NETAPP WHITE PAPER

Unified Storage Architecture
Enabling today's dynamic data center

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EXECUTIVE SUMMARY

The traditional model for enterprise storage requires a different storage system for each storage function. One storage architecture might be deployed for primary network-attached storage (NAS), another for storage area networks (SANs), with additional platforms for secondary storage, archive, and compliance. Because of the obvious complexity and cost of such an approach, many vendors in the storage industry have begun to talk about "unified" storage, co-opting the term from NetApp, which pioneered a unified storage architecture years ago. The solutions these vendors offer typically include the ability to accommodate both NAS and SAN protocols, but do so by combining NAS and SAN components with different architectures, management infrastructures, backup requirements, and so on, and rarely offer the scalability and performance necessary in today's enterprise environments.

This paper describes the elements of the NetApp® unified storage architecture in detail, including true multiprotocol support, a single management interface, integrated data protection, support for multiple tiers of storage (primary, secondary, and archive/compliance), quality of service, and the ability to act as a front end for legacy storage systems. NetApp is able to combine these features and more into a single platform capable of meeting your end-to-end storage needs, while demonstrating significant performance and cost-of-ownership advantages, setting the standard by which any storage solution that claims to be unified should be measured.

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1 INTRODUCTION

The enterprise data center is undergoing a radical transformation; server virtualization technology is changing the way both servers and applications are provisioned, while altering the workload on storage systems and increasing storage demand.

The trend toward server virtualization and consolidation is causing a transformation in the way that data centers are being designed, built, and managed. Data storage and data management are key elements of this transformation, because successful virtualization deployments depend upon a shared, networked storage infrastructure capable of eliminating the "silos" of storage associated with various application tiers. This data center transformation makes the idea of "unified storage" increasingly appealing. Unified storage is an important tool that can help address many existing data center challenges, including helping you get power, cooling, and space utilization under control. If you are in the midst of redesigning your data center or establishing a new infrastructure model, unified storage should be a key element of that effort.

But what is unified storage, and what are the requirements for a unified storage solution? Although the marketing literature for many solutions may claim a solution is unified, the reality is often something quite different.

NetApp believes that a true unified storage solution should be much more than a loosely coupled collection of components. In this paper, we'll examine a fundamentally simpler approach to storage, discuss unified storage building blocks, debunk some myths about unified storage performance, illustrate the solution's cost advantages, and describe what we see as the next steps in the evolution of NetApp unified storage.

DEFINITIONS

Let's begin with a few definitions so there is no confusion about what we mean by important terms.

- **Unified storage architecture.** A unified storage architecture creates a single, end-to-end foundation for dynamic data management. It goes beyond simple multiprotocol storage to provide integrated data management and data protection, support for all tiers of storage, quality of service, and other elements, all in a single platform. A unified storage architecture enables the creation of a common storage pool that can be networked and shared across a diverse set of applications with a common set of management processes. The ability to scale from small to very large storage capacity without compromising application performance or service levels is a key attribute.
- **Multiprotocol storage.** A multiprotocol storage system supports both block-based and file-based access in a single storage platform, incorporating Fibre Channel (FCP) and iSCSI access for blocks and NFS and CIFS access for files. Applications can utilize two or more of these protocols simultaneously. The ability to run Fibre Channel protocol over Ethernet (FCoE) is emerging as a key ingredient of modern multiprotocol infrastructures.
- **Dynamic data center.** The dynamic data center is one that leverages a utility computing model, centralized resource management, and rapid and flexible resource allocation to support a wide range of data center applications. This includes the ability to rapidly commission and decommission applications, provision (and reprovision) required resources, and nondisruptively migrate applications and data between resources to meet time-varying application service level requirements. It also includes the ability to seamlessly expand the underlying infrastructure and/or retire older components while maintaining continuous application operations through nondisruptive migration.
- **Unified fabric.** A unified fabric provides a high-bandwidth, single-wire approach in which all of a data center's I/O activity can be consolidated, regardless of underlying network protocols and data formats. From a server and storage perspective, this will reduce the required number of host bus adapters, NICs, switches, and cables. A unified fabric will allow increased data center scalability with improved performance and fault tolerance. The first step toward achieving a unified fabric is having the ability to run Fibre Channel over Ethernet.

