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METHOD AND APPARATUS FOR PERFORMING DRIVE-BASED UPDATES TO DISK ARRAY CONTROLLERS

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates in general to mass storage systems, and more particularly to a method and apparatus for performing drive-based updates to disk array controllers.

2. Description of Related Art.

Modern mass storage subsystems are continuing to provide increasing storage capacities to fulfill user demands from host computer system applications. Further, it is very important that a computer storage system perform reliably. For example, some real time computer storage systems are used to control complex and sometimes dangerous production processes. Failure within storage systems of this type may have adverse consequences both for the products being produced as well as for the health and safety of the surrounding environment. As another example, computer storage systems are often used in mission critical roles. Once again, failure within these types of storage systems may have extremely serious consequences. Of course, even in cases where the failure of a computer system is not dangerous, failure may still be inconvenient and/or expensive.

Various storage device configurations and geometries are commonly applied to meet the demands for higher storage capacity while maintaining or enhancing

reliability of the mass storage subsystems. A popular solution to these mass storage demands for increased capacity and reliability is the use of multiple smaller storage modules configured in geometries that permit redundancy of stored data to assure data integrity in case of various failures. In many such redundant subsystems, recovery from many common failures can be automated within the storage subsystem itself due to the use of data redundancy, error codes, and so-called "hot spares" (extra storage modules which may be activated to replace a failed, previously active storage module). These subsystems are typically referred to as redundant arrays of inexpensive (or independent) disks (or more commonly by the acronym RAID). The 1987 publication by David A. Patterson, et al., from University of California at Berkeley entitled A Case for Redundant Arrays of Inexpensive Disks (RAID), reviews the fundamental concepts of RAID technology.

There are five "levels" of standard geometries defined in the Patterson publication. The simplest array, a RAID level 1 system, comprises one or more disks for storing data and an equal number of additional "mirror" disks for storing copies of the information written to the data disks. The remaining RAID levels, identified as RAID levels 2, 3, 4 and 5 systems, segment the data into portions for storage across several data disks. One or more additional disks are utilized to store error check or parity information. Many other varieties of RAID levels exist, with many being proprietary. Yet, the general aspect of providing protection against storage system failures is the goal.

RAID storage subsystems typically utilize an array controller that shields the user or host system from the details of managing the redundant array. The controller

makes the subsystem appear to the host computer as one (or more), highly reliable, high capacity disk drive. In fact, the RAID controller may distribute the host computer system supplied data across a plurality of the small independent drives with redundancy and error checking information so as to improve subsystem reliability. Frequently RAID subsystems provide large cache memory structures to further improve the performance of the RAID subsystem. The cache memory is associated with the control module such that the storage blocks on the disk array are mapped to blocks in the cache. This mapping is also transparent to the host system. The host system simply requests blocks of data to be read or written and the RAID controller manipulates the disk array and cache memory as required.

Each of these configurations (geometries or RAID levels) may be preferred over the others in particular applications depending upon performance or reliability requirements. It is vital to proper operation of the RAID storage subsystem that the configuration information be maintained. Each disk drive of the disk array must be in a known address and/or physical position with respect to the various interface and control busses. The order of the various disk drives in their respective groupings is critical to proper operation of the RAID subsystem. Furthermore, many RAID storage subsystems permit a plurality of groupings of disk drives to be simultaneously operable within the subsystem. Each grouping may be operating under a different RAID geometry to satisfy the needs of a particular application.

Initial implementations of RAID were in the form of software device drivers that had to be added to the host computer system. It quickly became apparent that the overhead involved in managing the RAID was significant, and made the

computer run much slower. Because storage demands weigh heavily on a processor, executing all the read and write operations on the disk system results in a huge number of I/O interrupts. If these were to be processed by a host CPU, then the host would be doing little else. To ease this burden, storage vendors and motherboard designers have contemplated alternative methods of processing I/O.

One alternative to host based I/O control is to implement an I/O processor directly on the storage controller to handle most of the I/O to its connected drives. This is called a controller-based RAID. In the host-based I/O control, all the RAID functions are handled directly by the file system and device drivers of the host operating system. However, with a RAID controller, most of the RAID functions are passed on to the RAID controller to manage. There is still I/O between the host CPU and the controller, but a significant portion of this is reduced with controller-based systems. This hardware RAID controller concept provides greater performance while maintaining all the benefits of the RAID technology. Thus, a RAID controller organizes the disk drives into the RAID configuration and controls the interaction between the individual disk drives.

