Intel® RAID Controller SRCSAS144E

Technical Product Specification

Revision History

Date	Revision Number	Modifications
June, 2006	1.0	Initial Release

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1.   Introduction

1.1   Purpose of this Document

This document provides a detailed description of the Intel® RAID Controller SRCSAS144E and the software required to support it.

1.2   Product Overview

The Intel® RAID Controller SRCSAS144E supports both serial-attached SCSI (SAS) and serial ATA (SATA) disk drives. Supporting dual architectures allows solutions to be customized for performance, reliability, system expansion flexibility and hard drive capacity. The RAID Controller SRCSAS144E provides flexibility and helps lower total cost of ownership with a standardized server and storage infrastructure. It is designed with four internal SAS ports and four external SAS ports; and the controller utilizes a x4 or wider PCI Express* server board slot.

1.3   Operating System Support

The following operating systems are fully validated and supported at product launch. The latest service pack/update available at start of the test run will be tested:

- Microsoft* Windows Server 2003* 32-bit
- Microsoft Windows Server 2003 64-bit Edition
- Red Hat* Linux 3.0 32-bit
- Red Hat Linux 3.0 64-bit Edition
- Red Hat Linux 4.0 32-bit
- Red Hat Linux 4.0 64-bit Edition
- SuSE* Linux Enterprise Server 9 32-bit
- SuSE Linux Enterprise Server 9 64-bit Edition

The following operating systems will be tested with a baseline installation of the operating system. The latest service pack/update available at start of the test run will be tested.

- Microsoft Windows 2000* Server
- Microsoft Windows XP* 32-bit
- Microsoft Windows XP x64

The following operating systems will be validated as a baseline operating system installation post launch:

- SuSE* Linux Enterprise Server 10 32-bit
- SuSE Linux Enterprise Server 10 x86-64
- Novell* NetWare 6.5 32-bit
- Novell NetWare 6.5 x86-64

1.4   List of Features

- Supports SAS devices at speeds up to 300MB/second per port
- Supports the SATA II protocol over SAS transport
- Contains four internal SAS ports and four external SAS ports
- Supports up to 32 physical devices and 64 logical drives
- Supports RAID levels 0, 1, 5, 10, and 50.
- Online capacity expansion
- Online RAID level migration
- Physical drive roaming
- RAID controller migration
- Fast virtual drive initialization
- Hot spare drive configuration, both private and global
- SAS/SATA drive hot plug
- Auto rebuild
- Variable data stripe size configured per virtual drive
- 128 MB of ECC DDR2 SDRAM integrated on the controller
- Read and write cache policy
- SAF-TE, SES2, and SGPIO intelligent enclosure support
- PCI hot plug support
- Background media test (Patrol Read)
- Background data integrity test

2. Hardware

2.1 Hardware Architectrural Overview

2.1.1 Block Diagram
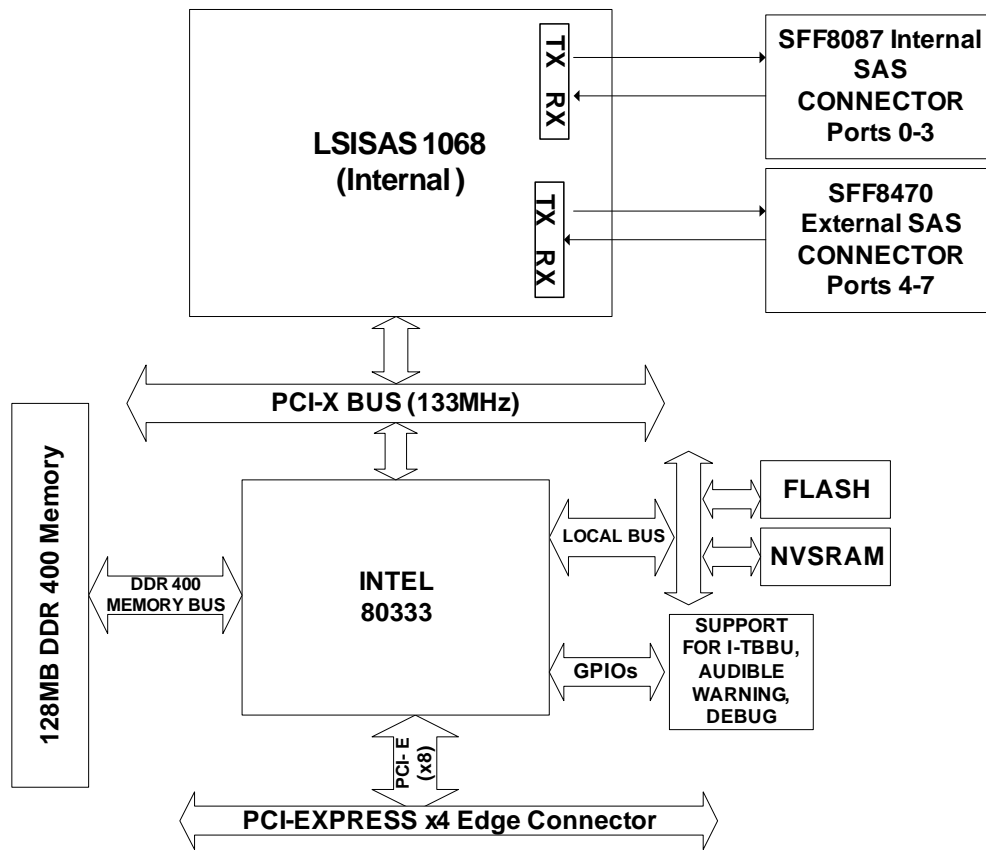
Figure 1. Hardware Block Diagram

2.2   Physical Layout

Memory   **Intel 80333 I/O Processor**   **Speaker**   **Battery Connector (Backside)**

SSF8470 SAS/SATA Connector   **PCI Express X4 Connector**   **LSI 1068 SAS Controller**   **SSF8087 SAS/SATA Connector**
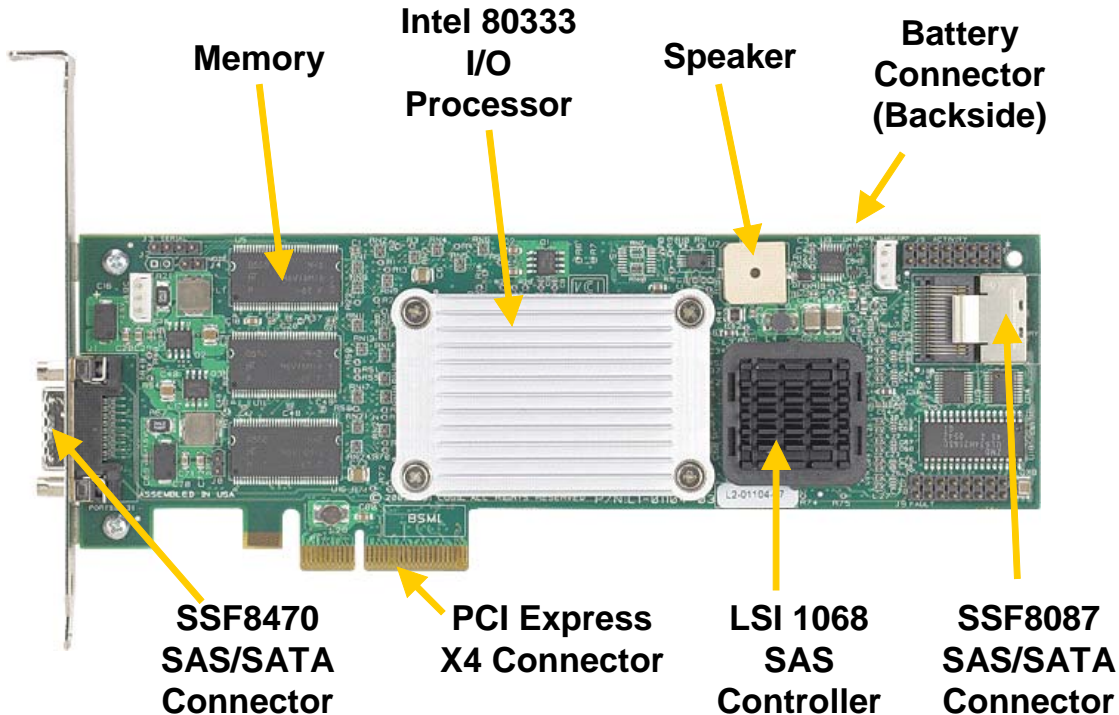
Figure 2. Intel® RAID Controller SRCSAS144E Physical Layout

