White Paper

A Look at Modular RAID on Motherboard (MROMB)

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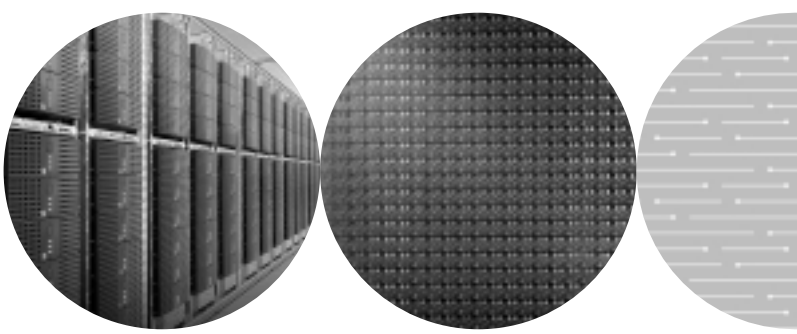

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Meeting increasing storage demands in smaller physical space

The demand for increased storage imposed by today's computing requirements is driving searches for new ways to store and protect stored data in a shrinking rack space environment. While processor clock rates have grown steadily over the past twenty years, the need for storage space has grown substantially and the expense of physical space has increased, fueling a need for compact, reliable, highly available and modular storage solutions.

With demand for storage space seriously outpacing demands for processing power, redundant array of independent disk (RAID) technology is increasingly used to meet the need for protected high-density storage space. But though critical data exists in businesses of every size, RAID technology has not been deployed indiscriminately, due to cost, complexity and support issues.

Zero channel RAID (ZCR) or modular RAID on motherboard (MROMB) is becoming an attractive choice for other equipment manufacturers (OEMs) looking to implement cost-effective hardware RAID solutions in high-density servers. A zero-channel RAID adapter is a peripheral component interconnect (PCI) RAID controller that doesn't have any small computer serial interface (SCSI) channels on board, but is instead designed to use the on-board SCSI channels of the server motherboard to implement a cost-effective hardware RAID solution.

Unlike RAID on motherboard (ROMB), which puts all RAID related components on the motherboard, MROMB offers the flexibility of a full-featured add-in card with efficient system resource use, and therefore low cost. The major difference between a RAID add-in card and an MROMB card is that the MROMB card lacks a SCSI input/output (I/O) chip. MROMB is similar to an add-in RAID card in that it is installed in a PCI slot on the motherboard, but the slot must have been modified to support a PCI MROMB RAID card. When the MROMB card is inserted in this special slot, the on-board SCSI channels of the motherboard become a RAID-enabled subsystem, capable of almost all the functionality of a full featured, add-in RAID card. When not occupied by the specially designed RAID add-in card, the PCI slot can be used as a standard 64-bit 66 MHz PCI or PCI-X slot.

MROMB can also be implemented through a dedicated, small form factor PCI connector on the motherboard and a credit-card sized RAID card designed to fit it. The low profile form factor of this solution meets customer needs for physically smaller servers. But because of the dedicated hardware, this approach is more expensive for motherboard manufacturers to apply. It has the advantage of not consuming a PCI slot, a resource which could be at a premium in low-profile 1U and 2U server systems. As designers increasingly locate most components (such as video, network interface card (NIC) and so on) on the motherboard, however, minimizing the use of PCI resources becomes less of an issue.

Current host-based hardware RAID solutions

The most common way to add RAID capability to a server is using a host-based adapter (HBA) RAID card (see Figure 1). It is also generally the most expensive approach since it duplicates some components already present on the motherboard, in particular the SCSI I/O components. It is quite flexible, however, because the processing power, software and I/O logic are incorporated on the RAID card.

At the other end of the price spectrum is the ROMB approach. ROMB is an efficient, cost-effective solution that leverages the RAID components that are already built into the motherboard. With the ROMB approach, however, the motherboard manufacturer is burdened with the expense of implementing the RAID solution on every motherboard produced, the cost of which is passed on to the end-user—even if the user never takes advantage the RAID functionality.

