Choosing Between Monolithic Versus Modular Storage: Robustness, Scalability and Price Are the Tiebreakers

Stanley Zaffos, Valdis Filks

Monolithic storage arrays continue to lead their modular counterparts in availability, scalability and throughput, but improvements in modular designs are making these less-expensive systems increasingly attractive to enterprises. IT managers need to study the strengths and limitations of each architectural design and let their organization's needs, both present and future, guide their decisions.

Key Findings

- The market for modular and monolithic storage has become increasingly chaotic as major vendors launch new products that blur the feature lines between modular and monolithic storage systems.
- Modular systems are gaining market share from monolithic systems as new systems scale performance, throughput and capacity faster than user requirements.
- Monolithic systems have advantages in scalability and robustness that will not be overcome for at least the next two generations of modular systems, but their price can be prohibitive, particularly with small configurations.
- Innovation generally appears first in the modular array segment in the form of new features, functions and inclusive pricing models, because these systems are refreshed at a faster rate than the monolithic storage segment.

Recommendations

- Prioritize business and operational needs first before narrowing down your vendor/product list, because business requirements should lead the decision-making process.
- Quantify the economic cost of downtime and the probability of worst-case electronics failures occurring, and their impact on the storage system’s ability to meet SLAs.
- Quantify the time needed to do microcode updates, taking into account their impact on system performance and throughput, as well as their impact on the storage system’s ability to meet SLAs.
- Identify the impacts that changing storage systems and/or vendors would have on operations, including disaster recovery, and challenge vendors to assist you in finding the most appropriate configuration for your organization.

© 2010 Gartner, Inc. and/or its Affiliates. All Rights Reserved. Reproduction and distribution of this publication in any form without prior written permission is forbidden. The information contained herein has been obtained from sources believed to be reliable. Gartner disclaims all warranties as to the accuracy, completeness or adequacy of such information. Although Gartner's research may discuss legal issues related to the information technology business, Gartner does not provide legal advice or services and its research should not be construed or used as such. Gartner shall have no liability for errors, omissions or inadequacies in the information contained herein or for interpretations thereof. The opinions expressed herein are subject to change without notice.
WHAT YOU NEED TO KNOW

This document was revised on 23 June 2010. For more information, see the Corrections page on gartner.com.

Gartner clients often ask if they need to purchase yet another monolithic storage array for their data storage needs, or whether a modular system may be just as suitable. While monolithic or enterprise-class storage arrays provide better availability, scalability and throughput, they are generally more expensive at the outset.

- Use your operational and business needs, present and future, to guide your purchase strategy.
- If you bought monolithic storage arrays several years ago, review your buying strategy concerning storage. You may find that you can achieve the same levels of reliability, availability and serviceability (RAS) for less investment.

ANALYSIS

Advances in modular storage arrays, and the standardization and commoditization of hardware components, are closing the gap between some monolithic and modular storage systems, with scale, capacities, functions and features of high-end modular systems overlapping those on the low end of monolithic systems. Note these recent trends:

- New, simpler management tools and price models, such as inclusive data services, make modular storage systems much easier to purchase, upgrade and manage than monolithic storage arrays.
- Monolithic storage arrays have richer features in some traditional areas, such as replication, but not in the more recent technological developments, such as automated tiering, thin provisioning and primary deduplication.

Defining Monolithic and Modular Storage Systems

Monolithic storage systems comprise large collections of drives with lots of host connectivity and the ability to mask most transient and permanent electronics failures from the storage area network (SAN). They can directly connect to hundreds of servers and legacy systems. They have many controllers that share direct access to a global memory cache of fast memories (hundreds of gigabytes). Monolithic arrays are initially more expensive than modular arrays. However, they have redundancy features that are built in to enhance reliability.