2.3   Major Components

2.3.1   Intel® 80333 Intelligent I/O Processor

The RAID Controller SRCSAS144E features the Intel® IOP333 I/O processor, operating at 500 MHz. The Intel® IOP333 features a high-performance internal bus, dual-ported memory controller, high-bandwidth PCI Express to PCI-X bridge, and an improved interrupt controller to provide a high-performance, highly integrated processor solution. For information, see http://developer.intel.com/design/iio/iop333.htm.

2.3.1.1   Processor Core

The Intel® IOP333 continues to build on Intel's strength in delivering high-performance, low-power Intel XScale® microarchitecture processors. It integrates Intel® Super-Pipelined RISC Technology with a 7-stage integer / 8-stage memory Super-Pipelined core, 32 kbyte data and instruction caches. The version selected for this RAID controller operates at 500 MHz. The internal bus operates at 333 MHz and offers internal bandwidth of up to 2.7 GB/sec.

2.3.2   Flash Memory

The Intel® Advanced+ Book Block Flash Memory (C3) device, manufactured on Intel's latest 0.13 µm and 0.18 µm technologies, represents a feature-rich solution for low-power applications. The C3 device incorporates low-voltage capability (3 V read, program, and erase) with high-speed, low-power operation. Flexible block-locking allows any block to be independently locked or unlocked. Additional information on this product can be obtained from the Intel® Flash Memory website at http://www.intel.com/design/flash.

This non-volatile storage can be accessed for firmware updates and recovery. For firmware recovery, set the IOP mode-select jumper J4 to 0 Mode. Mode 0 firmware recovery requires the use of a firmware recovery utility and a firmware image file.

2.3.3   SDRAM (Cache)

The Intel® RAID Controller SRCSAS144E includes 128 MB of Integrated DDR2 400 ECC SDRAM registered memory. This memory is connected directly to the memory controller interface bus of the IOP, and serves as storage for the executable code transferred from the flash. It also serves as cache during RAID transactions. Cache mode selection takes immediate effect while the server is online and is available on a per virtual drive basis. The IOP memory controller provides single-bit ECC error correction with multi-bit detection support.

The Intel® RAID Smart Battery AXXRSBBU3 provides a battery backup option for data cached in the memory.

Figure 3. Intel® RAID Smart Battery AXXRSBBU3 Accessory

2.3.4   SAS Controller

The LSI Logic* LSISAS1068 eight-port controller provides 1.5 and 3 Gb/s data transfer rates per port (with 8 to 10-bit encoding this translates to about 150MB/s and 300MB/s), the controller also leverages an electrical and physical interface that is compatible with Serial ATA technology. The controller has the following features:

- 8-port SAS/SATA controller
- 1.5 and 3 Gb/s SAS and SATA data transfer rates per port, full duplex
- Port independent auto-negotiation
- Point to point SAS/SATA drive connection
- Supports SATA II
- Native command queuing (available post launch)
- Port selector for dual-port drives
- 64-bit, 133-MHz PCI-X* host interface
- Backward compatible with 33/66-MHz PCI
- Supports 3.3 volt signaling levels
- Hot plug/hot swap support
- PCI power management
- Interrupt coalescing
- Flash and local memory interface

2.3.5   Diagnostic Features

2.3.5.1   Audible Alarm

The audible alarm will beep when a drive has failed and it will beep during a rebuild. The drive failure alarm beeps as follows:

- Degraded array: Short tone, one second on, one second off.
- Failed array: Long tone, three seconds on, one second off.
- Hot spare commissioned: Short tone, one second on, three seconds off.

The drive failure tones repeat until the problem is corrected or until the alarm is silenced or disabled. The alarm can be silenced or disabled on the controller's properties page in the BIOS Console or by using the failed drive options pane in the Intel® RAID Web Console 2.

- Silencing the alarm is temporary, the alarm will sound again when an additional failure is detected or when the system is rebooted and the failure still exists.
- Disabling the alarm is persistent across errors and reboots, the alarm will remain disabled until it is re-enabled.

The build alarm tone functions differently. It remains on during the rebuild. After the rebuild completes, an alarm with a different tone will sound, signaling the completion of the rebuild. This is a one-time, non-repeating, tone.

2.3.5.2   LED Placement and Function

A single LED is located on the back side of the controller near the battery connector. This LED signals when unwritten data remains in cache when power is removed (dirty cache). Additional LED signaling is available through stake pin connectors located on the controller. See Section 2.3.6.

2.3.5.3   SAS Connectors

The Intel® RAID Controller SRCSAS144E provides one external SSF8470 and one internal SSF8087 SAS/SATA signal connectors. Both SSF8470 and SSF8087 connectors provide support for four SAS/SATA ports. Sideband signals are not used with this controller.

SSF8470 SAS/SATA Cable (not included

SSF8470 SAS/SATA Connector

SSF8087 SAS/SATA Connector

SSF8087 SAS/SATA Cable (Included)
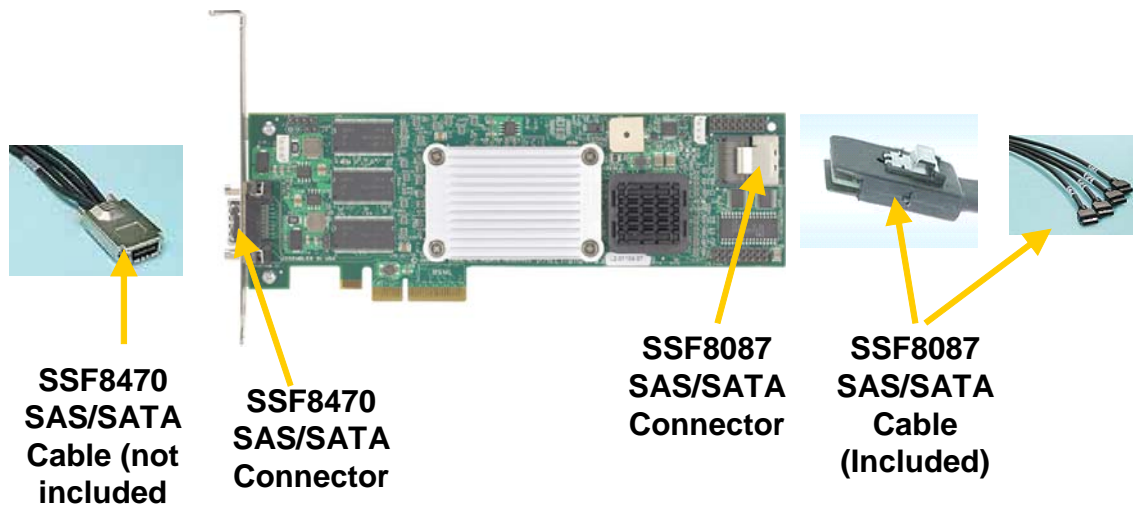
Figure 4. SAS Connectors

2.3.5.3.1   SAS Connector Pinout

Signal names are with respect to the host; the device connected to the host reverses the signal names. Transmit pins connect to receive pins on the other device. The SAS/SATA connector is keyed at pin 1. These pin-outs for the serial ATA connector are not compatible with the legacy PATA connector.