ENTERPRISE CHALLENGES AND OBJECTIVES

When we look at typical enterprise challenges and objectives, the need for a unified storage architecture starts to come into focus. Many data centers have grown organically over time. New storage systems have been dedicated to each new application, often without enough consideration for what existed before. In many cases, this situation has been complicated by mergers and acquisitions that bring together disparate infrastructures.

Enterprise data centers often provide tiers of storage targeted to meet the needs of different applications. (Note that this type of storage tiering doesn't necessarily map directly to the technology tiers that storage vendors talk about—tier 1: high-speed FC disk, tier 2: SATA disk, tier 3: online archive, tier 4: tape). The highest storage tier in an enterprise data center offers the most robust features to meet the requirements of mission-critical applications. Lower tiers typically have decreasing levels of performance and availability (and cost) suited to different application categories. These enterprise tiers may be created using equipment from different vendors with different storage architectures.

The resulting silos of storage have increased overall cost because of complex management, low storage utilization, and direct data center costs for power, space, and cooling. Backup and recovery processes are complicated, and the time needed to accomplish them has increased to an unacceptable level. Implementing a consistent DR strategy is difficult or impossible, and the need to tailor each DR solution for each storage silo makes the cost and complexity prohibitive.

Table 1) Enterprise challenges that a unified storage architecture can help address.

Enterprise Challenge	How a Unified Storage Architecture Helps
Emergence of server virtualization makes backup, recovery, and DR more challenging.	Data protection is fully integrated at the storage level. Backup and recovery are designed into the underlying data structure and consistent across multiple classes of data.
Increased downtime and costs result from ad hoc processes across heterogeneous infrastructure.	Consistent processes enable faster response and fewer errors while enabling policy-based automation.
Increase the productivity of people, systems, and infrastructure across multiple applications.	Provides a single framework for data management with a common set of processes and training requirements.
Existing technology is difficult to repurpose and scale.	One storage platform adapts to the full range of data types, access methods, and capacities required across a diverse spectrum of enterprise applications.
Storage utilization is low resulting in poor data center efficiency.	Storage is pooled, allowing sharing of infrastructure and capacity with on-demand provisioning. Space saving technologies such as deduplication and thin provisioning reduce space, power, and cooling costs.
Infrastructure inherited through M&A and other means is difficult to integrate in a rational manner.	Common software architecture can accommodate and add value to storage devices/arrays from all major vendors.

THE NEED TO UNIFY STORAGE

In order to address these challenges and reduce storage acquisition and operational costs, enterprises are looking for ways they can simplify and unify storage infrastructure across both storage protocols and storage tiers. The goals of those seeking to unify storage include:

- Improve service levels.
- Reduce costs of redundancy and minimize the number of point solutions.
- Move toward an end-to-end data protection plan (backup/recovery, D/R, archiving) with a single management interface.
- Implement a recovery-centric approach to storage that minimizes downtime after an outage.
- Provide multisite infrastructure that protects as many applications as possible (cheaper network bandwidth contributes to making this practical).
- Add the ability to delegate more functions to application and system admins (this requires a common pool of storage coupled with policy-based tools).

When you begin to examine other vendors' "unified" storage offerings in light of these goals, you quickly realize that not all unified storage is created equal.

OTHER "UNIFIED" SOLUTIONS

For some storage vendors, unified storage just means the ability to support both NAS and SAN with a storage solution bundled under a single product family name. Vendors may make claims of multiprotocol support regardless of how integrated a solution is. Some solutions consist of a bundle of separate SAN and NAS components—such as a NAS gateway configured in front of SAN storage—each with its own user interface and data protection mechanism. At best, the commonality is the physical disks, and even those are dedicated for SAN or NAS without the flexibility you need to quickly reallocate storage for use with different protocols. This may be thought of as a "bolt–together" unified storage solution.

You may also find that these so-called unified storage products are bounded and nonscalable. Such solutions are often targeted at small and medium-sized businesses; they are composed of multiple components wired together in a way that won't scale beyond narrow limits.

If you evaluate such solutions against the enterprise goals for unified storage described in the previous section, you'll find that they do little to satisfy any of the goals. Section 7 of this paper provides five tests you can use to determine whether a particular solution has a truly unified storage architecture.