Gartner defines a modular disk array product as an external, controller-based redundant array of independent disks (RAID). These systems come in two variants: dual-controller architectures with separate cache memory in each, and scale-out architectures that can have many nodes with cache in each node. Dual-controller architectures mirror writes into the cache located in each controller to prevent loss of data, and they hold between 16 GB and 32 GB of memory. Scale-out architectures with multiple nodes usually continue caching reads, and frequently writes, in the presence of node failures. Modular systems are less expensive than monolithic systems, and, if stacked with enough controllers and shelves, they can handle large amounts of data. Excluding mainframes, they can directly connect to tens or hundreds of servers. Table 1 outlines the two sets of criteria by which Gartner classifies storage systems as monolithic or modular.
Table 1. Monolithic Versus Modular — Definitional Criteria

<table>
<thead>
<tr>
<th>Monolithic storage arrays meet the following criteria:</th>
<th>Modular storage arrays meet the following criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use a multiple-controller architecture</td>
<td>• Use a dual-controller, scale-out or cluster architecture</td>
</tr>
<tr>
<td>• Support mainframe and open-systems environments</td>
<td>• Support Unix, Linux, Windows, VMware and NetWare environments</td>
</tr>
<tr>
<td>• Support Fibre Connectivity (FICON) or Fibre Channel (FC) host connectivity</td>
<td></td>
</tr>
<tr>
<td>• Support z/OS and/or other mainframe operating systems</td>
<td></td>
</tr>
</tbody>
</table>

Source: Gartner (June 2010)

In large data centers, monolithic or modular installations are mostly connected to servers via SAN switches using fan-out architectures, where many servers are consolidated by logically sharing the same physical storage array connections. For all but the largest configurations, modular arrays can now support hundreds of server connections using this method, while monolithic arrays can support thousands of servers. Storage array port oversubscription needs to be considered when designing and architecting these configurations. This depends on the input/output (I/O) access patterns concerning bandwidth and latency required by the attached servers. Table 2 provides an architectural comparison of monolithic and modular storage systems.

Table 2. Architectural Comparison of Monolithic Versus Modular Storage Systems

<table>
<thead>
<tr>
<th>Architectural Characteristic</th>
<th>Monolithic</th>
<th>Modular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-end host connections</td>
<td>Up to 230 ports or connections generally implemented using proprietary circuit boards and application-specific integrated circuits (ASICs)</td>
<td>Up to 32 ports implemented either with proprietary circuit boards or commodity host bus adapters (HBAs) as initiators</td>
</tr>
<tr>
<td>Controllers</td>
<td>Dedicated and proprietary in most cases, but some are using commodity components and/or scale out architectures</td>
<td>Established vendors generally using proprietary circuit boards while emerging storage vendors are generally using commodity motherboards</td>
</tr>
<tr>
<td>Firmware or operating systems</td>
<td>Proprietary or highly customized niche real-time operating systems</td>
<td>Unix-based operating systems with cut-down kernels</td>
</tr>
<tr>
<td>Memory</td>
<td>Some high cost, but mostly dynamic random-access memory (DRAM) with error correction code (ECC)</td>
<td>Commodity DRAM with ECC and evolving to incorporate NAND Flash</td>
</tr>
<tr>
<td>Back-end controllers</td>
<td>Proprietary backplanes and protocol converters but newer designs use more standard interconnects.</td>
<td>Commodity interconnects. Combined with the front end controller on one board. One to two in quantity. More in scale out architectures.</td>
</tr>
</tbody>
</table>
## Decision-Making Criteria

For IT managers, the choice between monolithic and modular systems involves several factors. Chief among these should be the business needs of the organization followed by technical factors. Consider:

1. **Enterprise size and configuration.** How big is your organization? Does it have remote sites? Often, in a centralized hierarchical organization, only the central IT department can purchase storage infrastructure items. In a decentralized organization, local groups may purchase and maintain their own storage. Often, modular systems make sense in the latter scenario, but in either case, the storage strategy should determine the process.

2. **Budget.** Modular systems are less expensive at the outset because they can use open or easily ported software and commodity components. However, they may incur more costs in downtime, or require special utilities or devices to make them work well. Additional expenses can also be incurred if more modular systems than needed are deployed to ensure that SLAs are met in the presence of controller failures. Conversely, with monolithic systems, management and operational costs may be lower because of their superior tolerance of electronics failures and economies of scale that simplify disaster recovery, improve staff productivity and reduce the number of systems needed to support the application workloads. While monolithic storage arrays can also use commodity components, they usually include costly proprietary hardware components, such as application-specific integrated circuits (ASICs), backplanes, and packaging, which adds to the cost.

