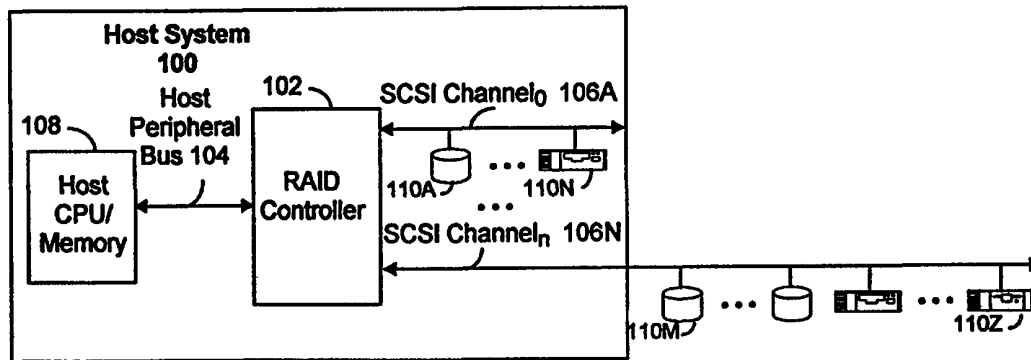




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<p>(21) International Application Number: PCT/US99/01282 (22) International Filing Date: 20 January 1999 (20.01.99) (30) Priority Data: 09/009,945 21 January 1998 (21.01.98) US (71) Applicant: MYLEX CORPORATION [US/US]; 34551 Ardenwood Boulevard, Fremont, CA 94555 (US). (72) Inventors: SURUGGUCHI, Krishnakumar, Rao; 32875 Bluebird Court, Fremont, CA 94555 (US). KAILASH; 165 Park Ellen Drive, San Jose, CA 95136 (US). (74) Agents: ANANIAN, Michael, R. et al.; Flehr, Hohbach, Test, Albritton &amp; Herbert LLP, Suite 3400, 4 Embarcadero Center, San Francisco, CA 94111-4187 (US).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: AN APPARATUS AND METHOD FOR AUTOMATIC CONFIGURATION OF A RAID CONTROLLER



(57) Abstract

The present invention pertains to an apparatus and method for automatically configuring disk drives connected to a RAID controller. The automatic configuration mechanism is able to generate a full configuration of the disk drives connected to a RAID controller both at system initialization or bootup and at runtime. The mechanism uses a robust criteria to configure the disk drives which allows the drives to be configured in accordance with one or more RAID levels and which considers any existing configurations. The automatic configuration mechanism is advantageous since it eliminates user interaction, time, and knowledge often required to configure disk drives connected to a RAID controller.

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## AN APPARATUS AND METHOD FOR AUTOMATIC CONFIGURATION OF A RAID CONTROLLER

### Brief Description of the Invention

The present invention relates generally to peripheral controllers. More particularly, the invention relates to the automatic configuration of Redundant Array of Independent Disks (RAID) controllers.

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### Background of the Invention

RAID is a technology used to improve the I/O performance and reliability of mass storage devices. Data is stored across multiple disks in order to provide immediate access to the data despite one or more disk failures. The RAID  
10 technology is typically associated with a taxonomy of techniques, where each technique is referred to by a RAID level. There are six basic RAID levels, each having its own benefits and disadvantages. RAID level 2 uses non-standard disks and as such is not commercially feasible.

15 RAID level 0 employs "striping" where the data is broken into a number of stripes which are stored across the disks in the array. This technique provides higher performance in accessing the data but provides no redundancy which is needed for disk failures.

20 RAID level 1 employs "mirroring" where each unit of data is duplicated or "mirrored" onto another disk drive. Mirroring requires two or more disk drives. For read operations, this technique is advantageous since the read operations can be performed in parallel. A drawback with mirroring is that it achieves a storage efficiency of only 50%.

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In RAID level 3, a data block is partitioned into stripes which are striped across a set of drives. A separate parity drive is used to store the parity bytes associated with the data block. The parity is used for data redundancy. Data can be regenerated when there is a single drive failure from the data on the remaining drives and the parity drive. This type of data management is advantageous since it requires less space than mirroring and only a single parity drive. In addition, the data is accessed in parallel from each drive which is beneficial for large file transfers. However, performance is poor for high I/O transaction applications since it requires access to each drive in the array.

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In RAID level 4, an entire data block is written to a disk drive. Parity for each data block is stored on a single parity drive. Since each disk is accessed independently, this technique is beneficial for high I/O transaction applications. A drawback with this technique is the single parity disk which becomes a bottleneck since the single parity drive needs to be accessed for each write operation. This is especially burdensome when there are a number of small I/O operations scattered randomly across the disks in the array.

In RAID level 5, a data block is partitioned into stripes which are striped across the disk drives. Parity for the data blocks is distributed across the drives thereby reducing the bottleneck inherent to level 4 which stores the parity on a single disk drive. This technique offers fast throughput for small data files but performs poorly for large data files.

A typical data storage system can contain a number of disk storage devices that can be arranged in accordance with one or more RAID levels. A RAID controller is a device that is used to manage one or more arrays of RAID disk drives. The RAID controller is responsible for configuring the physical drives in a data storage system into logical drives where each logical drive is managed in accordance with one of the RAID levels.

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RAID controllers are complex and difficult to configure. This is due in part to the numerous possible configurations that can be achieved, the knowledge required by a user to configure such a system, and the time consumed by a user in configuring the controller. In one such RAID controller configuration procedure, an automatic configuration feature is provided that attempts to alleviate the user's input by automatically configuring a number of devices at system initialization. However, this automatic configuration feature is very limited and only operates where all the physical disk drives are of the same physical size and where there are between 3 to 8 disk drives. In this case, the automatic configuration feature configures the disk drives as a single drive group defined as a RAID level 5 system drive with no spare drives. This configuration is limited providing no other alternate configurations.

Accordingly, there exists a need for an automatic RAID controller configuration mechanism that can accommodate various types of RAID level configurations and for disk drives having various physical dimensions.

#### Summary of the Invention

The present invention pertains to an apparatus and method for automatically configuring disk drives connected to a RAID controller. The automatic configuration mechanism is able to generate a full configuration of the disk drives connected to a RAID controller both at system initialization or bootup and at runtime. The mechanism uses a robust criteria to configure the disk drives which allows the drives to be configured in accordance with one or more RAID levels and with various default settings that affect the operation of the disk array.

In a preferred embodiment, the automatic configuration mechanism includes a startup configuration procedure that provides the automatic configuration capability at system initialization and a runtime configuration procedure that automatically configures disk drives connected to the RAID controller at runtime. The startup configuration procedure generates a full configuration of the disk drives. The configuration specifies the logical drives that are formed and the associated operational characteristics for each logical drive which includes the RAID level, the

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