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Data Storage Investment Optimization in Military Installations:

SCSI to EIDE/SATA

EXECUTIVE SUMMARY

Maximizing the use of existing and future data storage assets is a critical requirement for military and government IT managers who must control costs while maintaining operational continuity and support growing application demand for more information. This white paper from Kadence Systems highlights the major impediments military and government IT managers face as they seek to maximize the ROI (return on investment) in storage assets throughout the life of the product.

Kadence Systems examines an innovative approach to building a bridge controller which allows robust, SCSI (Small Computer Systems Interface) based servers to be used with newer and less expensive technology: disk drives. The major goals and benefits of this approach are:

1. Significantly extend the product/system life cycle while reducing the storage management and data migration costs.

2. Enhance the usable capacity of storage assets while reducing the total product cost and maintaining overall system performance.

3. Rapid introduction of newer technology devices in military environments with minimal operational interference.

4. Cost effective and seamless replacement of obsolete SCSI devices in an otherwise robust data storage subsystem.

REPLACING SCSI STORAGE IN MILITARY INSTALLATIONS

More than 25 years old, SCSI is a mature data storage industry standard interface which provides high connectivity, high flexibility, and high performance. The longevity and popularity of SCSI has resulted in the installation of SCSI devices into thousands of systems, in both military and commercial environments. During this tenure, SCSI has not only grown from 1MB/Sec to 320MB/Sec transfer rate, but has also maintained system level compatibility so that all SCSI devices, old and new, can co-exist on the same bus. After 25 years of stability, however, the laws of physics are catching up and the SCSI interface in its current form is finally being retired with the release of Ultra III SCSI (320MB/Sec).

While a majority of the consumer and commercial applications are moving on to adopt newer storage technologies such as fibre-channel at the high end and EIDE/SATA at the low end, military environments have some unique impediments in adapting to newer technologies. For example, operational reliability and continuity in a military environment is significantly more crucial than, for instance, a digital video streaming consumer application. To replace a proven, reliable interface like SCSI with another newer interface device will require significant system integration, verification and test resources. Another impediment is related to the cost of replacing the interface since other systems components such as the Host Bus Adapter (HBA), cabling, software device drivers, etc. must be replaced and/or upgraded. These costs coupled with integration, test, and verification costs for relatively complex and fewer military installations could become prohibitive. Furthermore, newer technological devices do not lend themselves well for adoption by existing military systems. It is far more practical to change the device's personality so that it can be adopted by the existing military system instead of replacing the entire system to adapt to the new device.

SOLVING THE SCSI STORAGE ROI PROBLEM

A bridge controller such as the SEIDEIII from Kadence Systems (see Fig. I) can help optimize the data storage investment as follows:

1. Improved Price and Performance: SCSI performance at EIDE/SATA prices.

2. Extend the life cycle of legacy SCSI systems

3. Software transparent replacement of hard to find or out of production SCSI devices with non-SCSI devices.

4. Adoption of newer (non-SCSI) technologies into legacy SCSI based systems with minimal impact to the rest of the system.