3. **Management.** Modular arrays have simpler configuration and management interfaces, and can improve storage administrator productivity. Conversely, management of monolithic storage arrays caters to heritage architectures and provides low-level configuration options. There has been some movement toward scale-out. However, IT managers can customize and tune monolithic arrays — a costly, time-consuming task that requires expert assistance. With the volume of data and storage growing, it is increasingly difficult and costly to manually tune storage for all applications. Manual tuning does not scale and is not productive as fully automated storage systems. In corner cases for specific applications, it can be a benefit.

4. **Connectivity.** Historically, monolithic storage had extra connectivity, such as FC, iSCSI, FICON and ESCON. However, today’s modular storage arrays have all this too, except for connections such as FICON to niche systems such as Unisys, IBM AS/400 (i-series) and IBM z-series mainframes. So, connectivity is not as significant a factor as it was.

### Architectural Characteristic

<table>
<thead>
<tr>
<th>Internal data path connections</th>
<th>Monolithic</th>
<th>Modular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separate control and data paths. Dual pathing with auto failover. Standardized protocols based on SCSI, such as FC. Several control and data paths in quantity.</td>
<td>Standardized low cost protocols, such as SAS, SATA or FC. Dual pathing and failover is dependent on protocol used. For example, SAS-2 and FC have higher availability than SATA. The control paths are often not separate from data paths.</td>
<td></td>
</tr>
</tbody>
</table>

### Disks

<table>
<thead>
<tr>
<th>Monolithic</th>
<th>Modular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher-cost FC disks, but also lower-cost PATA and SATA. Up to 2,800 disk drives</td>
<td>Moving quickly from FC with most using lower-cost SAS and SATA. Up to 1,300 disk drives.</td>
</tr>
</tbody>
</table>

*Source: Gartner (June 2010)*
5. **Operational complexity.** Monolithic system scalability reduces operational complexity by supporting connectivity to mainframes and having more physical ports to connect to distributed systems’ SANs. Many companies use monolithic arrays to help consolidate more storage into less space without losing performance when servers are added.

6. **Loss/risk management.** In a monolithic system, there can be a number of electronics failures that are hidden from the SAN and attached servers, except for their impact on performance and system throughput. Modular systems can also maintain data accessibility in the presence of electronics failures, but they generally rely on path failure software, which means that the failures are not hidden from the SAN and servers.

7. **Features.** Emerging storage companies, such as Compellent; Dell, with its EqualLogic series; HP, with its LeftHand series; IBM XIV; NetApp; Pillar Data Systems; Oracle, with its 7000 series; and 3PAR, have been driving innovation into storage systems; any shortlist of valuable new functionality would include automated tiered storage, deduplication, thin provisioning and new RAID algorithms that rebuild data faster than traditional algorithms. The established modular and monolithic vendors, with a few exceptions, have been reacting to these innovations by retrofitting new functionality into their systems, while maintaining backward compatibility. Usually, this new functionality has not been introduced into the vendors’ modular and monolithic systems at the same time, which reflects that their modular or monolithic systems are built on different technology platforms. Examples of current modular storage system families that have been enhanced with new functionality include EMC CLARiiON (aka CX4) series and Hitachi Data Systems AMS 2000 series. Examples of monolithic systems that have added new functionality first introduced by emerging storage include EMC Symmetrix VMAX, Hitachi Data Systems USP V and IBM DS8000 series.

8. **Performance and throughput.** Dual-controller modular systems with limited amounts of cache and compute capacity are inherently disadvantaged relative to monolithic systems, particularly with multitenant workloads. However, multinode scale-out architectures hold the promise of helping modular systems to asymptotically approach monolithic storage system levels of throughput and availability.

9. **Availability.** For the highest availability, reliability and legacy system support, choose monolithic storage arrays. However, do not forget to implement strict change management processes and procedures to manage these arrays to obtain high availability. Storage arrays without good management processes and proactive maintenance will not obtain the highest availability levels.