The MROMB approach (see Figure 2) is designed to offer the best of both worlds. A MROMB implementation provides great flexibility in equipping a system with RAID, just as the HBA approach does. By using the onboard SCSI I/O processor built into the motherboard instead of providing a duplicate SCSI I/O controller, the MROMB solution can be priced closer to that of a ROMB solution.

In addition, MROMB controllers provide a compact, low-profile form factor consistent with the limited space requirements of 1U and 2U high-density servers. The cost to the motherboard manufacturer for implementing MROMB is generally affordable.

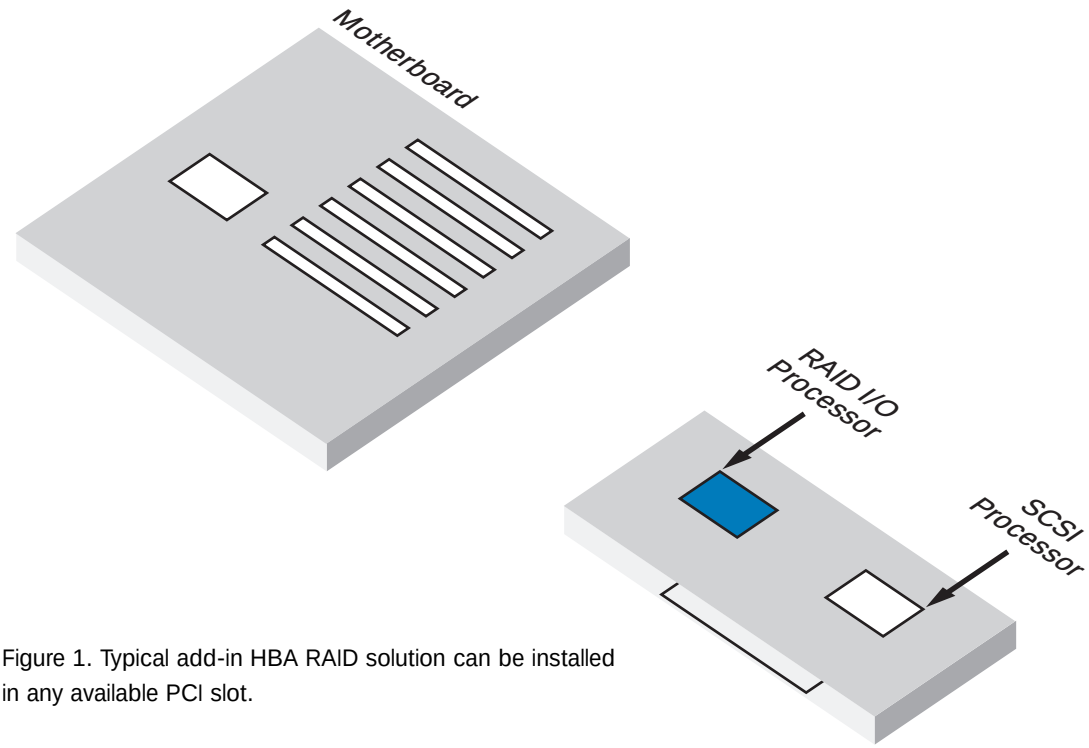

Figure 1. Typical add-in HBA RAID solution can be installed in any available PCI slot.

The evolution of RAID on motherboard solutions

Incorporating a zero channel RAID on motherboard solution is not entirely new. All major RAID vendors have explored proprietary solutions.

Beginning in 1998 and 1999, several product families were introduced that used innovative technologies on the motherboard to create RAID solutions. While implementation details differed, these solutions were based on the same fundamental concepts, which were:

- Build a PCI RAID card around an I/O processor, such as the Intel® i960® Rx reduced instruction set computing (RISC) chip.
- De-populate the SCSI I/O processor and connectors.
- Incorporate special interrupt logic that steers the host I/O interrupts to a pre-assigned system PCI RAID or proprietary slot, which in turn delivers control of the onboard motherboard SCSI chips to the RAID controller.