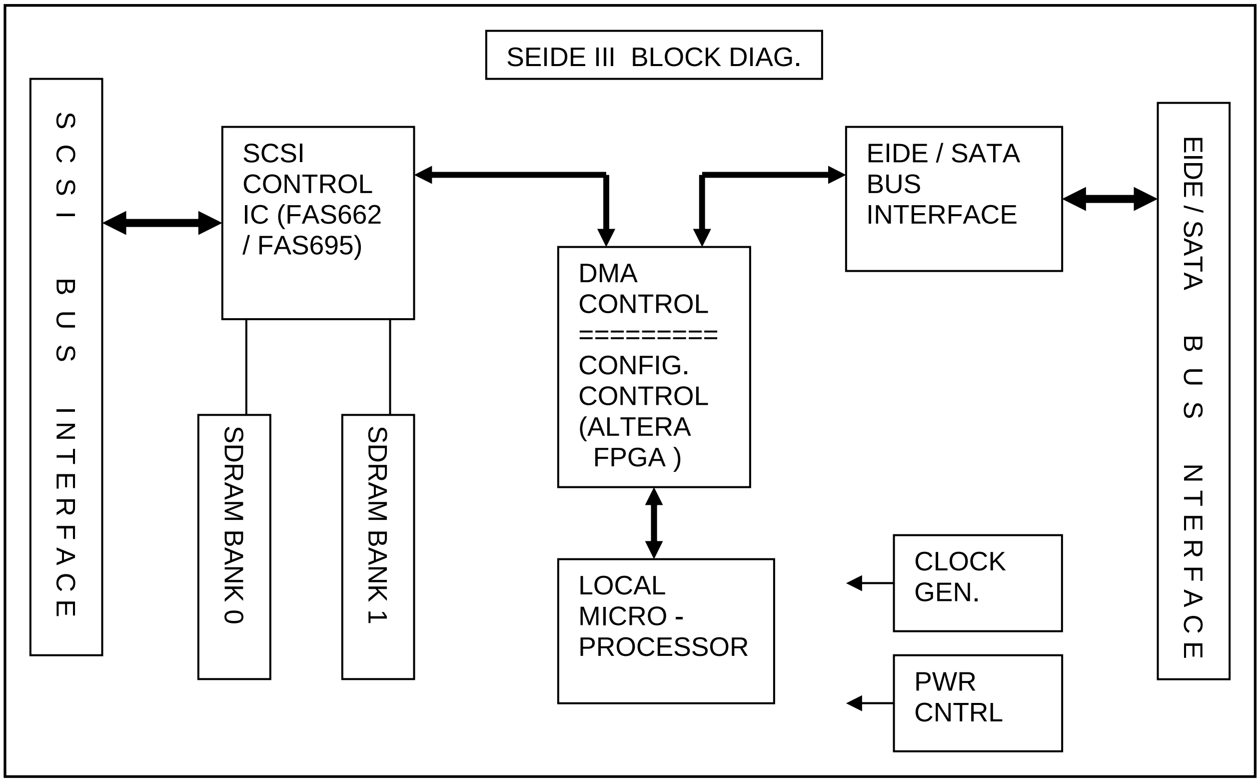

FIG. 1: SEIDEIII BRIDGE CONTROLLER BLOCK DIAGRAM

Let us now examine each of the claims in detail:

Improved Price/Performance: SCSI Performance at EIDE/SATA prices:

SCSI provides higher performance or data throughput than EIDE. On EIDE, only one command can be executed at a time. Using the Disconnect/Reconnect feature, however, SCSI allows multiple command execution to one or more devices. Also, on EIDE, only one master (and one slave) device per port is allowed, whereas SCSI supports at least seven devices (up to 15 devices in wide SCSI) per port. As a result, multiple devices can process data transfer requests simultaneously and share the bus bandwidth. Additional SCSI features such as parity (and optional CRC in the newer versions of SCSI), automatic retries, scatter-gather and command queuing, etc. lead to significant performance improvement over EIDE, which do not allow such features. EIDE, however, uses the built-in DMA channel of the computer, controlled by the host CPU. Since the resources are already there, the cost is significantly lower. EIDE is, therefore, attractive for users who mainly focus on obtaining the lowest price.

By inserting a bridge controller between the SCSI host bus adapter (HBA) and the target SCSI devices, and replacing the SCSI devices with EIDE devices, one can obtain SCSI performance (up to 320MB/Sec) and reliability features such as disconnect/reconnect, command queuing, parity (or CRC) protection with significantly lower cost EIDE devices. While the cost of the bridge controller must be added to the equation, the fact that its cost is shared among up to seven devices (and up to 15 devices using Wide SCSI), increases the overall performance benefits.

Extend the Life Cycle of Legacy SCSI Subsystem:

After reigning for more than 20 decades as the data storage interface of choice, SCSI has finally come to the end of its active life cycle. Although it is mature and feature rich, it is forced to yield to newer, technologically superior serial interfaces (FC, SATA, FireWire, etc.) as the data storage interfaces of choice. Unfortunately, there are millions of active SCSI based installations today which will have to be uprooted over a period of time. This requires not only the direct replacement cost attributed to the cost of the SCSI devices, but also the amount of time required to integrate, test and perform compatibility tests of the newer software, newer hardware, etc. It makes sense, therefore, to extend the life cycle of the legacy SCSI subsystem at minimal cost and minimal time.

