

October 2000
13JE-1000A-WWEN

Prepared by Storage Products
Group

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Contents

Introduction.....2
What customers can expect
from Compaq RAID ADG
solution.....3
RAID ADG Features and
Benefits.....3
Choosing a RAID level5
When customers should use
RAID ADG.....6
Summary6
Notice.....7

New Advanced RAID Level for Today's Larger Storage Capacities: *Advanced Data Guarding*

Abstract: The purpose of this paper is to communicate the advantages of utilizing Compaq's new RAID innovation, Advanced Data Guarding (ADG).

RAID ADG provides a new level of fault protection at a high level of capacity utilization. Designed to be first supported on the Smart Array 5300 Controller, RAID ADG is ideal for applications requiring larger storage volumes, delivering a powerful fault tolerant solution at a lower implementation price.

Every Compaq server customer implementing an array with 8 or more hard disk drives should consider this new RAID level.

This innovative Compaq solution for the Smart Array 5300 is patent pending and is not a feature of competitors' PCI RAID products.

Introduction

With a growing need for larger storage capacity, customers are demanding reliable ways to protect large volumes of data stored across an increasing number of disk drives. RAID technology allows a group of disk drives to be “tied” together to act like a single logical disk drive from the operating system perspective, providing increased performance and fault tolerance. Currently, Compaq offers very reliable RAID systems with the family of [Smart Array Controllers](#) that support RAID 0, 1, 0+1, and 5.

For customers who wish to create large logical drives with a high number of disk drives or high capacity disk drives they need to consider the limitation of current RAID schemes. With RAID 1, it is expensive to create large volumes based upon the consumption of disk drives for mirroring. With RAID 5, it is not recommended to configure a logical drive array with greater than 14 drives due to risk of data loss.

In addition, today's larger disk drive capacities may leave an array exposed to a considerable amount of risk following a single disk drive failure due to the time required to rebuild the failed drive. A second drive failure in a mirrored set in RAID 1 and any second drive failure in RAID 5 would cause an array to fail, causing data loss and downtime. With this in mind, larger capacity disk drives present new risks due to longer drive rebuild times.

Compaq's new Advanced Data Guarding reduces the risk of an array failure and requires far less storage capacity overhead than RAID 1.

The following table illustrates the current RAID levels used by customers, their purposes, and limitations, compared to the new advanced RAID level from Compaq:

Table 1. RAID levels and functions

RAID LEVEL	PURPOSE	LIMITATION
RAID 0	Increased performance when no RAID protection is required.	No fault tolerance and highly vulnerable to failure.
RAID 1, 0+1	Mirroring: Identical data stored on multiple drives, high fault tolerance, improved performance.	Requires 50% of capacity to be dedicated to fault protection. Expensive to implement across large volumes (doubling the cost-per-capacity).
RAID 5	Distributed Data Guarding: Parity data is distributed across all drives. Protects against the failure of any one drive in an array. Provides improved performance at a minimum cost.	Lower fault tolerance. Not recommended for volumes greater than 14 drives. Too risky for large volumes.
NEW RAID ADG	Advanced Data Guarding: Two sets of parity data distributed across all drives. Protects against the failure of any two drives in an array. Provides high fault tolerance at a minimum implementation cost.	Lower performance than other RAID levels.

What customers can expect from Compaq RAID ADG solution

RAID ADG is a new advanced RAID level that increases the number of sets of parity, creating multiple sets striped across the disks to provide unparalleled fault tolerance, greater than RAID 1 or RAID 5, and at a lower cost implementation than RAID 1. Designed for support on the [Smart Array 5300 Controller](#), RAID ADG is ideal for applications requiring large volumes. Available in the 1st quarter of 2001, with the Smart Array 5300 Controller, RAID ADG can safely protect an array up to 56 total drives, ensuring customers of a powerful solution with high fault tolerance.

Some customers' needs now require a fault tolerance scheme that would provide higher reliability than RAID 5 at a lower cost than RAID 1. Compaq recognized these customers' needs for high capacity RAID protection on a single storage array that could span a large number of disks. Customers can now complete their server/storage solution with a Compaq innovation - Advanced Data Guarding (RAID ADG) system.