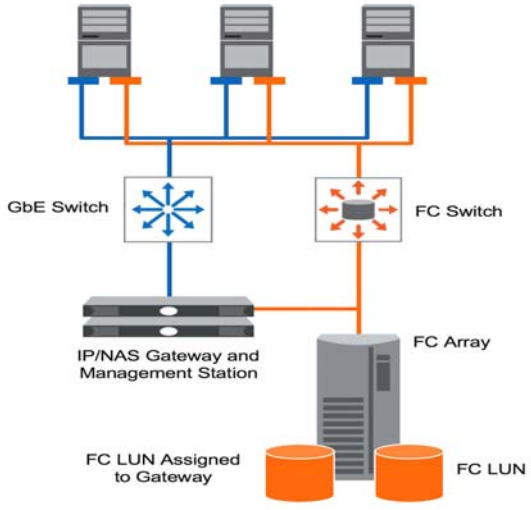

Figure 1) Bolt-together approximation of a unified storage solution.

2 A SIMPLER APPROACH TO UNIFIED STORAGE

In this section we examine the things that make NetApp storage—or any truly unified storage solution—simpler. In addition to having the ability to run multiple storage protocols on the same system, it comes down to how quickly and easily you can accomplish all the tasks associated with storage, from provisioning to data protection, and how broadly those management capabilities can be leveraged.

- **Single provisioning interface.** A single interface is needed to effectively pool storage, creating one model for defining data containers that can be allocated and dynamically managed (sized and resized) for use by a wide range of applications, whether they need block (SAN) or file (NAS) access.
- **Common management framework.** Having a single data model and toolset enables a consistent management framework across many applications and workloads. A set of common management services creates a hierarchy of value, from management of physical storage to application-level integration.
- **Policy-based automation.** Having a single provisioning interface and a common management framework in turn makes possible policy-based automation that allows storage administrators to delegate some or all of the responsibility for provisioning and management tasks. This extends a single toolset across the organization, allowing system administrators, application administrators, DBAs, and others to quickly accomplish storage tasks without storage administrator involvement.
- **Shared data protection at the storage level.** A single data protection architecture encompasses everything from a single file to full disaster recovery—all based on the same basic foundation. Starting with our Snapshot™ copy technology, NetApp has built a consistent set of tools that leverage that underlying capability, extending its use for a wide range of applications both in the data center and at remote offices. The result is near-instant data recovery and the ability to extend a consistent set of data protection tools to files, LUNs, databases, and applications.
- **Ability to incorporate legacy storage.** The reality in almost every data center is that you have substantial investments in storage from a variety of vendors. NetApp can extend many of the unified storage advantages described in preceding bullets to your existing storage. NetApp V-Series systems are able to virtualize storage from EMC, HP, HDS, IBM, and others.

As shown in Figure 2, this approach depends upon the ability to unify multiple technologies, protocols, and classes of data on top of a single software foundation, enabling much greater consolidation of storage infrastructure, including storage for primary, secondary, and archive data.

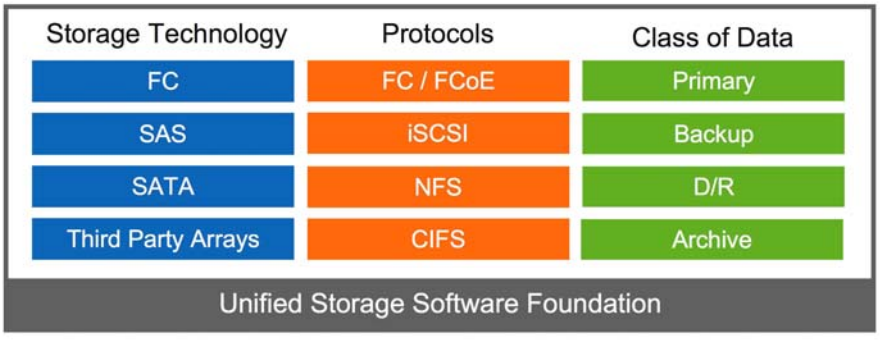

Figure 2) Integration of multiple technologies and classes of data.

3 NETAPP UNIFIED STORAGE ARCHITECTURE: BUILDING BLOCKS

This section describes the key technologies that make NetApp unified storage systems uniquely suited for enterprise storage needs. The combination of these building blocks, incorporating key technologies for thin provisioning, space-efficient scalable Snapshot copies, and deduplication, makes NetApp unified storage a fundamentally efficient architecture.

SINGLE OPERATING ENVIRONMENT

The NetApp Data ONTAP® operating environment is the software foundation that underlies every NetApp storage system and is therefore the core of the NetApp unified storage architecture. Data ONTAP runs on storage systems ranging from a few disk drives to over a petabyte of storage.

