**Title**: NETWORK-CAPABLE RAID CONTROLLER FOR A SEMICONDUCTOR STORAGE DEVICE

**Abstract**: Embodiments of the present invention provide a network-capable RAID controller for a storage device of a serial attached small computer system interface/serial advanced technology attachment (PCI-Express) type that supports a low-speed data processing speed for a host. Specifically, embodiments of this invention provide a network-capable RAID controller coupled to one or more (i.e., a set of) semiconductor storage devices (SSDs). Among other components, the network-capable RAID controller comprises an input/output (I/O) controller coupled to a network interface. The network interface allows the network-capable RAID controller to communicate with an external network.
Description

Title of Invention: NETWORK-CAPABLE RAID CONTROLLER FOR A SEMICONDUCTOR STORAGE DEVICE

Technical Field

[1] The present invention relates to a RAID controller for a semiconductor storage device of a serial attached small computer system interface/serial advanced technology. Specifically, the present invention relates to a network-capable RAID controller.

Background Art

[2] As the need for more computer storage grows, more efficient solutions are being sought. As is known, there are various hard disk solutions that store/read data in a mechanical manner as a data storage medium. Unfortunately, data processing speed associated with hard disks is often slow. Moreover, existing solutions still use interfaces that cannot catch up with the data processing speed of memory disks having set of data input/output performance as an interface between the data storage medium and the host. Therefore, there is a problem in the existing area in that the performance of the memory disk cannot be properly utilized.

Disclosure of Invention

Technical Problem

[3] The present invention relates to a RAID controller for a semiconductor storage device of a serial attached small computer system interface/serial advanced technology. Specifically, the present invention relates to a network-capable RAID controller.

Solution to Problem

[4] Embodiments of the present invention provide a networkcapable RAID controller for a storage device of a serial attached small computer system interface/serial advanced technology attachment (PCIExpress) type that supports a low-speed data processing speed for a host. Specifically, embodiments of this invention provide a network-capable RAID controller coupled to one or more (i.e., a set of) semiconductor storage devices (SSDs). Among other components, the network-capable RAID controller comprises an input/output (I/O) controller coupled to a network interface. The network interface allows the network-capable RAID controller to communicate with an external network.

[5] A first aspect of the present invention provides a networkcapable RAID controller for a semiconductor storage device (SSD), comprising: a disk mount coupled to a set of SSD memory disk units, the set of SSD memory disk units comprising a set of volatile
semiconductor memories; a high-speed host interface coupled to the disk monitoring unit and the disk mount for providing set of host interface capabilities; a disk controller coupled to the high-speed host interface; an input/output (I/O) controller coupled to the disk controller; and a network interface coupled to the I/O controller for connecting the network-capable RAID controller to an external network.

A second aspect of the present invention provides a networkcapable RAID controller for a semiconductor storage device (SSD), comprising: a disk mount coupled to a set of SSD memory disk units, the set of SSD memory disk units comprising a set of volatile semiconductor memories; a high-speed host interface coupled to the disk monitoring unit and the disk mount for providing set of host interface capabilities; a disk monitoring unit coupled to the disk mount for monitoring the set of SSD memory disk units; a disk plug and play controller coupled to the disk monitoring unit and the disk mount for controlling the disk mount; and a disk controller coupled to the high-speed host interface; an input/output (I/O) controller coupled to the disk controller; and a network interface coupled to the I/O controller for connecting the network-capable RAID controller to an external network.

A third aspect of the present invention provides a method for forming a network-capable RAID controller for a semiconductor storage device (SSD), comprising: coupling a disk mount to a set of SSD memory disk units, the set of SSD memory disk units comprising a set of volatile semiconductor memories; coupling a high-speed host interface to the disk monitoring unit and the disk mount for providing set of host interface capabilities; coupling a disk controller to the high-speed host interface; coupling an input/output (I/O) controller coupled to the disk controller; and coupling a network interface to the I/O controller for connecting the network capable RAID controller to an external network.