The SCSI to EIDE bridge controller replaces the aging and more expensive SCSI devices with newer, less costly EIDE devices. All data storage devices –SCSI, EIDE or SATA – are electro-mechanical devices that, over a period of time break down and need to be replaced. As the commercial market has moved on from SCSI devices to EIDE/SATA devices, finding replacement SCSI devices to extend the life cycle of the legacy SCSI subsystem is costly and very difficult, if not impossible. Replacing the SCSI device with an EIDE/SATA drive and the Bridge Controller extends the life of the storage subsystem significantly. There is an MTBF (Mean Time Between Failures) associated with the bridge controller as well but, being an all electronic device, it has a significantly larger MTBF.

Software Transparent SCSI to non-SCSI Device Replacement:

The cost of replacement software and the associated costs of testing, integrating, and verifying full-compatibility of non-SCSI based data storage systems from SCSI based data storage systems could be significantly high. The complexity arises due to the fact that SCSI supports seven devices (up to 15 devices in wide SCSI mode) per port, and has several software features, such as disconnect/reconnect, command queuing, auto-retires, and parity/CRC protection.

By interfacing the bridge controller to the host (device driver) software on one end and the original SCSI devices (now replaced with the EIDE device) on the other, all software commands and protocols related to the application and its interface to the operating system are left unchanged. Not only is the SCSI software interface extremely powerful, versatile, robust and performance oriented, but it also has the benefit of being a matured, field- proven, ANSI approved protocol. The bridge controller allows integration of newer technology storage devices (EIDE/SATA), while maintaining complete software transparency.

Adoption of Newer Technology Products into SCSI based Systems:

With the advent of newer serial interfaced storage devices it is often desirable to incorporate the newer technologies into existing military systems as compared to the wholesale replacement of such systems. Quite often, however, the cost of integrating such products into existing systems is difficult, time consuming, and, if not executed properly, extremely costly. The economies of scale do not justify the manufacturer of the newer device to offer the product in both its newer, native interface, and the well proven, but older, SCSI interface. For example, the newer technology “blue ray" DVD player, or an EIDE interface based CD-ROM jukebox might be offered by manufacturers in only one type of interface, i.e. EIDE (or SATA).

By interfacing the bridge controller to the newer, technologically advanced devices at one end ("the back-end") and interfacing to the SCSI HBA on the front end, the system can be upgraded rather quickly. Again, SCSI has had the benefit of storage industry standardization (approved ANSI standards), and wide acceptance, and contribution to the standardization by almost all major data storage hardware and software suppliers. The infrastructure to develop and support SCSI hardware and software is also well established and mature. The ANSI committee envisioned several different types of SCSI devices (see Table 1). As a result, the bridge controller makes it practical to adapt newer products into SCSI-based systems.

CODE	**DESCRIPTION**
00h	Direct-access device (e.g., magnetic disk)
01h	Sequential-access device (e.g., magnetic tape)
02h	Printer device
03h	Processor device
04h	Write-once device (e.g., some optical disks)
05h	CD-ROM device
06h	Scanner device
07h	Optical memory device (e.g., some optical disks)
08h	Medium Changer device (e.g., jukeboxes)
09h	Communications device
0Ah-0Bh	Defined by ASC IT8 (obsolete)
0Ch	Storage Array Controller Devices (RAID)
0Dh	Enclosure Services
0Eh	Simplified Direct Access Devices (e.g., magnetic disks)
0Fh	Optical Card Reader/Writer Devices
10h	Bridge Controller Commands
11h	Object Based Storage Devices
12h	Automation / Drive Interface
1Eh	Well Known Logical Unit
1Fh	Unknown or no device type

TABLE 1: SCSI DEVICE TYPES

BRIDGE CONTROLLER IMPLEMENTATION REQUIREMENTS:

The design and implementation of the Bridge Controller is the key to improving data storage subsystem ROI while maximizing benefits. SEIDEIII from Kadence Systems, for example, is a typical SCSI to EIDE/SATA bridge controller which meets these requirements as follows:

1. **Performance:** Since SCSI transfer rates span from under 1MB/Sec to 320MB/Sec, the onboard SCSI Controller chip, such as the Q-Logic FAS662/FAS695 used on SEIDEIII, must adopt to this wide range of transfer bandwidth requirement with minimal software / hardware overhead. The entire data path through the Bridge Controller must also be designed to sustain the highest transfer speed unabated. Since the SCSI protocol is significantly different from the IDE protocol,

additional processing on the SCSI commands to meet the IDE protocol requirements is necessary. For example, a SCSI command with a very large amount of data to be transferred may require disconnection/reconnection during the course of the command execution, a feature not available in the EIDE/SATA protocol. The challenge is making the commands processing not only transparent to the host software, but also maintaining the data throughput.