Another problem with the use of array controllers arises from the difficulty of testing and monitoring the dynamic operation of the disk drive system. In-depth testing is normally performed as part of final assembly quality control. The throughput of array manufacture is limited by the length and complexity of such testing and the availability of dedicated testing stations. In addition, such testing is often desirable for monitoring the live operation of the disk drive array system and for evaluating the cause of any premature failure.

Traditional controller environments require that some sort of host tool be used to perform controller diagnostics and/or to update a controller's configuration or firmware. This step requires tools to be written for many host operating systems. The tools result in extra maintenance costs as long as the controller remains in the field. These prior methods also require some sort of in- band or out- of- band connection for the host utility to use in communicating with the controller. In the event that the controller or host is not able to communicate with the controller, there are no practical means of performing controller updates.

It can be seen then that there is a need for a simple and very effective method of performing Disk Array Controller (DAC) updates.

SUMMARY OF THE INVENTION

To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, the present invention discloses a method and apparatus for performing drive-based updates to disk array controllers.

The present invention solves the above-described problems by providing a simple and very effective method of performing Disk Array Controller (DAC) diagnostics and updating Disk Array Controller (DAC) firmware or configuration in any internal or external enclosure configuration.

A method in accordance with the principles of the present invention includes formatting a reserved data area in a update disk drive with an update for a disk array controller of a disk drive array, removing a spare disk drive from a bay of the disk drive array, inserting the update disk drive in the bay, detecting the inserted update disk drive and the update in the reserved data area and updating the disk drive controller according to the update provided on the inserted update disk drive.

Other embodiments of a method in accordance with the principles of the invention may include alternative or optional additional aspects. One such aspect of the present invention is that the update includes diagnostics.

Another aspect of the present invention is that the formatting further includes storing an indicator in a head of the reserved data area for the disk array controller to perform diagnostics.

Another aspect of the present invention is that the updating further includes performing diagnostics for the disk array.

Another aspect of the present invention is that the updating further includes storing the results of the diagnostics in a data section of the reserved data area.

Another aspect of the present invention is that the method further includes removing the update disk drive and processing the results of the diagnostics in the data section of the reserved data area.

Another aspect of the present invention is that the processing the results further includes displaying the results.

Another aspect of the present invention is that the update includes one of the group consisting of a configuration update and a firmware image update.

Another aspect of the present invention is that the formatting further includes storing an indicator that a configuration update is to be performed in the header of the reserved data area and a configuration for the disk array controller in the data sections of the reserved data area when the update includes a configuration update.

Another aspect of the present invention is that the updating further includes performing a configuration update for the disk array controller.

Another aspect of the present invention is that the updating further includes updating the reserved data area and marks completed operations listed in the data sections of the reserved data area as being completed.

Another aspect of the present invention is that the method further includes removing the update disk drive.

Another aspect of the present invention is that the formatting further includes storing an indicator that a configuration update is to be performed in the header of the reserved data area and a new firmware image for the disk array controller and flags in the data sections of the

reserved data area when the update includes a firmware image update.

Another aspect of the present invention is that the updating further includes performing a firmware image update for the disk array controller.

Another aspect of the present invention is that the updating further includes updating the reserved data area and marking completed operations listed in the data sections of the reserved data area as being completed.

Another aspect of the present invention is that the method further includes removing the update disk drive.

In another embodiment of the present invention, a disk drive is provided. The disk drive includes a data storage area and a reserved data area, wherein the reserved data area further includes update instructions and information for a disk array controller.

Another aspect of the present invention is that the update further includes an indicator in a header of the reserved data area for instructing the disk array controller to perform diagnostics.

Another aspect of the present invention is that the reserved data area further includes a data section for storing the results of the diagnostics.

Another aspect of the present invention is that the update further includes an indicator in a header of the reserved data area for instructing the disk array controller to perform a configuration update or a firmware image update.

Another aspect of the present invention is that the update further includes a configuration for the disk array controller in the data section of the reserved data area when the update includes a configuration update.