The result of years of continuous development, Data ONTAP is both stable and mature, and it contains a rich set of integrated features that other storage vendors usually charge for if they offer them at all:

- Space-efficient, scalable Snapshot technology, with negligible performance impact, which yields dramatic reductions in backup and recovery time and is the foundation of application-centric data protection
- Onboard deduplication of both primary and secondary data
- Dual-parity RAID that protects against double disk failures without significant performance impact; other vendors suggest using mirroring (doubling storage costs) for write-intensive workloads
- Thin provisioning, which allows multiple applications to share a single pool of on-demand storage so you don't have to provision more storage for one application while another application still has plenty of allocated but unused storage
- Quality of service (QoS) so that high- and low-priority workloads can share the same storage without impacting critical jobs

With a single software foundation, it is possible to meet the storage needs of the entire data center with one basic approach, which translates to less training, more staff productivity, and dramatically improved business agility.

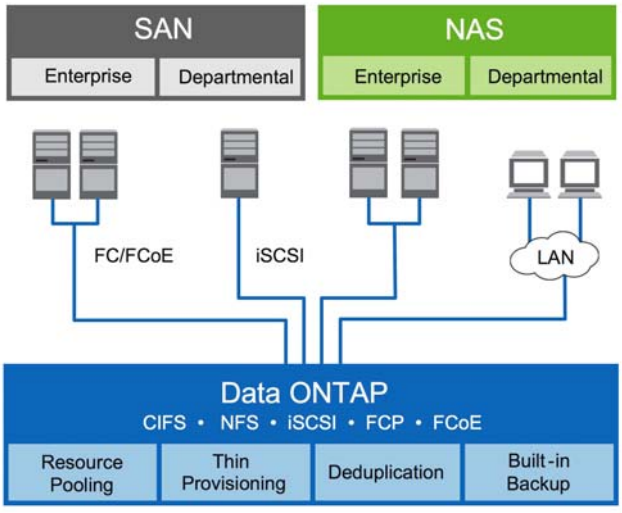

Figure 3) Unified storage foundation—Data ONTAP.

INTEGRATED, MULTIPROTOCOL ACCESS

While other multiprotocol storage solutions lack the level of integration necessary to make them truly unified, NetApp solutions integrate all the common file- and block-based storage protocols within Data ONTAP. Provisioning and management interfaces are the same, and data protection, management, and application-integration software work as expected, regardless of protocol.

You can easily run both file- and block-based storage protocols on a single storage system and apply core Data ONTAP features such as Snapshot, deduplication, and thin provisioning to all your data, regardless of the protocol you use. Of course, you can also dedicate individual storage systems for use by particular protocols if you prefer. You'll have a common management interface across all systems and the ability to repurpose a particular system and use it with a different storage protocol (or add a storage protocol) should your needs change. The NetApp unified storage architecture gives you flexibility to design the right solution for your needs today, without locking you into a limited solution that won't adapt to future needs.

SINGLE, SCALABLE ARCHITECTURE

Many of the "unified" solutions from other vendors lack the ability to scale. NetApp offers a single storage architecture across storage systems that range from workgroup or departmental solutions to full enterprise systems. That lets you choose the storage systems that are right for your requirements in various locations and to know that all will provide the multiprotocol access you need. A storage administrator who is trained on Data ONTAP will be able to leverage those skills to manage any NetApp storage system you have, whether it's a small departmental system in a remote office or an enterprise-class storage system with hundreds of terabytes of storage in your corporate data center.

NetApp storage systems also are able to scale both capacity and performance. You can start small with a single disk shelf and a few disks, and grow to many terabytes. Your investment in disk storage is protected in the event that you decide to upgrade your storage controller, so you don't have to go through a painful migration process. Other storage vendors often have different—and incompatible—operating environments for their low-end versus mid-range versus enterprise storage, so making the transition from one class of system to the next can require a painful data migration.

MULTIVENDOR ARRAY SUPPORT

Another significant dimension of NetApp unified storage is the ability to consolidate storage arrays from other vendors—in effect making your existing heterogeneous storage arrays part of a unified solution. With NetApp V-Series storage systems, you configure your existing storage arrays up front for use with the V-Series controller. After making that initial configuration, you can handle most of the ongoing management through NetApp management interfaces, effectively masking the heterogeneity of the underlying systems for more efficient management that leverages all the benefits of Data ONTAP, including thin provisioning, deduplication, and Snapshot. Your back-end systems may be Fibre Channel only, but using the NetApp V-Series you can repurpose that storage and use it for Fibre Channel, iSCSI, NAS, or any combination.