Table 1. SFF8087 Connector Pin-out

SFF8087 Connector to 4 Single Port Connectors Pinout				
Controller Pinout		Backplane Pinout		
SFF8087	Pin Def.	SATA Con	Pin Def	
A1	GND	7	GND	Port 0
A2	RX0+	6	TX+	Port 0
A3	RX0-	5	TX-	Port 0
B1	GND	4	GND	Port 0
B2	TX0+	3	RX+	Port 0
B3	TX0-	2	RX-	Port 0
B4	GND	1	GND	Port 0
A4	GND	7	GND	Port 1
A5	RX1+	6	TX+	Port 1
A6	RX1-	5	TX-	Port 1
A7	GND	4	GND	Port 1
B5	TX1+	3	RX+	Port 1
B6	TX1-	2	RX-	Port 1
B7	GND	1	GND	Port 1
B8	Sideband 0			
B9	Sideband 1			
B10	Sideband 2			
A9	Sideband 3			
A10	Sideband 4			
A11	Sideband 5			
A8	Sideband 6			
B11	Sideband 7			
A12	GND	7	GND	Port 2
A13	RX2+	6	TX+	Port 2
A14	RX2-	5	TX-	Port 2
B12	GND	4	GND	Port 2
B13	TX2+	3	RX+	Port 2
B14	TX2-	2	RX-	Port 2
B15	GND	1	GND	Port 2
A15	GND	7	GND	Port 3
A16	RX3+	6	TX+	Port 3
A17	RX3-	5	TX-	Port 3
A18	GND	4	GND	Port 3
B16	TX3+	3	RX+	Port 3
B17	TX3-	2	RX-	Port 3
B18	GND	1	GND	Port 3

Figure 5. SFF8087 to Four-port Internal Cable Example

SFF-8470			
Signal	Pin	Signal	Pin
RX0+	S1	RX0+	S16
RX0-	S2	TX0-	S15
RX1+	S3	TX1+	S14
RX1-	S4	TX1-	S13
RX2+	S5	TX2+	S12
RX2-	S6	TX2-	S11
RX3+	S7	TX3+	S10
RX3-	S8	TX3-	S9
G1-G9	Signal Ground		
Housing	Chassis Ground		

Table 2: SFF-8470 External Connector Pinout

2.3.5.4   PCI Interface

The Intel® RAID Controller SRCSAS144E must be installed into a x4 or larger PCI Express* slot. The controller is backward-compatible with x4 or larger slots that are wired with x1 and x2 PCI Express lanes.

2.3.6   Intel® RAID Controller SRCSAS144E Jumpers
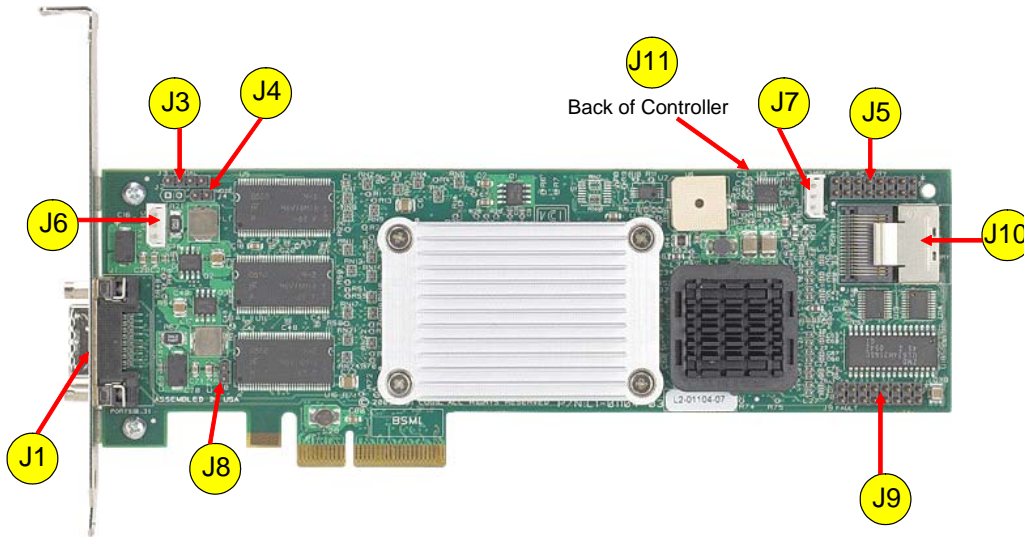
Figure 6. Jumper Locations

Table 3. Intel® RAID Controller SRCSAS144E Jumper Table

Jumper	Description	Type	Comments
J1	External SAS/SATA Port connector, Ports 0-3	SFF8470	Connection to SAS/SATA devices.
J3	Universal Asynchronous Receiver/Transmitter (UART)	3-pin connector	For factory and debug use
J4	Mode 0 select	2-pin connector	No jumper is required for normal operation. Setting the controller to Mode 0 holds the I/O processor in reset for firmware recovery. ▪ No Jumper = Normal operational mode. ▪ Jumper = Mode 0 for firmware recovery, requires a firmware recovery utility and firmware image file.
J5	Port actvity LED	8x2 header	LED signal for activity per port for eight ports
J6	Keyed I²C connector	3-pin connector	Out-of-band enclosure management (SAF-TE)
J7	Keyed I²C connector	3-pin keyed connector	Out-of-band enclosure management (SES2)
J8	Dirty Cache LED Header	2-pin connector	For connection to enclosure LED. When lit indicates the data in the cache has not been written to disk.
J9	Drive Fault LED Header	8x2 header	LED signal support for front panel drive fault per port.

J10	Internal SAS/SATA port connector, ports 4-7	SFF8087	Connection to SAS/SATA devices.
J11	Intel® RAID Smart Battery Connector	20-pin connector	Cable connector for the extrernal battery pack. This connector is located on the back side of the board.

