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MULTI-REQUESTER DETECTION OF POTENTIAL LOGICAL UNIT THRASHING AND PREEMPTIVE APPLICATION OF PREVENTIVE OR AMELIORATIVE MEASURES

Field of the Invention

The present invention relates to the field of multi-requester computer systems, and more particularly to coordination between I/O requesters for detecting potential logical unit thrashing and preemptively applying preventive or ameliorative measures.

Background of the Invention

It is well known in the field of computing in general to have controller systems for controlling resources, and in many computer systems, such controllers are provided in pairs that can be switched, either as a means of balancing processing load, or in order to provide some level of redundancy in the event of a controller failure. In most such systems, resources are presented to the host applications and system software in a logical, rather than a physical representation. For example, storage controllers may control storage disks to position data representing what a user sees as a "real" disk drive in some scattered form on the surfaces of several disks, perhaps to optimize the use of the disk surfaces or perhaps to optimize the time taken to seek the data. To the user, this scattering is invisible, as the representation to user programs is as a logical unit consisting of a disk, for example, the user's own "C-drive" on a typical personal computer. One example of such a resource controller system is a system comprising a pair of storage controllers that present disk storage to I/O requesters in the form of logical units, or LUNs.

Most RAID (Redundant Array of Independent Disks) controllers operate in pairs each presenting an image of the same set of RAID arrays (or partitions of RAID arrays) made out of storage shared by both controllers. In the eventuality of one RAID controller in the pair failing the RAID arrays are still accessible to requesters via the other controller and thus there is no single point of failure. The implementations of such RAID controllers can be split into two categories. Some RAID controllers are classed as "Active-Active" and allow simultaneous access to the same RAID array via either controller in the pair with no or virtually no degradation in performance. Other RAID controllers are classified as "Active-Passive" and allow only one controller to access a particular RAID array (or sometimes a partition of the RAID array) at a time. Some "Active-Passive" controllers require a particular sequence of commands to be issued to change which controller is active, while other controllers will

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automatically attempt to swap which controller is active depending on which controller receives I/O requests.

Allowing a single requester system to access storage presented by an "Active-Passive" pair of controllers is relatively straightforward. There are many implementations of software that can be used in the requester system that detect that there is an active and a passive controller both presenting the same storage and present these controllers as a single storage device, or LUN, to the requester. This software is also responsible for detecting when there is a problem in completing I/O requests via the active controller and performing the necessary tasks to make the other controller active -- automatically failing over to use the other controller without actually failing an I/O request back up to higher levels of software executing on the requester system.

However, when multiple requester systems share storage that is presented by an "Active-Passive" pair of controllers there is an additional problem -- namely, that all the requesters must agree which controller is active and must coordinate when to change the active controller. If requesters do not do this then a condition sometimes referred to as "LUN thrashing" occurs. In this condition, different requesters attempt to make a different controller the active controller of the pair. The result is that the role of active controller repeatedly swaps and as the time to swap the active controller is usually orders of magnitude longer than the time to process an I/O request, the result is a dramatic drop in the rate at which the controllers can process I/O. This result of LUN thrashing can present a serious performance problem, especially in large and complex, enterprise-level, storage systems, such as Storage Area Networks (hereafter referred to using the abbreviation "SAN").

Until recently, it has not been necessary for multiple requesters to directly access the same storage and thus the problem has not been previously addressed. However, as new direct access shared file systems (such as the IBM Storage Tank), clustered storage appliances (such as IBM 2145 Total Storage Virtualization Engine) and other SAN-based virtualization solutions become more common, the requirement for multi-requester access to storage has come into existence.

One way to avoid the problem of LUN thrashing altogether is to implement an "Active-Active" RAID controller. However, this is more difficult than producing an "Active-Passive" controller and also does not allow SAN-based virtualization solutions to work with existing active-passive RAID controllers.

A further way of avoiding the problem of LUN thrashing in systems allowing multiple requesters to access storage is to allow only one requester to have direct access to a particular LUN or RAID array and to forward all I/O requests from other requesters to that requester. This is effectively what network file systems such as NFS do. However, there is a significant performance penalty in forwarding the I/O requests from other requesters to that single requester. Again, this does not help in SAN-based virtualization systems.

A third possibility is to allow the RAID controllers themselves to control which controller will be active and which controller will be passive. The disadvantage of this implementation is that if both RAID controllers are functional but not all requesters can communicate with both RAID controllers because of a problem at the SAN level, the controllers may make the wrong decision as to which controller should be active and thus introduce a single point of failure.