Some customers find that they can deploy NetApp in front of their existing storage, use deduplication to recover storage capacity, and actually delay making additional storage purchases.

FLEXIBLE STORAGE TIERS

The NetApp unified storage architecture has the ability to support different tiers of storage with the same architecture and on the same storage system. (In this case, we're talking about technology tiers rather than enterprise-defined tiers.) These include a high-performance tier (Fibre Channel disk); a low-cost, high-capacity tier (SATA disk); and online archive tiers using write once read-many (WORM) technology to provide data permanence (FC or SATA).

In most vendor environments, these tiers are implemented using separate, discrete storage systems—and at this point it should come as no surprise that the different tiers often have different, and incompatible, storage architectures. This once again raises complexity and management overhead and limits flexibility. Having the ability to have all these tiers in a single architecture with consistent management in which you can provision different storage tiers in a single storage system, whenever it makes sense to do so, gives you unprecedented flexibility and allows you to accomplish more with less overhead.

SINGLE, CONSISTENT DATA PROTECTION ARCHITECTURE

Unified storage from other vendors often consists of separate, discrete software stacks for NAS versus SAN. This means you are stuck with a set of different, and largely incompatible, tools for protecting different types of data. You may need two solutions for backup (one for NAS and one for SAN) and two more solutions for disaster recovery.

The NetApp approach to data protection is different. As you've already seen, all NetApp software tools work in essentially the same way regardless of the storage protocol you are using. NetApp data protection tools are built on top of our space-efficient Snapshot technology, which captures a point-in-time image of a data volume and consumes additional storage only as the volume changes. Snapshot copies serve as the foundation for standard tape (and virtual tape) backups. You can also vault your Snapshot copies to secondary storage for longer-term, online retention. Storage on standard Windows®, Linux®, and UNIX® servers can also be included in this vaulting process.

For disaster recovery, NetApp provides efficient asynchronous or synchronous replication. Snapshot once again serves as the foundation for efficient asynchronous data transfers that replicate only changed blocks (rather than whole files) for efficient use of network bandwidth. All NetApp data protection software can be configured, managed, and monitored across all storage systems and all storage protocols from a single management console.

For application backup, NetApp provides the SnapManager® suite of products that integrate with popular applications including Oracle®; SAP®; Microsoft® Exchange, SQL Server™, and SharePoint®; and VMware® VI3. These tools integrate directly with the application, allowing administrators to put the application in hot backup mode, capture a consistent Snapshot copy, and then resume normal operation in seconds—forming a foundation for both backup and disaster recovery. These tools allow storage administrators to delegate specific storage management capabilities directly to application administrators for improved efficiency.

FLEXIBLE, DYNAMIC PROVISIONING

One of the features of Data ONTAP that NetApp users consistently comment on is the ability to nondisruptively grow and shrink data volumes as needs change. For example, you can provision a data volume for use with either NAS or SAN protocols and grow it over time to meet changing needs. This contrasts sharply with the traditional approach to provisioning in which you guess how much storage you're going to need and provision it all upfront. If you guess high, the space is wasted (or painful to recover). If you guess low, growing the LUN or volume may be equally painful.

You also have the option of using thin provisioning, another feature built into Data ONTAP, which allows an underlying pool of free storage to be oversubscribed by multiple storage volumes. New storage capacity can be provisioned on a just-in-time basis rather than leaving large amounts of storage sitting idle. Rather than making capacity planning decisions and provisioning to meet the needs of each individual volume, you plan and provision for the needs of the entire storage system. This is easier, less prone to mistakes, and results in more efficient storage utilization so less storage is needed.

As a result of these flexible provisioning methods, typical NetApp storage systems have utilization rates of 60% or higher. The industry norm for storage utilization averages from 35% to 45%.

CONSOLIDATION OF MULTIPLE WORKLOADS AND QUALITY OF SERVICE

Another important feature of the NetApp unified storage architecture is the ability to consolidate multiple application workloads on a single storage system. Most storage administrators are hesitant to do this with critical applications because they don't want to risk having less essential work impact performance.