**Advantageous Effects of Invention**

The storage device of a serial-attached small computer system interface/serial advanced technology attachment (PCI-Express) type supports a low-speed data processing speed for a host by adjusting synchronization of a data signal transmitted/received between the host and a memory disk during data communications between the host and the memory disk through a PCI-Express interface, and simultaneously supports a set of data processing speed for the memory disk, thereby supporting the performance of the memory to enable set of data processing in an existing interface environment at the maximum.

**Brief Description of Drawings**

These and other features of this invention will be more readily understood from the following detailed description of the various aspects of the invention taken in con-
junction with the accompanying drawings in which:

[10] Fig. 1 is a diagram schematically illustrating a configuration of a RAID controlled storage device of a serial attached small computer system interface/serial advanced technology attachment (PCI-Express) type according to an embodiment.

[11] Fig. 2 is a more specific diagram of a RAID controller coupled to a set of SSDs.

[13] Fig. 3 is a diagram of the RAID controller of Figs. 1 and 2.

[14] Fig. 4 is a diagram schematically illustrative a configuration of the highspeed SSD of Fig. 1.

[15] Fig. 5 is a diagram schematically illustrating a configuration of a controller unit in Fig. 1.

[16] The drawings are not necessarily to scale. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. The drawings are intended to depict only typical embodiments of the invention, and therefore should not be considered as limiting the scope of the invention. In the drawings, like numbering represents like elements.

**Best Mode for Carrying out the Invention**

[17] Exemplary embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth therein. Rather, these exemplary embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of this disclosure to those skilled in the art. In the description, details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the presented embodiments.

[18] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of this disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Furthermore, the use of the terms "a", "an", etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items. It will be further understood that the terms "comprises" and/or "comprising" or "includes" and/or "including" when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof. Moreover, as used herein, the term RAID means redundant array of independent disks (originally redundant array of inexpensive disks). In general, RAID
technology is a way of storing the same data in different places (thus, redundantly) on multiple hard disks. By placing data on multiple disks, I/O (input/output) operations can overlap in a balanced way, improving performance. Since multiple disks increase the mean time between failures (MTBF), storing data redundantly also increases fault tolerance.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art. It will be further understood that terms such as those defined in commonly used dictionaries should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Hereinafter, a RAID storage device of a serial attached small computer system interface/serial advanced technology attachment (PCIExpress) type according to an embodiment will be described in detail with reference to the accompanying drawings.

As indicated above, embodiments of the present invention provide a network-capable RAID controller for a storage device of a serial attached small computer system interface/serial advanced technology attachment (PCI-Express) type that supports a low-speed data processing speed for a host. Specifically, embodiments of this invention provide a network-capable RAID controller coupled to one or more (i.e., a set of) semiconductor storage devices (SSDs). Among other components, the network-capable RAID controller comprises an input/output (I/O) controller coupled to a network interface. The network interface allows the network capable RAID controller to communicate with an external network.

Provided is a network-capable RAID controlled storage device of a serial attached small computer system interface/serial advanced technology attachment (PCI-Express) type, which provides data storage/reading services through a PCI-Express interface. The RAID controller typically includes a disk mount coupled to a set of PCI-Express SSD memory disk units, the set of PCI-Express SSD memory disk units comprising a set of volatile semiconductor memories; a disk monitoring unit coupled to the disk mount for monitoring the set of PCI-Express memory disk units; a disk plug and play controller coupled to the disk monitoring unit and the disk mount for controlling the disk mount; a high-speed host interface coupled to the disk monitoring unit and the disk mount for providing set of host interface capabilities; a disk controller coupled to the high-speed host interface and the disk monitoring unit; an I/O controller coupled to the disk controller; and a network interface and a host interface coupled to the I/O controller.

