client program is designed to work specifically with one or more kinds of server programs and each server requires a specific kind of client program.

Client/Server: Relationship between machines in a communications network. The client is the requesting machine, the server the supplying machine. Also used to describe the information management relationship between software components in a processing system.

Data Sharing: SAN solution in which files on a storage device are shared between multiple hosts.

Disk Mirroring: Fault-tolerant technique that writes data simultaneously to two hard disks using the same hard disk controller.

Disk Pooling: SAN solution in which disk storage resources are pooled across multiple hosts rather than be dedicated to a specific host.

Enterprise Network: Geographically dispersed network under the auspices of one organization.

Fabric: Fiber channel employs a fabric to connect devices. A fabric can be as simple as a single cable connecting two devices. The term is most often used to describe a more complex network utilizing hubs, switches and gateways.

FCP: Fiber Channel Protocol - mapping of SCSI-3 operations to fiber channel.

Fiber Optic: Refers to the medium and the technology associated with the transmission of information along a glass or plastic wire or fiber.

Fiber Channel: Technology for transmitting data between computer devices at a data rate of up to 4 Gb/s. It is especially suited for connecting computer servers to shared storage devices and for interconnecting storage controllers and drives.

GBIC: GigaBit Interface Converter - Industry standard transceivers for connection of fiber channel nodes to arbitrated loop hubs and fabric switches.

Gigabit: One billion bits, or one thousand megabits.

Hardware: Mechanical, magnetic and electronic components of a system, e.g., computers, telephone switches, terminals and the like.

HUB: Fiber channel device that connects nodes into a logical loop by using a physical star topology. Hubs will automatically recognize an active node and insert the node into the loop. A node that fails or is powered off is automatically removed from the loop.

LAN: Local area network - network covering a relatively small geographic area (usually not larger than a floor or small building). Transmissions within a Local Area Network are mostly digital, carrying data among stations at rates usually above one megabit/s.

Latency: Measurement of the time it takes to send a frame between two locations.

Link: Connection between two fiber channel ports consisting of a transmit fiber and a receive fiber.

Link Control Facility: Termination card that handles the logical and physical control of the fiber channel link for each mode of use.

Local Area Network (LAN): Network covering a relatively small geographic area (usually not larger than a floor or small building). Transmissions within a Local Area Network are mostly digital, carrying data among stations at rates usually above one megabit/s.

Loop Topology: Interconnection structure in which each point has physical links to two neighbors resulting in a closed circuit. In a loop topology, the available bandwidth is shared.

MIA: Media Interface Adapter - MIAs enable optic-based adapters to interface to copper-based devices, including adapters, hubs, and switches.

Mirroring: Process of writing data to two separate physical devices simultaneously.

NAS: Network Attached Storage - term used to describe a technology where an integrated storage system is attached to a network that uses common communications protocols, such as TCP/IP.

Network: Aggregation of interconnected nodes, workstations, file servers, and/or peripherals, with its own protocol that supports interaction.

Network Topology: Physical arrangement of nodes and interconnecting communications links in networks based on application requirements and geographical distribution of users.

NFS: Network File System - A distributed file system in UNIX developed by Sun Microsystems which allows a set of computers to cooperatively access each other's files in a transparent manner.

Optical Disk: A storage device that is written and read by laser light.

Optical Fiber: A medium and the technology associated with the transmission of information as light pulses along a glass or plastic wire or fiber.

Peripheral: Any computer device that is not part of the essential computer (the processor, memory and data paths) but is situated relatively close by. A near synonym is input/output (I/O) device.

Port: Hardware entity within a node that performs data communications over the fiber channel.

Port Bypass Circuit: Circuit used in hubs and disk enclosures to automatically open or close the loop to add or remove nodes on the loop.

Protocol: Data transmission convention encompassing timing, control, formatting, and data representation.

RAID: Redundant Array of Inexpensive or Independent Disks. A method of configuring multiple disk drives in a storage subsystem for high availability and high performance.

Raid 0: Level 0 RAID support - Striping, no redundancy

Raid 1: Level 1 RAID support - mirroring, complete redundancy

Raid 5: Level 5 RAID support, Striping with parity

Router: A device that can decide which of several paths network traffic will follow based on some optimal metric. Routers forward packets from one network to another based on network-layer information.

SAN: Storage Area Network is a dedicated, centrally managed, secure information infrastructure, which enables any-to-any interconnection of servers and storage systems.

SC: Connector fiber optic connector standardized by ANSI TIA/EIA-568A for use in structured wiring installations.

Scalability: Ability of a computer application or product (hardware or software) to continue to function well as it (or its context) is changed in size or volume. For example, the ability to retain performance levels when adding additional processors, memory and/or storage.

SCSI: Small Computer System Interface - A set of evolving ANSI standard electronic interfaces that allow personal computers to communicate with peripheral hardware such as disk drives, tape drives, CD_ROM drives, printers and scanners faster and more flexibly than previous interfaces.

SCSI-3: SCSI-3 consists of a set of primary commands and additional specialized command sets to meet the needs of specific device types. The SCSI-3 command sets are used not only for the SCSI-3 parallel interface but for additional parallel and serial protocols, including fiber channel, Serial Bus Protocol (used with IEEE 1394 Firewire physical protocol) and the Serial Storage Protocol (SSP).

Server Message Block: This is a protocol for sharing files, printers, serial ports, and communications abstractions such as named pipes and mail slots between computers. SMB has transitioned into CIFS.

Striping: Method for achieving higher bandwidth using multiple Node Ports in parallel to transmit a single information unit across multiple levels.

Storage Media: The physical device itself, onto which data is recorded. Magnetic tape, optical disks, floppy disks are all storage media.

Switch: Component with multiple entry/exit points (ports) that provides dynamic connection between any two of these points

Switch Topology: Interconnection structure in which any entry point can be dynamically connected to any exit point. In a switch topology, the available bandwidth is scalable.

Tape Backup: Making magnetic tape copies of hard disk and optical disc files for disaster recovery.

Tape Pooling: SAN solution in which tape resources are pooled and shared across multiple hosts rather than being dedicated to a specific host.

TCP: Transmission Control Protocol - a reliable, full duplex, connection-oriented end-to-end transport protocol running on top of IP.

TCP/IP: Transmission Control Protocol/Internet Protocol - a set of communications protocols that support peer-to-peer connectivity functions for both local and wide area networks.

Topology: Interconnection scheme that allows multiple fiber channel ports to communicate. For example, point-to-point, arbitrated loop, and switched fabric are all fiber channel topologies.

WAN: Wide area network - network which encompasses inter-connectivity between devices over a wide geographic area. A wide area network may be privately owned or rented, but the term usually connotes the inclusion of public (shared) networks

Zoning: In fiber channel environments, the grouping together of multiple ports to form a virtual private storage network. Ports that are members of a group or zone can communicate with each other but are isolated from ports in other zones.