It is therefore desirable to have a method, apparatus and computer program that provides means, in a multi-requester storage system having Active/Passive paired storage controllers, for detecting potential LUN thrashing and preemptively applying ameliorative measures, especially in (but not limited to) SAN-based storage virtualization systems.

Summary of the Invention

The present invention accordingly provides, in a first aspect an arbitrator component at each of at least two I/O requesters operable to participate in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller; responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller and

to perform at least one of: enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

Preferably, said active-passive pair of resource controllers comprises storage controllers.

Preferably, said active-passive pair of resource controllers comprises storage controllers in a SAN.

Preferably, said active-passive pair of resource controllers comprises storage controllers in a SAN-based storage virtualization environment.

Preferably, said active-passive pair of resource controllers comprises storage controllers in a Storage Tank system.

Preferably, said active-passive pair of resource controllers comprises RAID storage controllers.

Preferably, said active-passive pair of resource controllers controls plural logical units and wherein responsive to detecting that each of said at least two I/O requesters has usable access to plural logical units at both of said active-passive pair of resource controllers, said arbitrator component is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller for each of said plural logical units based on a load-balancing algorithm.

The present invention provides, in a second aspect, an information processing system comprising at least two I/O requesters; an active-passive pair of resource controllers operable to present resources as logical units to said I/O requesters, a detector component at each of said at least two I/O requesters operable to detect usable access to one or more of said resource controllers; a communication component at each of said at least two I/O requesters operable to communicate an access state to at least one other of said at least two I/O requesters; an arbitrator component at each of said at least two I/O requesters operable to participate in arbitration to determine which of said active-passive pair of resource controllers is to be designated as an active resource controller; wherein responsive to

detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller; responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O requesters is operable to select said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller and to perform at least one of: enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

In a third aspect, the present invention provides a method for information processing comprising the steps of: participating in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller; responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and enabling requests to swap a passive to an active one of said active-passive

pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

In a fourth aspect, the present invention provides a method for information processing comprising the steps of: providing at least two I/O requesters; presenting resources as logical units to said I/O requesters, detecting, at each of said at least two I/O requesters, usable access to one or more of an active-passive pair of resource controllers; communicating an access state to at least one other of said at least two I/O requesters; participating in arbitration to determine which of said active-passive pair of resource controllers is to be designated as an active resource controller; wherein responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller; responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of: enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

In a fifth aspect, the present invention provides a computer program product tangibly embodied in a computer-readable storage medium, comprising computer program code means to, when loaded into a computer system and executed thereon, cause said computer system to perform the steps of: participating in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller; responsive to detecting that one of said at least two I/O requesters has usable access

to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of: enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

The problem addressed by the embodiments of the present invention is that of allowing multiple requesting hosts (or other systems that initiate I/O requests) to share storage or other resource that is presented by an "Active-Passive" pair of controllers while detecting potential LUN thrashing and preemptively applying measures to prevent or ameliorate the LUN thrashing.

Brief Description of the Drawings

A preferred embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram illustrating an arrangement of apparatus in accordance with a preferred embodiment of the present invention.

Figure 2 shows a flow diagram illustrating steps of a method in accordance with a preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiment

An arrangement of apparatus according to a preferred embodiment of the present invention is shown in Figure 1.

In Figure 1 are shown a pair of requesters 102, 104, connected to software 106 that is operable to present LUNs 108, 110 representing the same storage across access paths 118. It should be noted that LUNs have no independent existence but are merely representations of storage, in this case, the same storage, presented by controllers to requesters. As can be

seen in Figure 1 all the available access paths are shown such that requesters 102 and 104 are able to access either of LUNs 108, 110. This is not always the case, as will be described below.

LUNs 108, 110 are presented to the software 106 for onward presentation to the requesters 102, 104 by controllers 112, 114, which form an active-passive pair to control resource 116. In the exemplary embodiment described herein, the resource 116 is a RAID array, or a partition of a RAID array.

The preferred embodiment of the present invention requires the requesters 102, 104, which may be hosts or other systems capable of initiating I/O, to be able to communicate with each other -- this may be done using any conventional network or clustering technology, of which many examples are well-known in the art. When a requester 102, 104 initializes, it must determine whether it can communicate with both RAID controllers 112, 114 in the pair and then communicate this information with the other requester systems that are using the pair of RAID controllers 112, 114. The requesters 102, 104 can then make a collective decision based on the information gathered from all the requesters as follows:

If both the requesters 102, 104 that are using the pair of RAID controllers can communicate with both controllers 112, 114 , the requesters can collectively decide which controller will be the active controller and all requesters can issue I/O requests to that controller. An additional advantageous feature that may be preferred is that, if a pair of RAID controllers presents multiple RAID arrays or LUNs, the requesters can collectively decide to make one controller active for some of the LUNs and the other controller active for the other LUNs and hence balance the I/O workload between the controllers.