SEIDEIII from Kadence Systems implements such challenging tasks by integrating a high performance, Ultra 320 SCSI Controller chip (Q-Logic FAS662/695), and a proprietary DMA engine implemented on a custom FPGA. Additionally, to facilitate SCSI protocol conversion to EIDE protocol, including supporting all powerful SCSI features which has made SCSI highly versatile, an onboard 16-bit microprocessor with its dedicated resources (i.e., flash RAM based firmware, local RAM, diagnostic and download ports, Operator interface and display port, etc.) is included.

2. **Functionalities:** While functionalities supported by EIDE/SATA devices are limited and significantly less than those supported by SCSI, it is necessary to maintain software compatibility when replacing the SCSI devices with the EIDE/SATA devices. For example, SCSI protocol allows multiple hosts (initiators) to access multiple SCSI devices on the same SCSI bus. If the Bridge Controller is utilized to replace SCSI devices with EIDE/SATA devices, it must allow connections of multiple hosts (initiators) to access multiple EIDE devices.

SEIDEIII from Kadence Systems implements these functional requirements using onboard firmware and associated local resources. The SEIDEIII modular architecture allows growth path such that, as newer EIDE/SATA devices are added to the supported device list, any additional features provided by these EIDE/SATA drives are implemented to their fullest. The SEIDEIII onboard microprocessor, and its downloadable firmware, facilitates these enhancements seamlessly.

3. **Cost:** One of the primary objectives of the Bridge Controller design is to improve the price performance by keeping costs down. The design architecture of the Bridge Controller plays a significant role in determining the recurring cost of the Bridge Controller hardware. For example, to maintain high throughput, onboard RAM buffers may be implemented. Since memory is one of the more expensive components, keeping its use to a bare minimum is preferred. This is where highly optimized design architecture plays an important role in maintaining low-costs.

SEIDEIII from Kadence Systems optimizes the design architecture by using industry standard, field proven mature components which provide the required performance, flexibility, and on-chip memory (FIFOs) to contain costs. Instead of using PCI interface based VLSI components, for example, the SEIDEIII uses components with the simplified, generic, microprocessor bus interface-based components. For facilitating the high speed data transfers, multiple FIFOs are built into the DMA engine which is implemented using the Altera FPGA. For systems which do not require Ultra 320 SCSI transfer rates, a version of SEIDEIII is implemented with no external memory buffers (implemented via SDRAMs). All necessary data buffering is done using FIFOs built into the FPGA.

4. **Compatibility:** Since EIDE/SATA protocol is significantly different from the SCSI protocol, it is extremely important to make sure that the Bride Controller design can accommodate idiosyncrasies and any anomalies when switching between the two protocols. While it is possible to implement all the protocol conversion functionalities inside an ASIC, for example, it requires a

significant amount of resources to test and validate all of the functionalities. Performance optimization is often sacrificed in favor of lower cost via such ASIC implementation. Another reason for implementing the features and non-critical functions into downloadable firmware is that, while SCSI is a proven, standardized protocol, it is impractical to make any changes on the host interface (initiator) side of the SCSI protocol. It is likely that when such a significant change to the system environment is being made, issues may be discovered which could require a change. For practical reasons, all changes must be made on the Bridge Controller.

SEIDEIII from Kadence Systems has gone through extensive test and validation exercises. While no significant issues were discovered during the design validation, some idiosyncrasies and minor problems were discovered. All required changes were implemented on SEIDEIII, maintaining full compatibility with the existing SCSI systems.

CONCLUSIONS:

Military IT managers' need to maximize the return on investment in storage assets requires careful analysis of several criteria. Technological advances tend to not only make hardware investment less valuable but also susceptible to requiring additional resources (time and money) to test, integrate and validate affected system components. For SCSI-based systems, this White Paper suggests an innovative Bridge Controller-based solution, which allows the use and extension of current and future data storage assets not only to improve the ROI, but to also rapidly introduce newer technological devices in military environments with minimal operational interference.