RAID ADG Features and Benefits

- ✓ RAID ADG can tolerate multiple simultaneous drive failures without downtime or data loss.¹
- ✓ Ideal for applications requiring large logical drives
- ✓ Can safely protect an array up to 56 total drives
- ✓ Greater fault tolerance than RAID 1 or RAID 5
- ✓ Lower implementation cost than RAID 1
- ✓ Supports Online Spare Drive
- ✓ Supports Online RAID Level Migration from RAID 1 or RAID 5

¹ A RAID ADG Enabler Module must be attached to the controller to enable RAID ADG configuration via Array Configuration Utility (ACU). The module is shipped with the 128MB cache board.

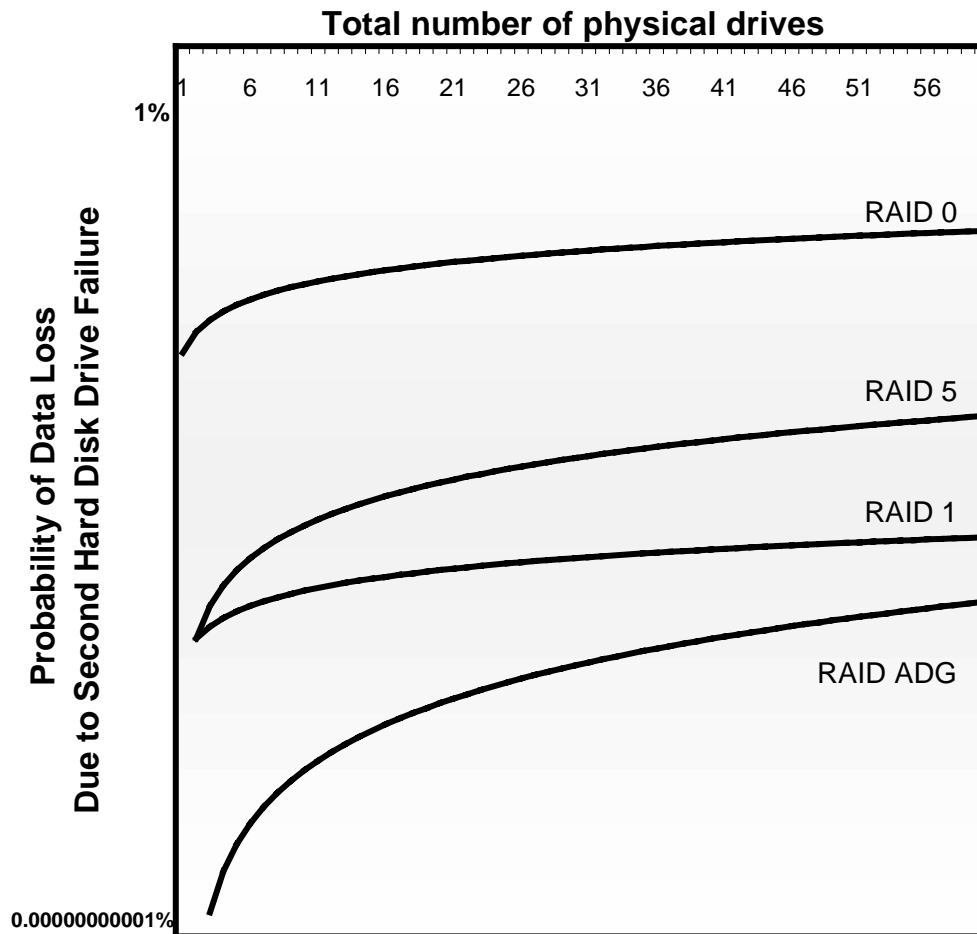
RAID ADG provides greater fault tolerance

With growing numbers of individual disk drives needed in a single logical volume on a single controller, RAID ADG provides higher data reliability than previously available from a RAID storage provider. In Figure 1 below, RAID ADG has a superior fault tolerance when compared to RAID 5 or RAID 1.

Figure 1 shows the probability of logical drive failure for various RAID levels and different physical drive counts:

- With RAID 0, the logical drive will fail if one physical drive fails.
- With RAID 5, the logical drive will fail if two physical drives fail.
- With RAID 1 or 0+1, the maximum number of hard drives that can fail without failure of the logical drive is $n/2$. However, a RAID 0+1 logical drive will fail if only two hard drives fail, if they are mirrored to each other.
- With RAID ADG, three hard drives must fail before data loss is incurred.