The storage device of a serial attached small computer system interface/serial advanced technology attachment (PCI-Express) type supports a low-speed data...
processing speed for a host by adjusting synchronization of a data signal transmitted/
received between the host and a memory disk through a PCI-Express interface, and simultaneously
supports a set of data processing speed for the memory disk, thereby supporting the
performance of the memory to enable set of data processing in an existing interface en-
vironment at the maximum. It is understood in advance that although PCI-Express
technology will be utilized in a typical embodiment, other alternatives are possible. For
example, the present invention could utilize SAS/SATA technology in which a SAS/
SATA type storage device is provided that utilizes a SAS/SATA interface.

Referring now to Fig. 1, a diagram schematically illustrating a configuration of a
PCI-Express type, RAID controlled semiconductor storage device (e.g., for providing
storage for a serially attached computer device) according to an embodiment of the
invention is shown. As depicted, Fig. 1 shows a RAID controlled PCI-Express type
storage device 110 according to an embodiment of the invention which includes a SSD
memory disk unit 100 (referred to herein as SSD memory disk unit, SSD, and/or SSD
memory disk unit) comprising: a plurality of memory disks having a plurality of
volatile semiconductor memories/memory units (also referred to herein as set of SSD
memory disk units 100); a network-capable RAID controller 800 coupled to SSD
memory disk units 100 (shown as unit 810); an external network 120 is in direct com-
munication with network-capable RAID controller 800; a controller unit 300; an
auxiliary power source unit 400 that is charged to maintain a predetermined power
using the power transferred from the host through the PCI-Express host interface unit;
a power source control unit 500 that supplies the power transferred from the host
through the PCI-Express host interface unit to the controller unit 300, the SSD memory
disk units 100, the backup storage unit, and the backup control unit which, when the
power transferred from the host through the PCI-Express host interface unit is blocked
or an error occurs in the power transferred from the host, receives power from the
auxiliary power source unit and supplies the power to the SSD memory disk unit
through the controller unit; a backup storage unit 600A-B that stores data of the SSD
memory disk unit; and a backup control unit 700 that backs up data stored in the SSD
memory disk unit in the backup storage unit, according to an instruction from the host
or when an error occurs in the power transmitted from the host; and a redundant array
of independent disks (RAID) controller 800 coupled to SSD memory disk unit 100,
controller 300, and internal backup controller 700.

The SSD memory disk unit 100 includes a plurality of memory disks provided with a
plurality of volatile semiconductor memories for set of data input/output (for example,
DDR, DDR2, DDR3, SDRAM, and the like), and inputs and outputs data according to
the control of the controller 300. The SSD memory disk unit 100 may have a con-

figuration in which the memory disks are arrayed in parallel.

[26] The controller unit 300 adjusts synchronization of data signals transmitted/received between the PCI-Express host interface unit 200 and the SSD memory disk unit 100 to control a data transmission/reception speed between the PCI-Express host interface unit 200 and the SSD memory disk unit 100.

[27] Referring now to Fig. 2, a more detailed diagram of a RAID controlled SSD 810 is shown. As depicted, a PCI-e type network-capable RAID controller 800 can be directly coupled to any quantity of SSDs 100. Among other things, this allows for optimum control of SSDs 100. Also among other things, the use of a network-capable RAID controller 800:

  1. Supports the current backup/restore operations.
  2. Provides additional and improved backup function by performing the following:
     a) The internal backup controller determines the backup (user's request order or the status monitor detects power supply problems);
     b) The Internal backup controller requests a data backup to SSDs;
     c) The internal backup controller requests an internal backup device to back up data immediately;
     d) Monitors the status of the backup for the SSDs and Internal backup controller; and
     e) Reports the internal backup controller's status and end-op.

  3. Provides additional and improved restore function by performing the following:
     a) The internal backup controller determines the restore (user's request Order or the status monitor detects power supply problems);
     b) The internal backup controller requests a data restore to the SSDs;
     c) The internal backup controller requests an internal backup device to restore data immediately;
     d) Monitors the status of the restore for the SSDs and Internal backup controller; and
     e) Reports the Internal backup controller status and end-op.