Table 3 summarizes information that can help you decide when to use which system.

**Table 3. Monolithic Versus Modular — Decision-Making Criteria**

<table>
<thead>
<tr>
<th>Use monolithic systems when:</th>
<th>Use modular systems if:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• You need mainframe connectivity.</td>
<td>• You only require connections to standard protocols, such as FC, FCoE, iSCSI, NFS, or CIFS.</td>
</tr>
<tr>
<td>• You need extremely high RAS and short recovery point objectives and recovery time objectives.</td>
<td>• Your SLAs can tolerate the impact of microcode updates and the possibility of a controller failure bringing the systems out of compliance for some number of hours.</td>
</tr>
<tr>
<td>Use monolithic systems when:</td>
<td>Use modular systems if:</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>• You need scalability for very large storage consolidation projects.</td>
<td>• You are an early adopter of new features and functions, such as primary deduplication and automated tiering, and scalability is adequate. While some modular systems claim no practical limits for the number of LUNs and snapshots, a more common limit is approximately 16,000 volumes or LUNs.</td>
</tr>
<tr>
<td>• The number of logical unit numbers (LUNs) exceeds the architectural limits of modular storage system. Typical monolithic systems support 65,000 to 130,000 volumes or LUNs, including snapshots, which is usually more than sufficient for most organizations.</td>
<td></td>
</tr>
<tr>
<td>• You need to reduce the number of devices to manage.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Gartner (June 2010)

**Conclusion: Review Your Storage Strategy With an Eye to the Future**

Monolithic and modular storage systems are differentiated by price, RAS, functionality and scalability. Vendors in both segments are developing innovative implementations and architectures, such as scale-out and scale-up storage, that blur the lines between the two. Both monolithic and modular storage are often used in large enterprise environments. Overlap is pervasive, and is bound to become more so as modular designs continue to advance.

We advise customers who bought monolithic storage arrays several years ago to review their buying strategy concerning storage. A modular storage array in 2010 may have all the RAS and features of a monolithic storage array of several years ago, and meet all customer requirements at a lower price.

**Action items:**

- Create at least three design scenarios that use different technologies to expand and investigate other options.
- Task a central architectural team with providing tactical guidelines and rules on which protocol technologies or storage architectures can and cannot be used, with cost as a consideration.
- Analyze such factors as company size, budget, SLAs, dependence on IT future scaling requirements and RAS requirements to decide which product to implement and from which market segment. Factor in downtime when evaluating costs.
- Check that the high-availability claims of modular and monolithic storage concerning live software upgrades, active device replacement of components, replication features, consistency groups, and snapshot scale and work as claimed. For example, some modular storage arrays are limited by the number of snapshots; consistency groups for replication and hot swap of all components are not available; and hot upgrades take longer than specified.
- Verify and scrutinize vendor promises of new features and functions in monolithic arrays. The vendor road maps and promises are often not met within the stated time scales.

**RECOMMENDED READING**

"Monolithic Block-Access Disk Array Storage Price Forecast: 1H10 Through 1H11"
“Modular Block-Access Disk Array Storage Price Forecast: 1H10 Through 1H11”

REGIONAL HEADQUARTERS

Corporate Headquarters
56 Top Gallant Road
Stamford, CT 06902-7700
U.S.A.
+1 203 964 0096

European Headquarters
Tamesis
The Gianty
Egham
Surrey, TW20 9AW
UNITED KINGDOM
+44 1784 431611

Asia/Pacific Headquarters
Gartner Australasia Pty. Ltd.
Level 9, 141 Walker Street
North Sydney
New South Wales 2060
AUSTRALIA
+61 2 9459 4600

Japan Headquarters
Gartner Japan Ltd.
Aobadai Hills, 6F
7-7, Aobadai, 4-chome
Meguro-ku, Tokyo 153-0042
JAPAN
+81 3 3481 3670

Latin America Headquarters
Gartner do Brazil
Av. das Nações Unidas, 12551
9° andar—World Trade Center
04578-903—São Paulo SP
BRAZIL
+55 11 3443 1509