2.4 Hardware Architectural Features

Table 4. Hardware Architectural Feature

Feature	Intel® RAID Controller SRCSAS144E
RAID levels	0, 1, 5, 10, 50 6, 60 available post launch via a firmware update
Number of devices	Up to 32 devices per controller
Device types	SAS or SATA hard drives
Data transer rate	300 MB/s per port
PCI bus	x4 PCI Express*
Memory	128 MB ECC DDR2 400 SDRAM Integrated on the Controller
Battery backup	External battery module (Intel® RAID Smart Battery AXXRSBBU3)
SAS connector	One internal SSF8087 connector and one external SFF8470 connector.
IOP	Intel® 80333 I/O processor, which performs hardware exclusive OR (XOR) assistance
Card dimensions	7.71 inches by 2.525 inches
Serial port	4-pin serial debug (requires transceiver)
Compatible devices	32 physical devices, 64 logical drive, mixed capacity, mixed SATA and SAS (not recommended); non-disk devices including expanders.
Firmware	4 Mbit in flash ROM

2.5 Electrical Characteristics

Table 5. Electrical Characteristics

Storage Adapter	PCI Express* +12V	PCI Express +5.0V	PCI Express +3.3V	PCI Power
SRCSAS144E	115 mA if battery is present	1.5 A	N/A	15W

2.6 Environmental Specifications

Table 6. Environmental Specifications

Specificaton	Description
Operating temperature	0 degrees Centigrade to 55 degrees Centigrade. (The maximum operating temperature decreases to +45 degrees Centigrade when the Intel® Remote Smart Battery AXXRSBBU3 is installed)
Relative humidity range	5% to 90% noncondensing
Maximum dew point temperature	32 degrees Centigrade
Airflow	300 linear feet per minute (LFPM)

Table 7. Storage and Transit Specifications

Specification	Description
Temperature range without battery	-30 degrees Centigrade to +80 degrees Centigrade (dry bulb)
Temperature range with battery	0 degrees Centigrade to 45 degrees Centigrade (dry bulb)
Relative humidity range	5% to 90 % noncondensing

2.6.1.1   Safety Characteristics

The Intel® RAID Controller SRCSAS144E meets or exceeds the requirements of UL flammability rating 94 V0. Each bare board is also marked with the UL flammability rating. For boards installed in a PCI bus slot, all voltages are lower than the SELV 42.4 V limit.

2.7   Supported Device Technology

2.7.1   Support for Hard Disk Drive Devices

The Intel® RAID Controller SRCSAS144E integrates eight high-performance SAS/SATA ports (four internal and four external) that provide support for both SAS and SATA hard drives. Each port supports SAS and SATA devices using the SAS Serial SCSI Protocol (SSP), Serial Management Protocol (SMP), and Serial Tunneling Protocol (STP). The SSP protocol enables communciation with other SAS devices. STP allows the SAS RAID controller to communicate with SATA devices via SATA commands.

2.7.2   SAS Expander Support

The RAID Controller SRCSAS144E supports LSI Logic* expanders and Vitesse* SAS expanders that are used as a component in Intel enclosures. Other expanders may be supported post launch, based on market conditions and customer requirements.

2.7.3   Support for Non Hard Disk Drive Devices

Because SAS-based non hard drive devices were not available at the time of development of this controller, support for these devices will be determined as they become available. For information on the SRCSAS144E support for non hard drive devices, see the *Intel® RAID Controller SRCSAS144E Tested Hardware and Operating System List*.

2.7.4   Enclosure Management Support

The Intel® RAID Controller SRCSAS144E supports the following enclosure management protocols.

- SAF-TE enclosure management in-band from the RAID controller to the backplane.
- SES2 enclosure management in-band to expander-based backplanes and out-of-band to direct-connect backplanes.

3.   Software

The software stack described below is referred to as the *SAS Software Stack* and is planned for use with the current SAS RAID controllers and future RAID controllers that are compatible with SAS and SATA technology. This software stack includes software pieces used in RAID controller firmware, RAID controller BIOS, and RAID controller drivers and utilities. The graphic shows the inter-relationship of these software pieces.
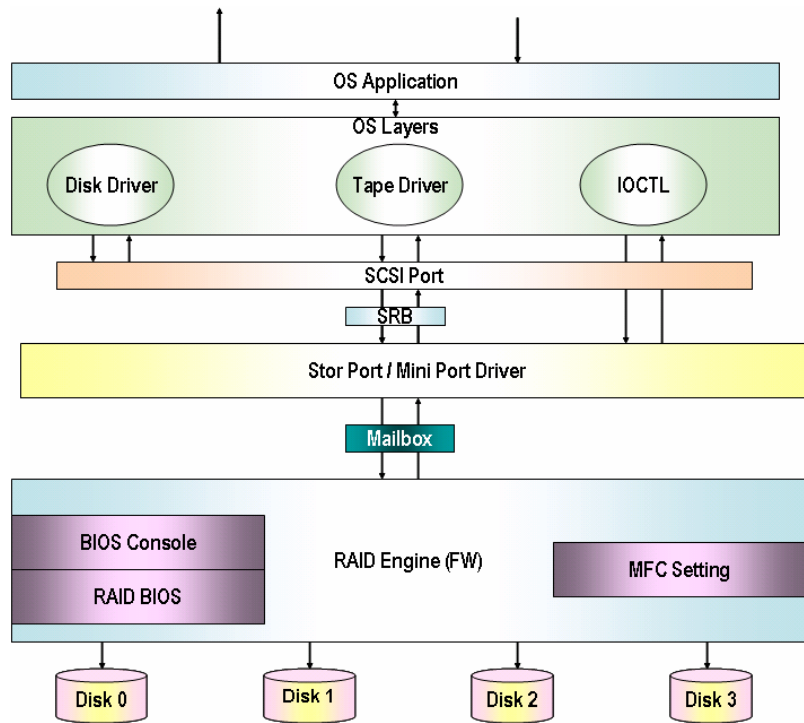
Figure 7. Software Block Diagram

3.1 Common Layers

3.1.1 Firmware

The frmware is composed of multiple software layers allowing for maximum flexibility, reuse and maintainability. These layers are described below.

3.1.1.1 MFC Settings

These are default settings that are programmed at the factory and consist of two types of settings.

- Settings that are not modifiable in the field. These include the PCI IDs.
- Settings that can be modified using a utility. These include default cache settings, rebuild rates, and other BIOS and operational defaults. Access to the MFC modification utility is restricted.

Additional information on MFC definitions and default settings is available upon request.

3.1.1.2 RAID BIOS

The RAID BIOS is the expansion ROM software defined in the PCI specification. It performs the RAID controller initialization from host system memory during POST.

3.1.1.3 Intel® RAID BIOS Console Configuration Utility

The Intel® RAID BIOS Console Configuration utility provides a graphical user interface. It is a full-featured monitoring and configuration utility for managing all aspects of the RAID subsystem and many features of the RAID controller. The utility is accessed by pressing the <Ctrl>+<G> keys during system boot time. See the *Software User Guide: Intel® RAID Controller SRCSAS144E* for details about this utility.

3.1.1.4 RAID Firmware Engine

The RAID firmware contains the algorythms for mapping physical to virtual devices, RAID level algorithms, data redundancy calculation algorythms, and error detection, logging, and reporting capabilities.

3.1.2 API

To configure the Intel® RAID Controller SRCSAS144E, a set of interfaces known as the IOCTL interface has been developed to allow an application to issue commands to the controller through the driver. Commands that determine adapter properties and change the parameter settings can be issued. The API package defines a higher level of commands and functions for developers who want to configure the RAID adapters from their own utility. This is implemented as a 32-bit dynamic link library (DLL) for Windows* operating systems and through a set of binaries for other operating systems. Access to the API libraries is restricted.