Various problems were associated with these early solutions, however. For example:

- Some operating system installations install unnecessary generic I/O drivers that try to control the device and produce driver conflicts when the generic driver and the RAID controller firmware try to access the same device.
- Optional ROMs on other add-in cards from the same manufacturer could interfere with the operation of the add-in RAID card.
- The initialization device select (IDSEL) signal, which identifies devices on the PCI bus, can be left uncontrolled on the host system I/O device.

The IDSEL problem is the most common, and is aggravated by the fact that a standardized way to control IDSEL has not been developed for the different chipsets used by motherboard design engineers and manufacturers. Up to now, it has been up to the host BIOS to accommodate each variation and implement each new implementation. This lack of standardization has inhibited the development of a consistent core host BIOS across different platforms and limited the deployment of MROMB solutions in general.

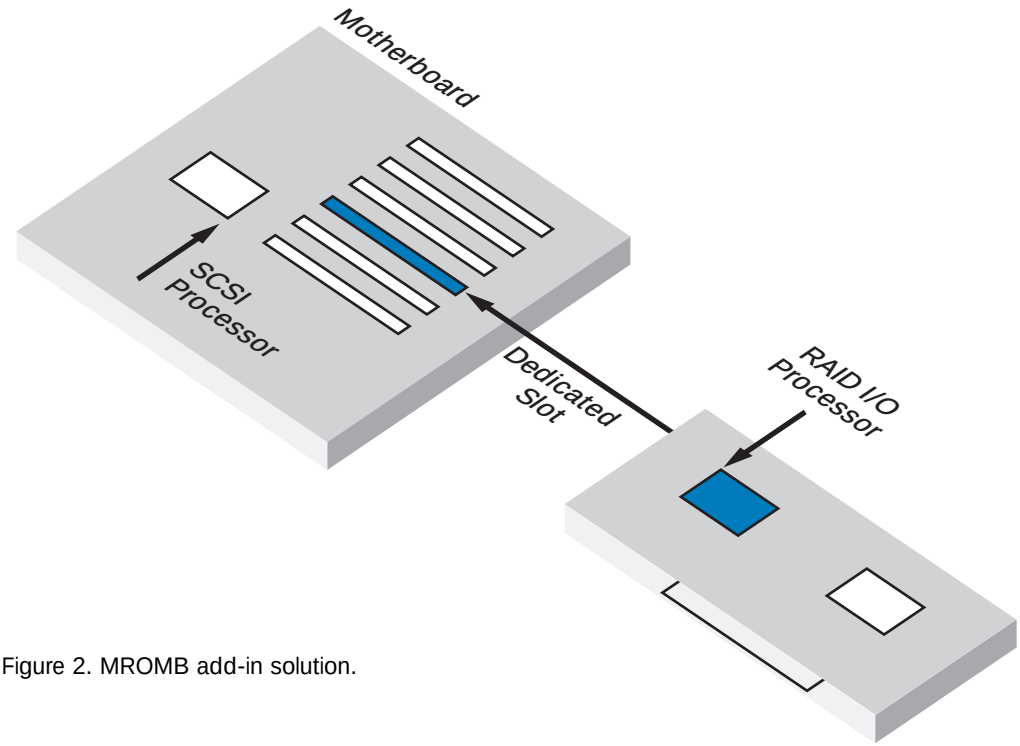

Figure 2. MROMB add-in solution.

Introducing next-generation MROMB solutions

New ways of implementing MROMB technology have recently emerged.

Intel and Adaptec, Inc. have both introduced inexpensive, modular RAID technologies designed to allow OEMs to deploy RAID technology on mid-range server boards.