Another aspect of the present invention is that the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

Another aspect of the present invention is that the update further includes a new firmware image for the disk array controller and flags in the data section of the reserved data area when the update includes a firmware image update.

Another aspect of the present invention is that the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

In yet another embodiment of the present invention, a system for performing drive-based updates for a disk array controller in a disk array is provided. The system includes a plurality of disk drives arranged in parallel to provide a redundant array of disk drives, a disk array controller for communicating with the redundant array of disk drives and a data bus coupling the disk array controller to the redundant array of disk drives, wherein one of the redundant array of disk drives includes a spare disk drive, the spare disk drive including a data storage area and a reserved data area, formatted to include an update for updating the disk array controller.

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and form a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to accompanying descriptive matter, in which there are illustrated and described specific examples of an apparatus in accordance with the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding parts throughout:

Fig. 1 illustrates the traditional approach to performing disk array updates;

Fig. 2 illustrates an operating environment for performing drive-based updates to disk array controllers according to the present invention;

Fig. 3 illustrates a enlarged view of a disk drive illustrating a Reserved Disk Area for storing update information according to the present invention;

Fig. 4 illustrates a block diagram of a uniquely formatted Reserved Disk Area (RDA) according to the present invention;

Fig. 5 illustrates a flow chart of a first embodiment wherein controller diagnostics are performed without the need for host tools or external connections; and

Fig 6 illustrates a flow chart of a second embodiment wherein a controller's firmware is updated without the need for host tools or external connections.

DETAILED DESCRIPTION OF THE INVENTION

In the following description of the exemplary embodiment, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration the specific embodiment in which the invention may be practiced. It is to be understood that other embodiments may be utilized as structural changes may be made without departing from the scope of the present invention.

Fig. 1 illustrates the traditional approach to performing disk array updates 100. Traditional controller environments require that some sort of host 110 communicate with a disk array controller 120 to perform controller updates 130, such as to perform diagnostics or to update the configuration or firmware of a controller 120. This step requires tools to be written for many host operating systems 110. Thus, these tools are platform and operating system dependent. Further, these tools result in extra maintenance costs as long as the controller 120 remains in the field. These host-base methods also require some sort of in-band or out- of- band connection for the host utility 110 to use in communicating with the controller 120. The controller 120 must handle the protocol and be able to communicate with the host 110. In the event that the host 110 and the controller 120 cannot communicate, there are no practical means of updating the controller 120.

Fig. 2 illustrates an operating environment 200 for performing drive-based updates to disk array controllers according to the present invention. In Fig. 1, a disk array controller 210 is coupled to a bus 212 for communicating with an array of disk drives 220-228. In Fig. 1, an array of five disk drives 220-228 are illustrated. According to generally implemented procedures, the spare disk drive 228 may be "hot swapped" or removed. According to the

present invention, the removed drive is replaced with a drive 228 containing the updates. However, those skilled in the art will recognize that the present invention is not meant to be limited to any particular number of drives.

In Fig. 2, in contrast to the traditional approach, a disk drive 228 is used to update the array controller 210. The disk drive 228 may be programmed to store the upgrade. For example, configuration data, a new firmware image or controller diagnostics may be stored on the disk drive 228. Further, the disk drive 228 may be configured to indicate that an update is to be performed. Since disk array controllers 210 always communicate with disk drives 220-228, the communications path between the controller 210 and the disk drive 228 will always be supported.

Fig. 3 illustrates a enlarged view of a disk drive 300 illustrating a Reserved Disk Area for storing update information according to the present invention. Disk drives generally include space for storing data 310 available to the user and a fixed amount of space that is kept in reserve 320 for storing data unavailable to the user. Servo writing the disks in the disk drive provides positional information for finding a particular track or group of tracks. Critical information may be stored in the reserve area 320. The critical information is typically used to operate the disk drive 300 and is used by the operating system or hardware in the operation of the drive 300. The controller determines the Reserved Disk Area 320. Thus, the reserve area 320 is protected and provides a suitable area for storing critical system data. However, according to the present invention, the Reserved Disk Area 320 is used to provide the update information. The Reserved Disk Area 320 informs the controller that diagnostics are desired, that an update to the configuration is needed, or that a new firmware image is to be installed. The same RDA area 320 is used for configuration and other controller data storage and is not

used for storage of user data.