Figure 1. RAID ADG Fault Tolerance Comparison



Choosing a RAID level

Customers should consider a variety of factors when choosing which RAID level best suited for their needs. These factors include:

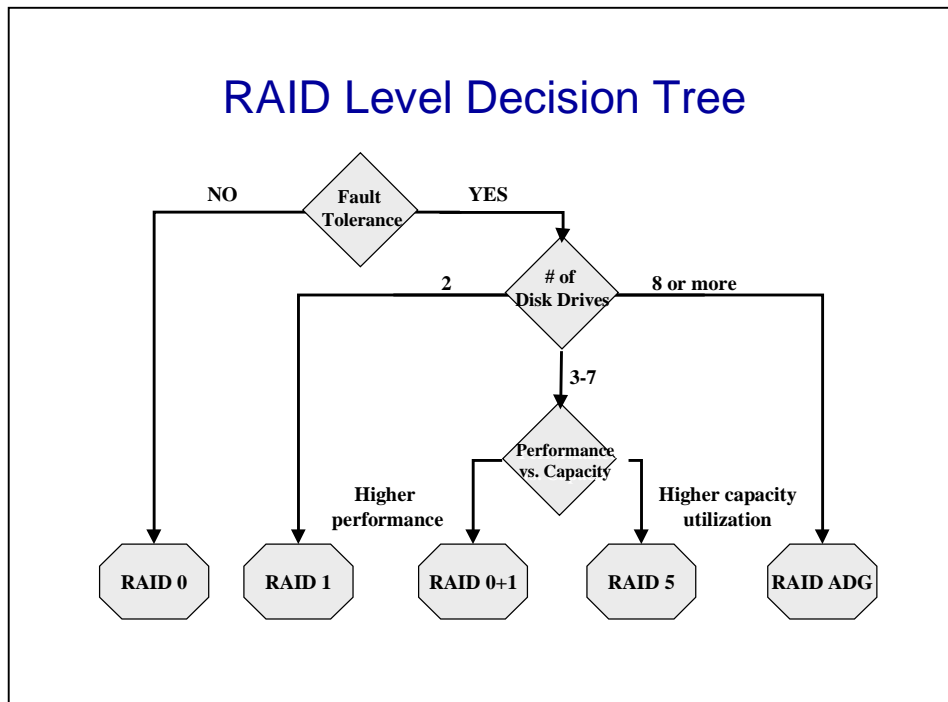
1. Capacity utilization and budget;
2. Availability and Uptime requirements; and
3. Performance requirements.

Tables 2 and 3 help determine which RAID level best suits particular requirements.

Table 2. Choosing a RAID method.

MOST IMPORTANT	SECONDARY IMPORTANCE	RAID LEVEL CHOICE
Cost Effectiveness (cost per usable capacity)	Fault Tolerance →	RAID ADG
	Performance →	RAID 5 (RAID 0 if fault tolerance is not needed)
Fault Tolerance	Cost Effectiveness →	RAID ADG
	Performance →	RAID 0+1
Performance	Cost Effectiveness →	RAID 5 (RAID 0 if fault tolerance is not needed)
	Fault Tolerance →	RAID 0+1

Table 3. RAID Level Decision Tree



When customers should use RAID ADG

Advanced Data Guarding is ideal for applications requiring larger storage volumes. RAID ADG is best implemented when customers have the following needs:

- ✓ For greater capacity utilization
- ✓ For mission-critical data
- ✓ When large logical drives are required
- ✓ When better capacity utilization than RAID 1 is needed
- ✓ When higher fault tolerance than RAID 1 or RAID 5 is necessary

In addition, customers can migrate from their existing RAID levels to RAID ADG and from RAID ADG to other RAID levels as well.

Note: If a RAID volume does not have available capacity equal to one disk drive, it may require adding a disk drive and expanding the RAID volume. Refer to the Compaq User Manual for more detailed information.

Summary

With RAID ADG, the new Compaq exclusive and advanced RAID level, customers are provided with a capacity utilization that is ideal for large capacity logical drives. Every Compaq server customer implementing RAID volumes with 8 or more hard disk drives should consider this new RAID level. **This innovative Compaq solution for today's large storage capacities is not provided by any other competitor.**

Note: RAID ADG is standard with the Compaq Smart Array 5304/128 and will be sold as an option with Smart Array models 5302/64 and 5302/32. RAID ADG will be available in 1Q/2001.

Notice

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Printed in the U.S.A.

First Edition (October 2000)
Document Number