Data ONTAP includes quality of service (QoS) capability as a standard feature. This capability works at the volume level; by simply giving higher priority to the volumes used by more critical applications, you can safely support multiple applications with a single, consolidated storage system. A higher priority gives a volume a greater percentage of available resources when a system is fully loaded. If higher-priority applications aren't busy, lower-priority applications can use available resources without limitation.

For example, Leuven University Hospital (UZ Leuven) consolidated all its critical Sybase database storage along with storage used by less critical SQL Server applications on a single set of NetApp storage systems. UZ Leuven uses the built-in Data ONTAP QoS feature, FlexShare™ to prioritize Sybase volumes (and

hence Sybase workloads) over SQL Server volumes, successfully supporting over 120 database instances and 1,500 concurrent Sybase users on the consolidated infrastructure.[1]

4 PERFORMANCE IMPACT

One of the myths that have been perpetuated about the NetApp unified storage architecture is that performance naturally suffers when you combine all these capabilities in one system. Particularly for SAN performance, some storage vendors say that imposing any type of data layout overhead on the data volume reduces performance.

In fact, the reverse is true. The fundamental way that NetApp writes data to a volume, whether NAS or SAN, is what makes possible all the data management features that distinguish NetApp from the competition. NetApp unified storage performs as well or better than competing storage solutions, and benchmark results show that performance, particularly under real-world conditions, is superior.

SAN PERFORMANCE

NetApp recently compared the performance of a NetApp FAS3040 storage system with an EMC CLARiiON CX3-40 on the SPC-1 benchmark. (In the interest of full disclosure, the FAS3040 is a unified storage system capable of running multiple protocols simultaneously, but it was only configured for Fibre Channel for this benchmark. The EMC system is a SAN-only configuration not capable of serving file-based protocols as configured.)

SPC-1 is a standard benchmark that generates a workload with characteristics of typical business applications such as database and e-mail with random I/O, queries, and updates. In independently audited results, the NetApp system delivered higher baseline performance (nearly 20% more I/O operations per second), despite being substantially less expensive than the EMC configuration (see Table 2).

The NetApp performance advantage really becomes apparent, however, when the same test is repeated with snapshots turned on. When a feature becomes a regular part of daily operation across a wide base of users, it makes sense to test the performance impact of that feature. The performance of the NetApp FAS3040 dropped only 3%; it still achieved 97% of its baseline performance (performance level without snapshots). The EMC system didn't fair nearly as well. Performance dropped by 64%; it only delivered 36% of baseline performance with the equivalent snapshot capability enabled.

Table 2) SAN performance with and without snapshots enabled.

Performance/Pricing	NetApp FAS3040	EMC CLARiiON CX3-40
Baseline SPC-1 IOPS	30,985.90	24,997.48
Baseline Price Performance	$13.61/SPC-1 IOPS	$20.72/SPC-1 IOPS
SPC-1 IOPS with Snapshot	29,958.60	8,997.17
Perf Impact of Snapshot	3%	64%
Snapshot Price Performance	$14.89/SPC-1 IOPS	$59.49/SPC-1 IOPS

In a subsequent study of SAN performance, the NetApp FAS3170 achieved a result of 60,515.34 SPC-1 IOPS. (The FAS3100 series is the next-generation follow-on to the FAS3000 series, of which the FAS3040

[1] http://partners.netapp.com/go/techontap/matl/UZLeuven.pdf

is a member.) This result—approximately 2x the performance seen for the NetApp FAS3040 or the EMC CLARiiON CX3-40—corresponds to price/performance of $10.01 per SPC-1 IOPS versus $13.61 per SPC-1 IOPS for the earlier NetApp result and $20.72 per SPC-1 IOPS for the EMC configuration.

NAS PERFORMANCE

A comparison of benchmark results for the NetApp FAS3170 versus the EMC Celerra NS80G illustrates a similar advantage for NetApp in the area of NAS performance. (Once again, the NetApp FAS3170 system, while fully unified storage capable, was only configured for NFS for the purposes of the benchmark. The EMC system is a NAS-only configuration.)

Using the SPEC SFS97_R1.v3 benchmark, the NetApp system posted throughput of 137,306 operations per second (OPS) with an overall response time (ORT) of 0.94 milliseconds, while the EMC system achieved throughput of 86,372 OPS at an ORT of 1.49. The NetApp configuration outperformed the EMC configuration by 59% in throughput with an ORT that was 36% faster. A low response time (ORT) is just as critical as throughput for many applications.