The present invention therefore provides a number of very distinctive advantages for controller updates. For example, the drive-based updates provides a known path that is always available for controller updates. This approach provides a very simple step for performing controller updates. One specially formatted disk 300 can be used over and over again to perform the controller updates, such as configuration and/or firmware updates or diagnostics. Moreover, no host or operating specific tools are required for performing controller updates.

Fig. 4 illustrates a block diagram of a uniquely formatted Reserved Disk Area (RDA) 400 according to the present invention. The RDA is updated to have a header 410 with numerous fields 420-430. One of the fields 420 is used to indicate the purpose of the RDA. This purpose field 420 is set during the formatting of the RDA 400 on the drive being used for performing the controller updates. The purpose field 420 is formatted to indicate that the RDA was formatted for updates, such as configuration and/or firmware updates or diagnostics. The RDA 400 is also configured to include a data area 440 including a variable number of data sections 450-458. These data sections 450-458 are used to store the configuration data, a new firmware image or diagnostic information. The RDA 400 is at a fixed offset from the end of the disk. For example, the RDA start is always equal to the disk size.

Now referring to both Figs. 2 and 4, the controller 210 is configured to process the RDA header 410 and RDA data sections 450-458. The RDA header 410 will be processed during the controller's handling of disk drives. That is, the RDA area 400 will be handled much like how configuration on disks are currently handled. When a new drive is inserted,

the controller 210 performs a channel scan and finds the new disk drive 228. The RDA header 410 is read from the drive 228. The RDA header 410 will then be processed and the controller 210 will perform the update as indicated in the purpose field 420 in the RDA header 410. The controller 210 also updates the RDA data sections 450-458 as appropriate. For example, if diagnostic are performed the controller updates the RDA data sections 450-458 with the diagnostic results. Also, in the case of configuration or firmware updates, the RDA data area 440 may be updated and certain operations, possibly indicated in the data sections 450-458, are marked as completed. This prevents these completed operations from being performed multiple times. Once the update has been completed, the special drive 228 can be removed.

Any drive can be formatted to contain a special RDA header 410 to perform the desired operation. This drive can then be used multiple times to perform the same operation, or reformatted to perform a new operation. One utility can be used to format the disk drive 228, and that utility can be ported to appropriate operating systems and/or used to interpret the results.

Fig. 5 illustrates a flow chart 500 of a first embodiment wherein controller diagnostics are performed without the need for host tools or external connections. First, a drive's RDA is formatted to indicate that controller diagnostics are to be performed 510. This drive is then inserted into a channel accessible by the controller 512. The controller scans the disk channel and finds the drive 514. The drive's RDA is processed 516 and the controller performs diagnostics 518. The results of the diagnostics are stored on the disk drive in one RDA data section 520. The drive may then be removed and brought to another results processing system and so that the RDA header and data section may be processed 522. The diagnostics results may then be displayed for analysis 524.

Fig 6 illustrates a flow chart 600 of a second embodiment wherein a controller's firmware is updated without the need for host tools or external connections. In this example, a controller operating in an enclosure with 10 drives is updated. Further, in this example, the controller is configured to have a configuration with a logical 8+1 RAID 5 volume and one hot spare. The first step is to update the RDA area of an 11th drive 610. The RDA area's header is formatted as a firmware upgrade RDA and will contain special flags and the new firmware image 612. The next step is to pull the hot spare of the current enclosure 614. The 11th drive is then inserted 616. The firmware recognizes the insertion of the new drive and reads its RDA header 618. The RDA indicates that this is a firmware upgrade RDA and the controller proceeds to update its firmware image 620. A special flag could then indicate that the controller should proceed to use the new image immediately by whatever means it needs to take 622, e.g., by rebooting.

Thus, the present invention provides a method and apparatus for performing drive-based updates to disk array controllers. The present invention provides a simple and very effective method of performing Disk Array Controller (DAC) diagnostics and updating Disk Array Controller (DAC) firmware or configuration in any internal or external enclosure configuration. The disk drive is used as the medium for updating the controller.

The foregoing description of the exemplary embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not with this detailed description, but rather by the claims appended hereto.