3.1.3   Operating System Driver

The operating system driver is the specific driver that communicates between the host resident application and the RAID controller using specific communications protocol.

3.2   User Interface

3.2.1   Intel® RAID BIOS Console 2 Configuration Utility

The Intel® RAID BIOS Console 2 configuration utility is an X-ROM based utility that can be accessed by pressing the <Ctrl>+>G> keys during POST. This utility will usually start at the completion of POST, but it may expand and operate during POST if sufficient PMM memory is available.

This utility is GUI-based that is most easily used with a mouse. The utility enables the user to easily configure the RAID controller properties, manage physical devices attached to the RAID controller, create and manage virtual drives, and manage the battery backup module. The RAID BIOS Console 2 configuration utility includes a configuration wizard that simplifies the process of creating disk arrays and virtual drives. The table below describes the available options.

Table 8. Intel® RAID BIOS Console 2 Configuration Utility Options

Option	Description
Adapter Properties	When you select the Adapter Selection option on the Main screen, The Intel® RAID BIOS Console 2 displays a list of the Intel® RAID adapters in the system. The Adapter Properties screen allows you to view and configure the software and hardware of the selected adapter.
Scan Devices	When you select the Scan Devices option on the Main screen, the Intel® RAID BIOS Console 2 checks the physical and virtual drives for any changes of the drive status. The RAID BIOS Console 2 displays the results of the scan in the physical and virtual drive descriptions.
Virtual Disks	The Virtual Disks screen provides options to Fast Initialize or Slow Initialzie Virtual Disk, Check Consistency, Display Virtual Disk properties, and Set Boot Drive as specified virtual disk. **Warning:** Initializing a virtual drive deletes all information on the physical drives that compose the virtual drive.
Physical Drives	This screen displays the physical drives for each port. From this screen, you can rebuild the physical arrays or view the properties for the physical drive you select.
Configuration Wizard	This option enables you to clear a configuration, create a new configuration, or add a configuration.
Adapter Selection	This option allows you to choose an Intel RAID adapter installed in the system.
Physical view	This option toggles between Physical View and Virtual View.
Events	This option displays the events generated by virtual disks, physical devices, enclosure, the Intel® Remote Smart Battery AXXRSBBU3, and the SAS controller.

3.2.2 Intel® RAID Web Console 2

The Intel® RAID Web Console 2 utility runs within the operating system. It is Java* GUI-based and enables the user to easily configure the RAID controller, disk drives, battery backup module, and other storage related devices connected to the RAID controller or embedded on the server board.

The utility is used the most easily with a mouse, and standard right and left mouse clicks are functional based on the operating system mouse configuration.

The RAID Web Console 2 includes a Configuration Wizard that simplifies the process of creating disk arrays and virtual drives. Within the Configuration Wizard, the user can select from several options:

- The Auto Configuration mode automatically creates the best possible configuration based on options configurable with available hardware.
- The Guided Configuration mode asks brief questions about the configuration, and then creates creates the configuration based on the answers provided.
- The Manual Configuration mode provides complete control over all aspects of the storage configuration.

A Reconstruction Wizard is available to increase or reduce the size of a virtual disk and to change the RAID level of an array.

See the *Software User Guide: Intel® RAID Controller SRCSAS144E* for detail description of these functions. The table below briefly describes the available options.

Table 9. Intel® RAID Web Console 2 Options

Option	Description
Menu Bar	Provides specific menu options including exit, rescan, operatioins, log and online help.
Physical / Virtual View Panel	Shows the hierarchy of physical / virtual devices in the server.
Properties / Operations / Graphical View Panel	Displays information about the selected device and the operations that can be performed on the selected device.
Event Log Panel	Displays the event log entries for the selected RAID controller.
Adapter Properties	Configure adapter properties. The configuration of these properties within the Intel® RAID Web Console 2 is limited to those poperties that can be performed without a reboot of the controller or that are not data destructive.
Physical Drive Properties	View physical drive properties including drive model, serial number, defect tables, and association with virtual drives.
Virtual Disk Properties	View virtual disk properties including drive size, stripe size, disk cache policy, array cache policy, virtual disk name and status.
Configuration Wizard	Clear a configuration, create a new configuration, or add a configuration.

3.3   Command Line Utility

The command line utility (CLU) is an operating system based text utility that allows the configuration of the RAID controller properties, configuration of disk arrays and virtual drives, configuration of cache settings, firmware update, and error reporting. The CLU is available upon request for DOS*, Windows*, and Linux* operating systems. For a list of all command line options see the *Command-Line User Guide.* The table below provides a synopsis of available options.

Table 10. Command Line Utility Options

Option	Description
Help	Command-line tool option to command help is embedded.
Controller Information	Provides information about controller properties and configuration.
Configuration information	Provides information on physical and virtual drives attached to the controller.
Configuration management	Allows configuration of the RAID controller, virtual drive properties, and hard drive cache configuration.
Configuration creation/deletion	Allows configuration or deletion of virtual drives including RAID level configuration, cache policy configuration, and hot spare configuration.

3.4   Flash Utility

This utility is an operating system based utility that allows you to update RAID controller firmware. It is available for DOS*, Microsoft Windows*, and Linux*. It is designed for use with a separate firmware update file. For a complete list of options, see the utility version release notes.

3.5   SNMP Support

The SNMP support includes MIB files that are available upon request for recompilation compatibility with existing SNMP enabled monitoring applications. An SNMP agent is also available. For operational details please refer to the release notes that accompany these files.

4. RAID Functionality and Features

4.1 Hierarcy

A fundamental purpose of a RAID system is to present a usable data storage medium (virtual drive) with some level of redundancy to a host operating system. The Intel RAID firmware is based on the concept of associating physical drives in arrays and then creating a virtual drive from that array that includes a functional RAID level. To create a virtual drive and present it to the host operating system, the RAID firmware typically follows these steps:

1. One or more physical drives are selected and associated as an array.

2. One or more arrays are associated and given a RAID level. This process creates a virtual drive and provides an option to initialize the virtual drive.

3. The RAID firmware presents the virtual drive to the operating system.

4.1.1   RAID Physical Drive Status

Table 11. RAID Physical Drive Status

Drive State	Code	Description
Unconfigured Good	Unconfigured Good	The drive is functioning normally, but is not part of a configured virtual drive and is not a hot spare.
Online	ONLN	The drive is online, is part of a configured virtual drive, and is functioning normally.
Hot Spare	HOTSP	A physical disk that is configured as a hotspare.
Failed	FAILED	A physical disk that was originally configured as Online or Hot Spare, but on which the firmware detects unrecoverable error.
Rebuilding	REBUILD	A physical disk to which data is beign written to restore full redundancy for a virtual disk.
Unconfigured Bad	Unconfigured Bad	A physical disk on which the firmware detects an unrecoverable error; the physical disk was Unconfigured Good or the physical disk could ot be initialized.
Missing;	Missing	A physical disk that was Online, but which as been removed from its location.
Offline	Offline	A physical disk that is part of a virtual disk but which has invalid data as far as the RAID configuration is concerned.
None	None	A physical disk with an unsupported flag set. An Unconfigured Good or Offlline physical disk that has completed the prepare for removal operation.