OTHER PERFORMANCE MEASURES

While operations per second and response time are certainly important measures of performance, there are other real-world measures that storage administrators may find at least as compelling. In a recent comparison, VeriTest, an independent testing service now part of Lionbridge, compared provisioning and volume cloning time for a NetApp FAS3070 versus an EMC CLARiiON CX3-80[2]. Following the published best practices for each company, it took 2.5x longer to provision an equivalent volume on the EMC system and 233x longer to clone a 400GB LUN.

5 COST ADVANTAGES OF UNIFIED STORAGE

At this point, you're probably thinking, "There must be a catch." If NetApp unified storage delivers this much value, then it must cost more. The truth is just the opposite. Because of the efficiency of Data ONTAP with built-in features such as Snapshot, instantaneous cloning, deduplication, dual-parity RAID, and thin provisioning, unified storage actually saves you substantial storage costs up front; reduces your costs for space, power, and cooling; and reduces management costs for substantial reductions in total cost of ownership (TCO) for common data center applications.

In typical data center environments, NetApp storage achieves rates of utilization ranging from 65–75% versus 35–45% for traditional storage. All these space savings add up to substantial reductions in the amount of storage needed to achieve a given amount of usable space, as illustrated in Figure 4.

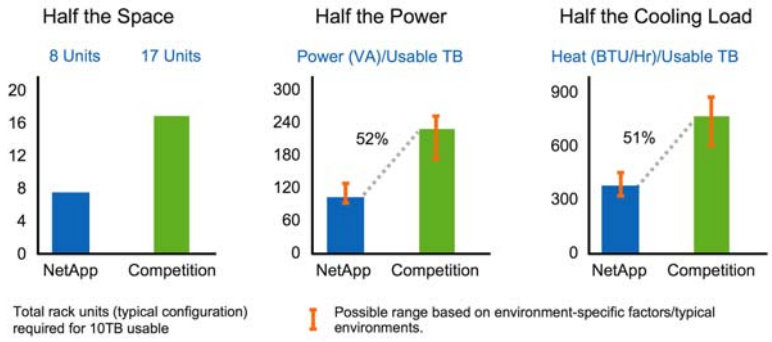

Figure 4) Data ONTAP enables significant cost reduction.

[2] http://www.lionbridge.com/competitive_analysis/reports/netapp/NetApp_FAS3070_vs_EMC_CX3-80_Executive_Summary.pdf

The final measure of efficiency is total cost of ownership in the real world running real applications. Oliver Wyman (formerly Mercer Management Consulting) undertook a series of TCO studies examining the cost of NetApp storage versus competing solutions for popular applications. The results speak for themselves, with TCO ranging from 30% to 55% lower.

Table 3) NetApp total cost of ownership vs. competing solutions (source: Oliver Wyman).

Application	TCO
Oracle	39% lower
SAP	55% lower
Exchange	30% lower
File Services	44% lower
Archive	35% lower
VMware	38% lower

6 THE FUTURE OF NETAPP UNIFIED STORAGE

Right now, there are a number of important trends in the industry as a whole, including growing interest in cloud computing and scale-out storage and the desire for a simplified network infrastructure. Ideally, your storage architecture should evolve to accommodate these trends without requiring disruptive changes to your entire operating environment.

The NetApp unified storage architecture has been proven to evolve to support new capabilities. In fact, since the Data ONTAP operating environment was first introduced in 1993, most of the enhancements that NetApp has added have been evolutionary—the company hasn't required users to throw out what they have and start again. NetApp has a deep commitment to that philosophy, and our unified storage architecture will deliver on the promise of the latest industry trends in a similar fashion.

SCALE OUT

The next step in the evolution of the NetApp unified storage architecture will be the addition of the scale-out storage technologies that NetApp pioneered. Your storage systems will become part of a global namespace, with the ability to transparently spread data across storage systems for greater performance, load balancing, and nondisruptive operation.

With all your storage under a common framework, the ability to scale out will become a logical extension. You'll be able to move to scale-out storage using existing storage; no forklift upgrade will be required. By joining together your existing storage with any future storage system purchases, you'll be able to achieve even greater levels of consolidation while scaling capacity, performance, and data availability far beyond today's limits.