[42] Referring now to Fig. 3, a diagram of the network-capable RAID controller 800 of Figs. 1 and 2 as coupled to a set (at least one) of SSDs 100A-N is shown in greater detail. As depicted, network-capable RAID controller 800 generally comprises a host interface 820, an I/O controller 824 coupled to host interface 820, a network interface 828 coupled to I/O controller 824, a disk controller 830 coupled to I/O controller 824 and a highspeed host interface 840. Also coupled to disk controller 830 is a disk monitoring unit 860, which is coupled to the disk mount 850. In general, SSDs 100 are mounted on disk mount 850, and are detected by disk monitoring unit 860. In addition, disk plug and play (PnP controller 870), controls the functions and/or detection functions related to disk mount 850. In general, RAID controller 100 controls the operation of SSDs 100. This includes the detection of SSDs 100, the storage and
retrieval of data therefrom, etc.

[43] As further shown in Fig. 3, network-capable RAID controller 800 has the capability to directly communicate with an external network 120 via I/O controller 824 and network interface 828. In general, network interface 828 handles all communications between network-capable RAID controller 800 and external network 120. Moreover, I/O controller 824 connects signals between host interface 820, network interface 828, and disk controller 830. Among other things, the configuration shown in Fig. 3 reduces host-based work load since the signal from external network 120 need not be routed through a host. Moreover, when there is a disconnection between the external network 120 and the disk, the host can monitor the status of the device.

[44] Referring now to Fig. 4, a diagram schematically illustrating a configuration of the set of SSD 100 is shown. As depicted, SSD/memory disk unit 100 comprises: a host interface 202 (e.g., PCI-Express host), which can be interface 200 of Fig. 1, or a separate interface as shown; a DMA controller 302 interfacing with a backup control module 700; an ECC controller 304; and a memory controller 306 for controlling one or more blocks 604 of memory 602 that are used as set of storage. Also shown are backup controller 700 coupled to DMA controller 302 and backup storage unit 600A coupled to backup controller 700.

[45] In general, DMA is a feature of modern computers and microprocessors that allows certain hardware subsystems within the computer to access system memory for reading and/or writing independently of the central processing unit. Many hardware systems use DMA including disk drive controllers, graphics cards, network cards, and sound cards. DMA is also used for intra-chip data transfer in multi-core processors, especially in multiprocessor system-on-chips, where its processing element is equipped with a local memory (often called scratchpad memory) and DMA is used for transferring data between the local memory and the main memory. Computers that have DMA channels can transfer data to and from devices with much less CPU overhead than computers without a DMA channel. Similarly, a processing element inside a multi-core processor can transfer data to and from its local memory without occupying its processor time and allowing computation and data transfer concurrency.

[46] Without DMA, using programmed input/output (PIO) mode for communication with peripheral devices, or load/store instructions in the case of multi-core chips, the CPU is typically fully occupied for the entire duration of the read or write operation, and is thus unavailable to perform other work. With DMA, the CPU would initiate the transfer, do other operations while the transfer is in progress, and receive an interrupt from the DMA controller once the operation has been done. This is especially useful in real-time computing applications where not stalling behind concurrent operations is critical.
Referring now to Fig. 5, the controller unit 300 of Fig. 1 is shown as comprising: a memory control module 310 which controls data input/output of the SSD memory disk unit 100; a DMA control module 320 which controls the memory control module 310 to store the data in the SSD memory disk unit 100, or reads data from the SSD memory disk unit 100 to provide the data to the host, according to an instruction from the host received through the PCIExpress host interface unit 200; a buffer 330 which buffers data according to the control of the DMA control module 320; a synchronization control module 340 which, when receiving a data signal corresponding to the data read from the SSD memory disk unit 100 by the control of the DMA control module 320 through the DMA control module 320 and the memory control module 310, adjusts synchronization of a data signal so as to have a communication speed corresponding to a PCI-Express communications protocol to transmit the synchronized data signal to the PCI-Express host interface unit 200, and when receiving a data signal from the host through the PCI-Express host interface unit 200, adjusts synchronization of the data signal so as to have a transmission speed corresponding to a communications protocol (for example, PCI, PCI-x, or PCI-e, and the like) used by the SSD memory disk unit 100 to transmit the synchronized data signal to the SSD memory disk unit 100 through the DMA control module 320 and the memory control module 310; and a set of interface module 350 which processes the data transmitted/received between the synchronization control module 340 and the DMA control module 320 at high-speed. Here, the set of interface module 350 includes a buffer having a double buffer structure and a buffer having a circular queue structure, and processes the data transmitted/received between the synchronization control module 340 and the DMA control module 320 without loss at high-speed by buffering the data and adjusting data clocks.