The Intel solution is RAID I/O steering, or RAIDIOS, which is designed to take advantage of MROMB solutions, such as the Intel® SRCMRU Zero Channel RAID card powered by the Intel® IOP303 RISC-based I/O processor. The Intel® IOP303 I/O processor is an open architecture, proven I/O processor used in many OEM RAID solutions. RAIDIOS allows two channels of onboard I/O SCSI to be used. Intel RAIDIOS logic circuitry can currently be found on such boards as the Intel® SCB2, SuperMicro* P4DP6 and other platforms. In fact, RAIDIOS has been adopted by most server board manufacturers implementing a PCI based ZCR solution.

Embedded RAID logic, or EMRL*, from Adaptec is specifically designed to be used with Adaptec Zero Channel RAID cards that contain the recently introduced Adaptec AIC* 7930W RAID I/O processor. EMRL requires more discrete logic on the motherboard than the Intel solution, a cost that has to be absorbed by the motherboard manufacturer. EMRL's dependence on a proprietary processor and need for discrete logic support components limit this approach's flexibility.

Adaptec has two such ZCR cards with different form factors shipping currently. One is a credit-card sized device that requires a special connector be placed on the motherboard instead of using an existing PCI slot, so it can be used for other purposes. The other is a standard PCI format card which can take advantage of EMRL or RAIDIOS.

MROMB technology overview

In a typical implementation of an attached PCI I/O device, such as an onboard SCSI controller, interrupt signals are routed to the host system's interrupt controller. When the device requires service from its host driver, the interrupt is received by the host interrupt controller and serviced accordingly.

Implementing RAID using the onboard SCSI device requires that I/O signals generated by the host be intercepted when they are issued. Once a signal is intercepted, it is passed to the RAID circuitry for processing and the requested data is then passed over to the I/O channel. To accomplish this, interrupt

signals directed to the onboard SCSI controller are rerouted to the special MROMB assigned PCI slot when the zero channel device is present using one of the MROMB technologies (see Figure 3).

When the system is booted, the host BIOS scans the PCI bus to locate all attached PCI devices. The IDSEL signal is used by the system to identify all I/O devices it finds and assign the needed resources to them.

When a ZCR adapter is present in its MROMB-enabled PCI slot, it takes control of the IDSEL signal and performs its own configuration cycles to the onboard SCSI I/O controller. This has the effect of hiding it from the host during its configuration cycles. Once the SCSI is hidden and the MROMB adapter controls the bus, it uses its MROMB controller logic to ensure that IDSEL for the SCSI devices are controlled by the MROMB card. This makes sure the host system never sees the SCSI devices and the MROMB card has full control and can now provide RAID functionality using the onboard SCSI I/O processor(s).

The dissimilar processes that the PCI or PCI-X 133 devices and MROMB use for handling host communication use produce timing differences, which lead to divergences in the operation of the RAIDIOS and EMRL implementation schemes.

Intel RAIDIOS compensates for timing differences by placing the control logic on the MROMB card. EMRL, on the other hand, requires that discrete logic compensating for the timing differences be installed on the motherboard. EMRL therefore requires design changes on the motherboard to make it work for PCI-X while RAIDIOS requires no such changes.

In either case, when the system is rebooted, the user is presented with the RAID controller setup BIOS screen instead of the standard onboard SCSI screen. By pressing a pre-defined hot-key combination, the user can access the processes for setting up the attached SCSI hard drives into a hardware RAID configuration, just as would be done for an HBA add-in RAID controller.