WHAT IS CLAIMED IS:

1. A method of updating a disk array controller of a disk drive array, comprising:

formatting a reserved data area in a update disk drive with an update for a disk array controller of a disk drive array;

removing a spare disk drive from a bay of the disk drive array;

inserting the update disk drive in the bay;

detecting the inserted update disk drive and the update in the reserved data area; and

updating the disk drive controller according to the update provided on the inserted update disk drive.

2. The method of claim 1 wherein the update comprises diagnostics.

3. The method of claim 2 wherein the formatting further comprises storing an indicator in a head of the reserved data area for the disk array controller to perform diagnostics.

4. The method of claim 3 wherein the updating further comprises performing diagnostics for the disk array.

5. The method of claim 4 wherein the updating further comprises storing the results of the diagnostics in a data section of the reserved data area.



6. The method of claim 5 further comprises removing the update disk drive and processing the results of the diagnostics in the data section of the reserved data area.

7. The method of claim 6 wherein the processing the results further comprises displaying the results.

8. The method of claim 1 wherein the update comprises one of the group consisting of a configuration update and a firmware image update.

9. The method of claim 8 wherein the formatting further comprises storing an indicator that a configuration update is to be performed in the header of the reserved data area and a configuration for the disk array controller in the data sections of the reserved data area when the update comprises a configuration update.

10. The method of claim 9 wherein the updating further comprises performing a configuration update for the disk array controller.

11. The method of claim 10 wherein the updating further comprises updating the reserved data area and marks completed operations listed in the data sections of the reserved data area as being completed.



12. The method of claim 11 further comprises removing the update disk drive.

13. The method of claim 8 wherein the formatting further comprises storing an indicator that a configuration update is to be performed in the header of the reserved data area and a new firmware image for the disk array controller and flags in the data sections of the reserved data area when the update comprises a firmware image update.

14. The method of claim 13 wherein the updating further comprises performing a firmware image update for the disk array controller.

15. The method of claim 14 wherein the updating further comprises updating the reserved data area and marking completed operations listed in the data sections of the reserved data area as being completed.

16. The method of claim 15 further comprises removing the update disk drive.

17. A disk drive for performing drive-based updates to a disk array controller in a disk array, comprising:

a data storage area; and

a reserved data area, wherein the reserved data area further comprises update instructions and information for a disk array controller.

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18. The disk drive of claim 17 wherein the update further comprises an indicator in a header of the reserved data area for instructing the disk array controller to perform diagnostics.

19. The disk drive of claim 18 wherein the reserved data area further comprises a data section for storing the results of the diagnostics.

20. The disk drive of claim 17 wherein the update further comprises an indicator in a header of the reserved data area for instructing the disk array controller to perform a configuration update or a firmware image update.

21. The disk drive of claim 20 wherein the update further comprises a configuration for the disk array controller in the data section of the reserved data area when the update comprises a configuration update.

22. The disk drive of claim 21 wherein the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

23. The disk drive of claim 20 wherein the update further comprises a new firmware image for the disk array controller and flags in the data section of the reserved data area when the update comprises a firmware image update.



24. The disk drive of claim 21 wherein the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

25. A system for performing drive-based updates for a disk array controller in a disk array, comprising:

a plurality of disk drives arranged in parallel to provide a redundant array of disk drives;

a disk array controller for communicating with the redundant array of disk drives; and

a data bus coupling the disk array controller to the redundant array of disk drives,

wherein one of the redundant array of disk drives comprises a spare disk drive, the spare disk drive comprising a data storage area and a reserved data area, formatted to include an update for updating the disk array controller.

26. The system of claim 25 wherein the update further comprises an indicator in a header of the reserved data area for instructing the disk array controller to perform diagnostics.

27. The system of claim 26 wherein the reserved data area further comprises a data section for storing the results of the diagnostics.

28. The system of claim 25 wherein the update further comprises an indicator in a

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header of the reserved data area for instructing the disk array controller to perform a configuration update or a firmware image update.

29. The system of claim 28 wherein the update further comprises a configuration for the disk array controller in the data section of the reserved data area when the update comprises a configuration update.

30. The system of claim 29 wherein the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

31. The system of claim 28 wherein the update further comprises a new firmware image for the disk array controller and flags in the data section of the reserved data area when the update comprises a firmware image update.

32. The system of claim 29 wherein the reserved data area is updated and operations listed in the data sections of the reserved data area are marked as being completed.