Referring back to Fig. 1, auxiliary power source unit 400 may be configured as a rechargeable battery or the like, so that it is normally charged to maintain a predetermined power using power transferred from the host through the PCI-Express host interface unit 200 and supplies the charged power to the power source control unit 500 according to the control of the power source control unit 500.

The power source control unit 500 supplies the power transferred from the host through the PCI-Express host interface unit 200 to the controller unit 300, the SSD memory disk unit 100, the backup storage unit 600A-B, and the backup control unit 700.

In addition, when an error occurs in a power source of the host because the power transmitted from the host through the PCI-Express host interface unit 200 is blocked, or the power transmitted from the host deviates from a threshold value, the power source control unit 500 receives power from the auxiliary power source unit 400 and supplies the power to the SSD memory disk unit 100 through the controller unit 300.
The backup storage unit 600A-B is configured as a low-speed non-volatile storage device such as a hard disk and stores data of the SSD memory disk unit 100.

The backup control unit 700 backs up data stored in the SSD memory disk unit 100 in the backup storage unit 600A-B by controlling the data input/output of the backup storage unit 600A-B and backs up the data stored in the SSD memory disk unit 100 in the backup storage unit 600A-B according to an instruction from the host, or when an error occurs in the power source of the host due to a deviation of the power transmitted from the host deviates from the threshold value.

The storage device of a serial-attached small computer system interface/serial advanced technology attachment (PCI-Express) type supports a low-speed data processing speed for a host by adjusting synchronization of a data signal transmitted/received between the host and a memory disk during data communications between the host and the memory disk through a PCI-Express interface, and simultaneously supports a set of data processing speed for the memory disk, thereby supporting the performance of the memory to enable set of data processing in an existing interface environment at the maximum.

While the exemplary embodiments have been shown and described, it will be understood by those skilled in the art that various changes in form and details may be made thereto without departing from the spirit and scope of this disclosure as defined by the appended claims. In addition, many modifications can be made to adapt a particular situation or material to the teachings of this disclosure without departing from the essential scope thereof. Therefore, it is intended that this disclosure not be limited to the particular exemplary embodiments disclosed as the best mode contemplated for carrying out this disclosure, but that this disclosure will include all embodiments falling within the scope of the appended claims.

The foregoing description of various aspects of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed and, obviously, many modifications and variations are possible. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of the invention as defined by the accompanying claims.

**Industrial Applicability**

The storage device of a serial-attached small computer system interface/serial advanced technology attachment (PCI-Express) type supports a low-speed data processing speed for a host by adjusting synchronization of a data signal transmitted/received between the host and a memory disk during data communications between the host and the memory disk through a PCI-Express interface, and simultaneously
supports a set of data processing speed for the memory disk, thereby supporting the performance of the memory to enable set of data processing in an existing interface environment at the maximum.
Claims

[Claim 1] A network-capable RAID controller for a semiconductor storage device (SSD), comprising:
   a disk mount coupled to a set of SSD memory disk units, the set of SSD memory disk units comprising a set of volatile semiconductor memories;
   a high-speed host interface coupled to the disk monitoring unit and the disk mount for providing set of host interface capabilities;
   a disk controller coupled to the high-speed host interface;
   an input/output (I/O) controller coupled to the disk controller; and
   a network interface coupled to the I/O controller for connecting the network-capable RAID controller to an external network.