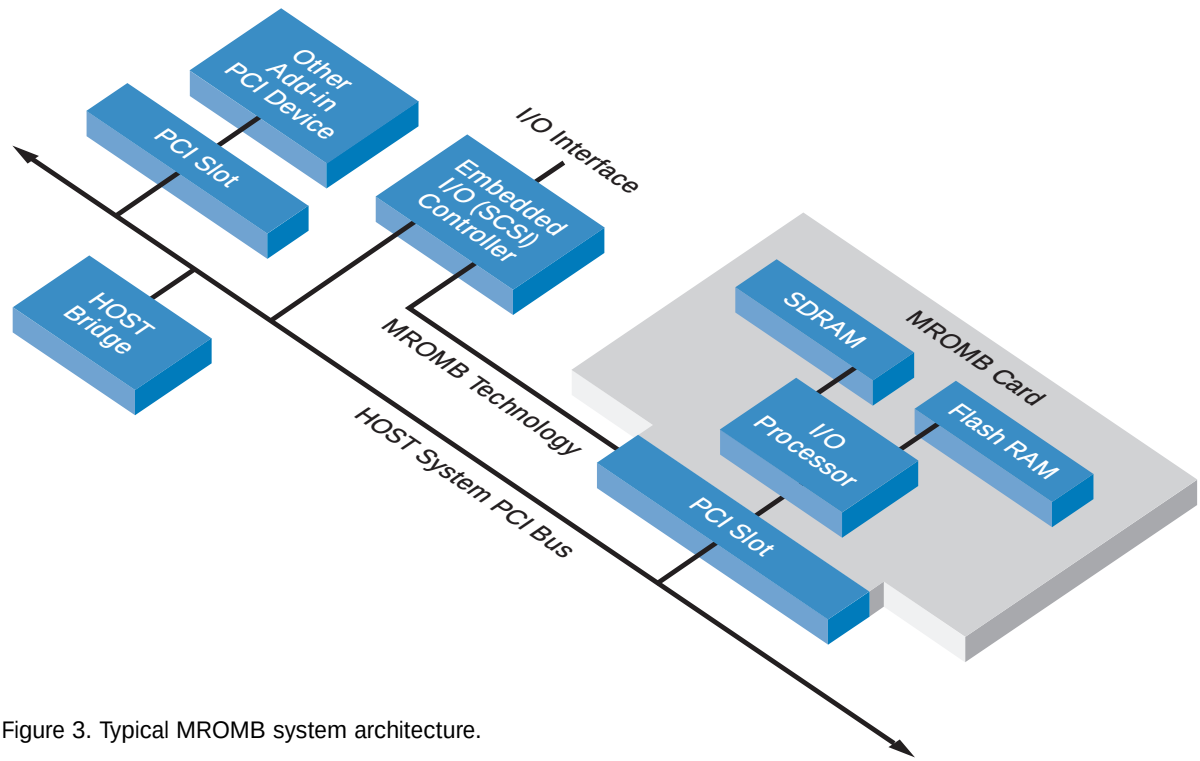

Figure 3. Typical MROMB system architecture.

Target markets

MROMB technology is of great interest to customers currently hampered by short supply of storage space and seeking high-density servers. This customer base includes, but is not limited to, Internet service providers (ISPs), application service providers (ASPs), storage service providers (SSPs) and other storage-hungry customers. These industry providers typically need the ability to quickly add processing power and require enormous amounts of protected storage.

Conclusion

The demand for denser, less expensive, higher performing storage solutions is leading to the deployment of MROMB technology on more and more motherboards.

MROMB cards are less expensive and generally smaller than add-in single and dual-channel host-based RAID solutions because they don't duplicate components, such as SCSI I/O, found on the motherboard. They provide advanced RAID performance similar to an add-in RAID card.

MROMB add-in cards do however require IDSEL interrupt logic, such as Intel RAIDIOS or Adaptec EMRL, to be present on the motherboard. While both technologies are relatively inexpensive for motherboard manufacturers to implement, the Intel solution offers greater flexibility. MROMB also combines the best of host-based RAID and ROMB solutions by providing the flexibility to upgrade at low cost without burdening motherboard makers with unnecessary expense.

Author's biography

Frank Poole is a RAID Technical Marketing Engineer for the Storage Components Division, Intel Corporation. Frank is responsible for assisting engineering in identifying and defining market opportunities and product development in SCSI, SATA and Fibre Channel storage as well as providing pre and post sales support to major OEM and ODM customers. Frank has over 6 years experience in server storage and comes to Intel through the 2001 acquisition of RAID industry innovator ICP vortex Computersysteme GmbH, Neckarsulm, Germany.

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