If one or both of the requesters 102, 104 cannot communicate with one of the controllers 112, 114 or one or both of the controllers is unable to service I/O requests for some other reason, the requesters can collectively make the decision not to attempt to use that controller.

If one of the requesters 102, 104 cannot communicate with one of the RAID controllers 112, 114 and the other requester cannot communicate with the other RAID controller, the requesters cannot use a particular RAID array or LUN without causing LUN thrashing. In this case the simplest solution is to deny access to one requester, although an alternative could be implemented that would allow both requesters to use the storage while keeping LUN thrashing to an acceptable minimum. For example, one requester

could be permitted to access the storage, but not to influence the decision as to which controller is active.

If during operation a RAID controller 112, 114 fails or for some other reason a requester 102, 104 is unable to issue I/O requests to a particular controller, the requester can request that the requesters reevaluate which controller to use. It is important that, if as a result of the reevaluation the decision is made to swap which controller is active, all I/O requests to that controller are quiesced prior to making the swap. The quiesce ensures that when the active controller is changed that no further I/O will be issued to the controller that has become passive, and thus avoids LUN thrashing occurring during the changeover period.

Similarly, if a requester that could not communicate with both RAID controllers subsequently (probably because of some service action) determines that it can now communicate with a RAID controller, this should be communicated so that the requesters can reevaluate which controller to use as the active controller.

If a requester 102, 104 cannot communicate with the other requester or, in a system comprising more than just two requesters, with a majority of the other requesters which are sharing a pair of RAID controllers, it cannot know which controller has been chosen as the active controller. Again the simplest solution is to deny access to the storage by that requester. However, in an alternative implementation, it may also be possible to permit the requester to use the storage but not to influence which controller is active.

Turning now to Figure 2, there is shown a method for detecting and preemptively ameliorating potential logical unit thrashing in a system having at least two I/O requesters.

The process begins at START step 200, which is either at system initialization or at a reinitialization caused by, for example, a change in the status of a requester or a controller.

At step 202, the controllers 112, 114, present resources as logical units to the I/O requesters 102, 104.

At step 204, each of the I/O requesters detects whether it has usable access to one or more of the resource controllers.

At step 206 each of the I/O requesters communicates its access state to the other I/O requester.

At step 208 each of the I/O requesters participates in arbitration to determine which of the active-passive pair of resource controllers is to be designated as the active resource controller. The outcome of the arbitration is determined at testing steps 210, 214, 218.

If, at step 210, each of the I/O requesters has usable access to both of said active-passive pair of resource controllers, the I/O requesters select at step 212 one of the active-passive pair of resource controllers to be designated as an active resource controller.

If, at step 214, one or both of the I/O requesters has usable access to only one of the active-passive pair of resource controllers, the I/O requesters select at step 216 the only one of the active-passive pair of resource controllers to be designated as the active resource controller.

If, at step 218, each of the I/O requesters has usable access only to different ones of the active-passive pair of resource controllers, the I/O requesters select at step 220 one of the active-passive pair of resource controllers to be designated as an active resource controller and also perform at least one of the following:

1. At step 222, enabling I/O requests from only that I/O requester that has usable access to that resource controller designated as an active resource controller; and

2. At step 224, enabling requests to swap a passive to an active resource controller from only the I/O requester that has usable access to the resource controller designated as an active resource controller.

Processing continues at step 228, which may be continued normal processing after the arbitration and selection steps described above, or may be error processing if the arbitration and selection steps produced no usable outcome. Such error processing is well known in the art, and requires no description here.

The message passing between requesters that is necessary to the preferred embodiment of the present invention is implemented using one of the known networking or clustering techniques of the art to allow the requesters to communicate with each other. It will be clear to one of ordinary skill in the art that such clustering techniques are suitable for

this purpose, and no further description of clustering techniques is necessary here.

It will be appreciated that the method described above may be carried out in suitable hardware or software, or a combination of both, but will most typically be carried out in software running on one or more processors (not shown), and that the software may be provided as a computer program element carried on any suitable data carrier (also not shown) such as a magnetic or optical computer disc. The channels for the transmission of data likewise may include storage media of all descriptions as well as signal carrying media, such as wired or wireless signal media.