4.1.2   RAID Virtual Drive Status

Table 12. RAID Virtual Drive Status

Drive State	Code	Description
Optimal	Optimal	The drive operating system is good. All configured drives are online.
Degraded	Degraded	The drive operating condition is not optimal because on of the configured drives has failed or is offline.
Offline	Offline	The drive is not available to the operating system and is unusable.

4.1.3   RAID Controller Drive Limitations

Only drives complying with the SAS and SATA specifications extentions are supported.

4.2   SAS Bus and ID Mapping

Devices on the SAS bus are persistently mapped, based on a SAS address.

4.3   RAID Features

4.3.1   RAID Level Support

The following RAID levels are supported on the Intel® RAID Controller SRCSAS144E.

Table 13. RAID Levels

RAID Level	Description
RAID 0	Data is striped to one or more physical drives. If using more than one disk, each stripe is stored on the drives in a "round robin" fashion. RAID 0 includes no redundancy. If one hard disk fails, all data is lost.
RAID 1	Disk mirroring: all data is stored twice, making each drive the image of the other. Missing data on one drive can be recovered from data on the other drive. RAID 1 requires two drives for each mirrored array.
RAID 5	Data striping with parity: data is Stripd across the hard disks and the controller calculates redundacy data (parity information) that is also striped across the hard disks. Missing data is rebuilt from parity. RAID 5 requires a minimum of three drives in the array but can be expanded to the capacity of the controller.
RAID 10	RAID 10 is accomplished by striping data across two or up to eight RAID 1 arrays. Missing data is rebuilt from redundant data stripes. RAID 10 requires a minimum of four drives.
RAID 50	RAID 50 is accomplished by striping data across two or up to eight RAID 5 arrays. Missing data is rebuilt from redundant data stripes. RAID 50 requires a minimum of six drives.

4.3.2   Cache Policies

RAID cache can be used to temporarily store data so it can be more quickly accessed, or to await drive readiness. Cache is available both on the RAID controller and on hard drives. The RAID controller read and write cache policy is set on a virtual drive level. This policy is set at the time the virtual drive is created, but it can be changed using the Intel® RAID BIOS Console 2 configuration utility, the command line utility, or the Intel® RAID Web Console 2 utility.

It may be unwise to enable some cache policies if a battery is not installed on the RAID controller. Drive cache is managed through a user configurable RAID controller option. However, the RAID controller battery does not protect data in drive cache in the event of a power interruption. Caution should be exercized in enabling drive cache.

Table 14. Cache Policies

Array Cache Policy	Cache Option	Description
Cache Policy	Direct I/O	When possible, no cache is involved for both reads and writes. The data transfers will be directly from host to disk and from disk to host.
	Cached I/O	All reads will first look at cache. If a cache hit occurs, the data will be read from cache; if not, the data will be read from disk and the read data will be buffered into cache. All writes to drive are also written to cache.
Read Policy	No Read Ahead	The controller does not use read-ahead.
	Read Ahead	Specifies that additional consecutive data stripes are read and buffered into cache.
	Adaptive Read Ahead	Specifies that the controller beins using read ahead if the two most recent disk accesses occurred in sequential sectors.
Write Policy	Write Through	The controller sends a data transfer completion signal to the host after the disk subsystem recieves all the data in a transaction and the data is successfully written to disk.
	Write Back	The controller sends a data transfer completions signal to the host when the controller cache receives all the data in a transaction and the data is then written to disk as the drive becomes available.
Hard Drive Cache	Read and Write Cache	Memory located on the hard drive is use to cache data going to or coming from the drive. Enabling hard drive cache can result in a performance improvement but data held in drive cache is not protected by the RAID controller.

4.3.3   Stripe Size

Stripe size determines the size of each data stripe on each hard drive. The options are 4, 8, 16, 32, 64, and 128 KB. The stripe size option is set during the virtual drive creation and cannot be changed without removing the virtual drive configuration and all data contained on the virtual drive.

4.3.4   Hot Spare Drives

Hot spare drives are drives designated to automatically replace a failed drive. Hot spare drives must be the same size or larger than the drives they may replace. They can be designated as a private hot spare drive assigned to one virtual drive, or they may be a global hot spare that is assigned to all virtual drives attached to the RAID controller. Hot spare drives can be designated using the Intel® RAID BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command line utility.

4.3.5   Hot-Plug Drive Support

Hot plug support allows hard drives to be insterted or removed from an enclosure without rebooting the system, as long as both the hard drive and server system backplane support hard drive hot plug functions.

The RAID controller will immediately recognize that a drive is removed and will put it into a virtual status of "Missing" until an I/O to the drive fails. The drive will then be changed to the status of "Failed." A drive inserted into an attached intelligent enclosure will be recognized as present. A drive inserted into an attached non-intelligent enclosure may require a bus scan to be detected. Hot plug of new drives is supported in both intelligent (SAF-TE) and non-intelligent enclosures.

4.3.6   Auto-declare Hot Spare Drive

If the RAID controller has a RAID array drive that is in a failed (degraded) state and the failed drive is removed and a new hard drive of the same size of larger is inserted into the same slot, the new drive will automatically be marked as a hot spare drive and a rebuild will begin automatically. A bus scan may be required in a non-intelligent enclosure.

4.3.7   Physical Drive Roaming

This feature allows the user to move drives to any port on the RAID controller without loss of configuration.

4.3.8   Virtual Drive Roaming

This feature allows the user to move a Virtual drive from one controller to another system/controller without loss of configuration or data. All virtual drives attached to the RAID controller must be moved as a unit.

4.3.9　　　　RAID Controller Migration

The RAID controller migration feature allows a defective RAID controller to be removed and replaced by a compatible RAID controller without a loss of configuration or data. To avoid a configuration mismatch, it is wise to reset the new controller configuration before attaching the array drives. If a configuration mismatch occurs, then care must be taken to use the configuration on the drives or all data may be lost.

4.3.10　　　　Online Capacity Expansion

Online capacity expansion (OCE) allows additional drives to be added to an array. The added capacity can be added to the virtual drive. OCE is available as an option in the Intel® BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command line utility.

4.3.11　　　　RAID-Level Migration

RAID-level migration allows for the migration of one RAID level to another. RAID-level migration may require the addition of additional physical drives as part of the process. RAID-level migration is an option in the Intel® RAID BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command line utility.

4.4　Operating Certifications

Microsoft Windows* Winqual certification (WHQL).

5.   Safety and Regulatory Certifications

5.1   Product Safety Compliance

- UL approval or acceptable NRTL (e.g. ETL) approval
- EN60950 (Europe)
- IEC60950 (International)
- CB Certificate & Report, IEC60950 (report to include all country national deviations)
- CE - Low Voltage Directive 73/23/EEE (Europe)

5.2   Product EMC Compliance – Class A Compliance

- FCC /ICES-003 - Emissions (USA/Canada) Verification
- CISPR 22 – Emissions (International)
- EN55022 - Emissions (Europe)
- EN55024 - Immunity (Europe)
- CE – EMC Directive 89/336/EEC (Europe)
- VCCI Emissions (Japan)
- AS/NZS 3548 Emissions (Australia / New Zealand)
- BSMI CNS13438 Emissions (Taiwan)
- RRL MIC Notice No. 1997-41 (EMC) & 1997-42 (EMI) (Korea)

5.3   Certifications / Registrations / Declarations

- CE Declaration of Conformity (CENELEC Europe)
- FCC/ICES-003 Class B Attestation (USA/Canada)
- C-Tick Declaration of Conformity (Australia)
- MED Declaration of Conformity (New Zealand)
- BSMI Certification (Taiwan)
- RRL Certification (Korea)

5.4   Supported Specifications and Standards

Table 15. Specifications and Standards

Standard	Description
SAS Specification 1.1	
Serial ATA specification 1.0a	
Extensions to Serial ATA specification 1.0a	
PCI Express Base Specification 1.0	
SAFTE	SCSI Accessed Fault-Tolerant enclosure management
SES	SCSI Enclosure Services (SES)
SSP	Serial SCSI Protocol (SSP) which maps in SCSI, supporting multiple initiators and targets
STP	Serial ATA Tunneled Protocol (STP) mapping Serial ATA, supporting multiple initiators and targets
SMP	Serial Management Protocol (SMP) a management protocol

Appendix A: Event Messages and Error Codes

This appendix lists the Intel® RAID Web Console 2 events that may appear in the event log.