[Claim 2] The network-capable RAID controller of claim 1, further comprising a disk monitoring unit coupled to the disk mount for monitoring the set of SSD memory disk units;

[Claim 3] The network-capable RAID controller of claim 2, the disk controller being further coupled to the disk monitoring unit.

[Claim 4] The network-capable RAID controller of claim 2, further comprising a disk plug and play controller coupled to the disk monitoring unit and the disk mount for controlling the disk mount.

[Claim 5] The network-capable RAID controller of claim 1, further comprising a host interface coupled to the I/O controller.

[Claim 6] The network-capable RAID controller of claim 5, the host interface unit being a PCI-Express host interface unit.

[Claim 7] The network-capable RAID controller of claim 1, further comprising a controller unit coupled to the RAID controller.

[Claim 8] The network-capable RAID controller of claim 1, each of the set of SSD memory disk units comprising:
   a host interface unit;
   a DMA controller coupled to the host interface unit;
   an ECC controller coupled to the DMA controller;
   a memory controller coupled to the ECC controller; and
   a memory array coupled to the memory controller, the memory array comprising at least one memory block.

[Claim 9] A network-capable RAID controller for a semiconductor storage device (SSD), comprising:
   a disk mount coupled to a set of SSD memory disk units, the set of SSD
memory disk units comprising a set of volatile semiconductor memories;  
a high-speed host interface coupled to the disk monitoring unit and the disk mount for providing a set of host interface capabilities; 
a disk monitoring unit coupled to the disk mount for monitoring the set of SSD memory disk units; 
a disk plug and play controller coupled to the disk monitoring unit and the disk mount for controlling the disk mount; and 
a disk controller coupled to the high-speed host interface; 
an input/output (I/O) controller coupled to the disk controller; and 
a network interface coupled to the I/O controller for connecting the network capable RAID controller to an external network.

[Claim 10] The network-capable RAID controller of claim 9, further comprising a host interface coupled to the I/O controller.

[Claim 11] The network-capable RAID controller of claim 10, the host interface unit being a PCI-Express host interface unit.

[Claim 12] The network-capable RAID controller of claim 9, each of the set of SSD memory disk units comprising: 
a host interface unit; 
a DMA controller coupled to the host interface unit; 
an ECC controller coupled to the DMA controller; 
a memory controller coupled to the ECC controller; and 
a memory array coupled to the memory controller, the memory array comprising at least one memory block.

[Claim 13] A method for forming a network-capable RAID controller for a semiconductor storage device (SSD), comprising: 
coupling a disk mount to a set of SSD memory disk units, the set of SSD memory disk units comprising a set of volatile semiconductor memories; 
coupling a high-speed host interface to the disk monitoring unit and the disk mount for providing set of host interface capabilities; 
coupling a disk controller to the high-speed host interface; 
coupling an input/output (I/O) controller coupled to the disk controller; and 
coupling a network interface to the I/O controller for connecting the network capable RAID controller to an external network.

[Claim 14] The method of claim 13, further comprising coupling a disk monitoring unit to the disk mount for monitoring the set of SSD memory disk
[Claim 15] The method of claim 14, the disk controller being further coupled to the disk monitoring unit.

[Claim 16] The method of claim 14, further comprising coupling a disk plug and play controller to the disk monitoring unit and the disk mount for controlling the disk mount.

[Claim 17] The method of claim 13, further comprising coupling a host interface to the I/O controller.

[Claim 18] The method of claim 17, the host interface unit being a PCI-Express host interface unit.

[Claim 19] The method of claim 13, further comprising coupling a controller unit to the RAID controller.

[Claim 20] The method of claim 13, forming each of the set of SSD memory disk units by:

coupling a DMA controller to the host interface unit;
coupling an ECC controller to the DMA controller;
coupling a memory controller to the ECC controller; and
coupling a memory array to the memory controller, the memory array comprising at least one memory block.