The present invention may suitably be embodied as a computer program product for use with a computer system. Such an implementation may comprise a series of computer readable instructions either fixed on a tangible medium, such as a computer readable medium, for example, diskette, CD-ROM, ROM, or hard disk, or transmittable to a computer system, via a modem or other interface device, over either a tangible medium, including but not limited to optical or analogue communications lines, or intangibly using wireless techniques, including but not limited to microwave, infrared or other transmission techniques. The series of computer readable instructions embodies all or part of the functionality previously described herein.

Those skilled in the art will appreciate that such computer readable instructions can be written in a number of programming languages for use with many computer architectures or operating systems. Further, such instructions may be stored using any memory technology, present or future, including but not limited to, semiconductor, magnetic, or optical, or transmitted using any communications technology, present or future, including but not limited to optical, infrared, or microwave. It is contemplated that such a computer program product may be distributed as a removable medium with accompanying printed or electronic documentation, for example, shrink-wrapped software, pre-loaded with a computer system, for example, on a system ROM or fixed disk, or distributed from a server or electronic bulletin board over a network, for example, the Internet or World Wide Web.

It will be appreciated that various modifications to the embodiment described above will be apparent to a person of ordinary skill in the art.

CLAIMS

1. An arbitrator component at each of at least two I/O requesters operable to participate in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein

responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller;

responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and

responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, said arbitrator component at each of at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller and to perform at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and

enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

2. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers comprises storage controllers.

3. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers comprises storage controllers in a SAN.

4. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers comprises storage controllers in a SAN-based storage virtualization environment.

5. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers comprises storage controllers in a Storage Tank system.

6. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers comprises RAID storage controllers.

7. An arbitrator component as claimed in claim 1, wherein said active-passive pair of resource controllers controls plural logical units and wherein responsive to detecting that each of said at least two I/O requesters has usable access to plural logical units at both of said active-passive pair of resource controllers, said arbitrator component is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller for each of said plural logical units based on a load-balancing algorithm.

8. An information processing system comprising

at least two I/O requesters;

an active-passive pair of resource controllers operable to present resources as logical units to said I/O requesters,

a detector component at each of said at least two I/O requesters operable to detect usable access to one or more of said resource controllers;

a communication component at each of said at least two I/O requesters operable to communicate an access state to at least one other of said at least two I/O requesters;

an arbitrator component at each of said at least two I/O requesters operable to participate in arbitration to determine which of said active-passive pair of resource controllers is to be designated as an active resource controller; wherein

responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O

requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller;

responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O requesters is operable to select said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and

responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, said arbitrator component at each of said at least two I/O requesters is operable to select one of said active-passive pair of resource controllers to be designated as an active resource controller and to perform at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and

enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

9. A method for information processing comprising the steps of:

participating in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein

responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller;

responsive to detecting that one of at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and

responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and

enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

10. A method for information processing comprising the steps of:

providing at least two I/O requesters;

presenting resources as logical units to said I/O requesters,

detecting, at each of said at least two I/O requesters, usable access to one or more of an active-passive pair of resource controllers;

communicating an access state to at least one other of said at least two I/O requesters;

participating in arbitration to determine which of said active-passive pair of resource controllers is to be designated as an active resource controller; wherein

responsive to detecting that each of said at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller;

responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and

responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of

resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and

enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.

11. A computer program product tangibly embodied in a computer-readable storage medium, comprising computer program code means to, when loaded into a computer system and executed thereon, cause said computer system to perform the steps of:

participating in arbitration to determine which of an active-passive pair of resource controllers is to be designated as an active resource controller; wherein

responsive to detecting that each of at least two I/O requesters has usable access to both of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller;

responsive to detecting that one of said at least two I/O requesters has usable access to only one of said active-passive pair of resource controllers, selecting said only one of said active-passive pair of resource controllers to be designated as an active resource controller; and

responsive to detecting that each of said at least two I/O requesters has usable access only to different ones of said active-passive pair of resource controllers, selecting one of said active-passive pair of resource controllers to be designated as an active resource controller and performing at least one of:

enabling I/O requests from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller; and

enabling requests to swap a passive to an active one of said active-passive pair of resource controllers from only that one of said at least two I/O requesters that has usable access to said one of said active-passive pair of resource controllers designated as an active resource controller.