The Intel® RAID Web Console 2 utility monitors the activity and performance of all controllers in the server and the devices attached to them. When an "event" occurs—such as the completion of a consistency check or the removal of a physical drive—an event message is displayed in the log displayed at the bottom of the Intel® RAID Web Console 2 screen. The messages are also logged in the Windows Application Log (Event Viewer). Error event levels are:

- PROGRESS: This is a progress posting event. Progress events are not saved in NVRAM.
- INFO: Informational message. No user action is necessary.
- WARNING: Some component may be close to a failure point
- CRITICAL: A component has failed, but the system has not lost data
- FATAL: A component has failed, and data loss has occurred or will occur
- DEAD: A catastrophic error has occurred and the controller has died. Seen only after the controller has been restarted.

The following table lists the Intel® RAID Web Console 2 event messages.

Number	Type	Description
0	Info	Firmware initialization started (PCI ID %04x/%04x/%04x/%04x)
1	Info	Firmware version %s
2	Fatal	Unable to recover cache data from TBBU
3	Info	Cache data recovered from TBBU successfully
4	Info	Configuration cleared
5	Warning	Cluster down; communication with peer lost
6	Info	Logical drive %s ownership changed from %02x to %02x
7	Info	Alarm disabled by user
8	Info	Alarm enabled by user
9	Info	Background initialization rate changed to %d%%
10	Fatal	Controller cache discarded due to memory/battery problems
11	Fatal	Unable to recover cache data due to configuration mismatch
12	Info	Cache data recovered successfully
13	Fatal	Controller cache discarded due to firmware version incompatibility
14	Info	Consistency Check rate changed to %d%%
15	Dead	Fatal firmware error: %s
16	Info	Factory defaults restored
17	Info	Flash downloaded image corrupt
18	Caution	Flash erase error
19	Caution	Flash timeout during erase
20	Caution	Flash error
21	Info	Flashing image: %s

Number	Type	Description
22	Info	Flash of new firmware image(s) complete
23	Caution	Flash programming error
24	Caution	Flash timeout during programming
25	Caution	Flash chip type unknown
26	Caution	Flash command set unknown
27	Caution	Flash verify failure
28	Info	Flush rate changed to %d seconds
29	Info	Hibernate command received from host
30	Info	Event log cleared
31	Info	Event log wrapped
32	Dead	Multi-bit ECC error: ECAR=%x
33	Warning	Single-bit ECC error: ECAR=%x
34	Dead	Not enough controller memory
35	Info	Patrol Read complete
36	Info	Patrol Read paused
37	Info	Patrol Read Rate changed to %d%%
38	Info	Patrol Read resumed
39	Info	Patrol Read started
40	Info	Rebuild rate changed to %d%%
41	Info	Reconstruction rate changed to %d%%
42	Info	Shutdown command received from host
43	Info	Test event: '%s'
44	Info	Time established as %s; (%d seconds since power on)
45	Info	User entered firmware debugger
46	Warning	Background Initialization aborted on %s
47	Warning	Background Initialization corrected medium error (%s at %lx
48	Info	Background Initialization completed on %s
49	Fatal	Background Initialization completed with uncorrectable errors on %s
50	Fatal	BI detected uncorrectable double medium errors (%s at %lx on %s)
51	Caution	Background Initialization failed on %s
52	Progress	Background Initialization progress on %s is %s
53	Info	Background Initialization started on %s
54	Info	Policy change due to BBU on %s from %s to %s
55	Info	Policy change due to user on %s from %s to %s
56	Warning	Consistency Check aborted on %s
57	Warning	Consistency Check corrected medium error (%s at %lx
58	Info	Consistency Check done on %s
59	Info	Consistency Check done with corrections on %s
60	Fatal	CC detected uncorrectable double medium errors (%s at %lx on %s)
61	Caution	Consistency Check failed on %s
62	Fatal	Consistency Check failed with uncorrectable data on %s
63	Warning	Consistency Check found inconsistent parity on %s at strip %lx
64	Warning	CC inconsistency logging disabled on %s (too many inconsistencies)
65	Progress	Consistency Check progress on %s is %s

Number	Type	Description
66	Info	Consistency Check started on %s
67	Warning	Initialization aborted on %s
68	Caution	Initialization failed on %s
69	Progress	Initialization progress on %s is %s
70	Info	Fast initialization started on %s
71	Info	Full initialization started on %s
72	Info	Initialization complete on %s
73	Info	LD Properties updated to %s (form %s)
74	Info	Reconstruction complete on %s
75	Fatal	Reconstruction of %s stopped due to unrecoverable errors
76	Fatal	Reconstruct detected uncorrectable double medium errors
77	Progress	Reconstruction progress on %s is %s
78	Info	Reconstruction resumed on %s
79	Fatal	Reconstruction resume of %s failed due to configuration mismatch
80	Info	Reconstructing started on %s
81	Info	State change on %s from %s to %s
82	Info	PD Clear aborted on %s
83	Caution	PD Clear failed on %s (Error %02x)
84	Progress	PD Clear progress on %s is %s
85	Info	PD Clear started on %s
86	Info	PD Clear completed on %s
87	Warning	Error on %s (Error %02x)
88	Info	Format complete on %s
89	Info	Format started on %s
90	Caution	Hot Spare SMART polling failed on %s (Error %02x)
91	Info	PD inserted: %s
92	Warning	PD %s is not supported
93	Warning	Patrol Read corrected medium error on %s at %lx
94	Progress	Patrol Read progress on %s is %s
95	Fatal	Patrol Read found an uncorrectable medium error on %s at %lx
96	Caution	Predictive failure: CDB: %s
97	Fatal	Patrol Read puncturing bad block on %s at %lx
98	Info	Rebuild aborted by user on %s
99	Info	Rebuild complete on %s
100	Info	Rebuild complete on %s
101	Caution	Rebuild failed on %s due to source drive error
102	Caution	Rebuild failed on %s due to target drive error
103	Progress	Rebuild progress on %s is %s
104	Info	Rebuild resumed on %s
105	Info	Rebuild started on %s
106	Info	Rebuild automatically started on %s
107	Caution	Rebuild stopped on %s due to loss of cluster ownership
108	Fatal	Reassign write operation failed on %s at %lx
109	Fatal	Unrecoverable medium error during rebuild on %s at %lx

Number	Type	Description
110	Info	Corrected medium error during recovery on %s at %lx
111	Fatal	Unrecoverable medium error during recovery on %s at %lx
112	Info	PD removed: %s
113	Warning	CDB: %s
114	Info	State change on %s from %s to %s
115	Info	State change by user on %s from %s to %s
116	Warning	Redundant path to %s broken
117	Info	Redundant path to %s restored
118	Info	Dedicated Hot Spare PD %s no longer useful due to deleted array
119	Caution	SAS topology error: Loop detected
120	Caution	SAS topology error: Unaddressable device
121	Caution	SAS topology error: Multiple ports to the same SAS address
122	Caution	SAS topology error: Expander error
123	Caution	SAS topology error: SMP timeout
124	Caution	SAS topology error: Out of route entries
125	Caution	SAS topology error: Index not found
126	Caution	SAS topology error: SMP function failed
127	Caution	SAS topology error: SMP CRC error
128	Caution	SAS topology error: Multiple subtractive
129	Caution	SAS topology error: Table to table
130	Caution	SAS topology error: Multiple paths
131	Fatal	Unable to access device %s
132	Info	Dedicated Hot Spare created on %s (%s)
133	Info	Dedicated Hot Spare %s disabled
134	Caution	Dedicated Hot Spare %s no longer useful for all arrays
135	Info	Global Hot Spare created on %s (%s)
136	Info	Global Hot Spare %s disabled
137	Caution	Global Hot Spare does not cover all arrays
138	Info	Created %s}
139	Info	Deleted %s}
140	Info	Marking LD %s inconsistent due to active writes at shutdown
141	Info	Battery Present
142	Warning	Battery Not Present
143	Info	New Battery Detected
144	Info	Battery has been replaced
145	Caution	Battery temperature is high
146	Warning	Battery voltage low
147	Info	Battery is charging
148	Info	Battery is discharging
149	Info	Battery voltage is normal
150	Fatal	Battery needs to be replacement
151	Info	Battery relearn started
152	Info	Battery relearn in progress
153	Info	Battery relearn completed

Number	Type	Description
154	Caution	Battery relearn timed out
155	Info	Battery relearn pending: Battery is under charge
156	Info	Battery relearn postponed
157	Info	Battery relearn will start in 4 days
158	Info	Battery relearn will start in 2 day
159	Info	Battery relearn will start in 1 day
160	Info	Battery relearn will start in 5 hours
161	Info	Battery removed
162	Info	Current capacity of the battery is below threshold
163	Info	Current capacity of the battery is above threshold
164	Info	Enclosure (SES) discovered on %s
165	Info	Enclosure (SAF-TE) discovered on %s
166	Caution	Enclosure %s communication lost
167	Info	Enclosure %s communication restored
168	Caution	Enclosure %s fan %d failed
169	Info	Enclosure %s fan %d inserted
170	Caution	Enclosure %s fan %d removed
171	Caution	Enclosure %s power supply %d failed
172	Info	Enclosure %s power supply %d inserted
173	Caution	Enclosure %s power supply %d removed
174	Caution	Enclosure %s SIM %d failed
175	Info	Enclosure %s SIM %d inserted
176	Caution	Enclosure %s SIM %d removed
177	Warning	Enclosure %s temperature sensor %d below warning threshold
178	Caution	Enclosure %s temperature sensor %d below error threshold
179	Warning	Enclosure %s temperature sensor %d above warning threshold
180	Caution	Enclosure %s temperature sensor %d above error threshold
181	Caution	Enclosure %s shutdown
182	Warning	Enclosure %s not supported; too many enclosures connected to port
183	Caution	Enclosure %s firmware mismatch
184	Warning	Enclosure %s sensor %d bad
185	Caution	Enclosure %s phy %d bad
186	Caution	Enclosure %s is unstable
187	Caution	Enclosure %s hardware error
188	Caution	Enclosure %s not responding
189	Info	SAS/SATA mixing not supported in enclosure; PD %s disabled
190	Info	Enclosure (SES) hotplug on %s was detected, but is not supported
191	Info	Clustering enabled
192	Info	Clustering disabled
193	Info	PD too small to be used for auto-rebuild on %s
194	Info	BBU enabled; changing WT virtual disks to WB
195	Warning	BBU disabled; changing WB virtual disks to WT
196	Warning	Bad block table on PD %s is 80% full
197	Fatal	Bad block table on PD %s is full; unable to log block %lx

Number	Type	Description
198	Info	Consistency Check Aborted Due to Ownership Loss on %s
199	Info	Background Initialization (BGI) Aborted Due to Ownership Loss on %s
200	Caution	Battery/charger problems detected; SOH Bad
201	Warning	Single-bit ECC error: ECAR=%x, ELOG=%x, (%s); warning threshold exceeded
202	Caution	Single-bit ECC error: ECAR=%x, ELOG=%x, (%s); critical threshold exceeded
203	Caution	Single-bit ECC error: ECAR=%x, ELOG=%x, (%s); further reporting disabled
204	Caution	Enclosure %s Power supply %d switched off
205	Info	Enclosure %s Power supply %d switched on
206	Caution	Enclosure %s Power supply %d cable removed
207	Info	Enclosure %s Power supply %d cable inserted
208	Info	Enclosure %s Fan %d returned to normal
209	Info	BBU Retention test was initiated on previous boot
210	Info	BBU Retention test passed
211	Caution	BBU Retention test failed!
212	Info	NVRAM Retention test was initiated on previous boot
213	Info	NVRAM Retention test passed
214	Caution	NVRAM Retention test failed!
215	Info	%s test completed %d passes successfully
216	Caution	%s test FAILED on %d pass. Fail data: errorOffset=%x goodData=%x badData=%x
217	Info	Self check diagnostics completed
218	Info	Foreign Configuration Detected
219	Info	Foreign Configuration Imported
220	Info	Foreign Configuration Cleared

Appendix B: Glossary

This appendix contains important terms used in the preceding chapters. For ease of use, numeric entries are listed first (e.g., "82460GX") with alpha entries following (e.g., "AGP 4x"). Acronyms are then entered in their respective place, with non-acronyms following.

Table 16. Glossary of Terms

Word / Acronym	Definition
API	Application Programing Interface
ECC	Error Correction Code
FUU	Flash Update Utility
FW	Firmware
Gb	Gigabit
GB	Gigabyte
HBA	Host Bus Adapter
Kb	Kilobit
KB	Kilobyte
LVD	Low Voltage Differential
Mb	Megabit
MB	Megabyte
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect
POST	Power On Self Test
RAID	Redundant Array of Independent Disks
SAF-TE	SCSI Accessed Fault Tolerant Enclosure, enclosure management that supports SCSI devices
SAS	Serial Attached SCSI
SCSI	Small Computer Systems Inteface
SES2	SCSI Enclosure Services 2nd generation, enclosure management that supports SAS devices
SGPIO	Serial General Purpose Input Output, Enclosure mangement that supports SATA devices
SNMP	Simple Network Management Protocol
XROM	PCI Expansion ROM, a BIOS utility accessed at system POST.
POST	Power On Self Test

Appendix C: Reference Documents

See the following documents for additional information:

- Intel® RAID Controller SRCSAS144E Hardware User Guide, document number D39308-002

- Intel® RAID Controller SRCSAS144E Software User Guide, document number C49617-008.

- Intel® RAID Controller SRCSAS144E Command Line User Guide, Version 1.0.