You can find out more about scale-out storage in a companion white paper entitled *Scale-Out Storage and the Dynamic Data Center of the Future.*[3]

[3] http://media.netapp.com/documents/wp-7042.pdf

UNIFIED FABRIC

Another trend that enterprise data centers will be able to leverage in the near future is the unification of storage area networks and local area networks (LANs), by extensions to classic Ethernet. This "unified fabric" is made possible by the Data Center Bridging (DCB) standard. DCB technology allows 10GbE the flexibility to support transmission mechanisms beyond Internet protocol, including Fibre Channel over Ethernet. This is the culmination of a consolidation trend that began with server virtualization and that continues today with storage consolidation and unified storage. Most data centers today have a Fibre Channel network for SAN storage in addition to an Ethernet infrastructure. Maintaining multiple types of network equipment—along with the tools and expertise needed to effectively manage different network technologies—adds significantly to data center cost and complexity.

NetApp has been selling Ethernet-based storage for the past 16 years, with demonstrated leadership in both NAS and iSCSI protocols. Because NetApp has already unified the storage endpoint with support for both Ethernet and Fibre Channel, the company is logically in the best position to drive the conversion to a totally Ethernet-based fabric. Ultimately, server virtualization will unify the server, the intervening network fabric will be unified with FCoE, and NetApp will provide unified storage that can accommodate all back-end storage needs. NetApp has already forged close relationships with leading providers of server virtualization software so that our storage offers maximum benefit with VMware ESX, Microsoft Hyper-V™, Citrix, Oracle VM, and others.

7 FIVE TESTS FOR DETERMINING IF YOU'RE BUYING UNIFIED STORAGE

How do you know if a storage solution that is marketed as "unified storage" really delivers as advertised? Here are five simple tests to help you decide.

1. **Does one storage architecture address *all* your storage needs?/Does all the storage run under a single operating system?**
   Many vendors offer different systems for different needs: primary NAS, primary SAN, secondary storage, archiving, compliance, and so on. This forces you to train people for each system, resulting in inefficiency. This approach also creates islands of storage that make it impossible to provision available storage where it is needed. This increases cost and adds to data center inefficiencies. A true unified storage architecture allows you to train your staff on a single operating environment with a single set of tools.

2. **Are all protocols supported *natively* in the same box?**
   The ability to serve multiple protocols from the same storage system has many advantages. It makes consolidation more effective by combining block and file data on the same system. This helps you freely mix and match workloads to greatly improve utilization. It also helps make your infrastructure more flexible by giving you the right to change your mind. You can choose iSCSI today and change that to Fibre Channel without migrating data or changing your data layout. Native multiprotocol, as opposed to gateway approaches, results in noticeable performance improvements.

3. **Are all your business needs managed by a single storage architecture?**
   Meeting your business requirements may result in multiple copies of data for production, backup, test and development, disaster recovery, archival, and compliance. Having different architectures for each of these business needs adds significant management cost and increases the number of full copies required to support your business. Consolidating these classes of storage to a unified storage architecture with a common set of tools can reduce management overhead and lower training costs.

4. **Can you easily consolidate storage for space, power, and cooling efficiency?**
   Another key advantage of the superior consolidation made possible with a unified storage architecture is reduced space, power, and cooling cost. Effective pooling of storage across all business requirements with advanced features like deduplication, thin provisioning, and virtual copies helps you make the most of your consolidated storage by avoiding redundant copies, thereby reducing your space, power, and cooling requirements.

5. **Are you forced to move to a different platform to meet objectives for performance, availability, or scalability?**
   Life is full of choices, but you shouldn't be forced to choose between performance, availability, and scalability when choosing a storage platform. A unified storage architecture allows you to tailor your solution to cost-effectively meet your performance and availability objectives and scales seamlessly as you grow.

8 CONCLUSION

The traditional model in the storage industry is one with multiple, incompatible storage architectures with incompatible processes requiring lots of experts. Because integration between architectures is expensive, this model results in functional silos of storage in which available storage cannot be easily allocated to the applications that need it.

Recognizing the limitations of this approach, some vendors have begun to offer what they describe as "unified" storage, but these solutions typically fall short in functionality, performance, and scalability. Only NetApp offers a truly unified storage architecture capable of meeting all your storage needs—NAS and SAN: primary, secondary, and archive—from a single platform with a single architecture. With NetApp, you can implement a single set of processes for all data management functions, including backup and disaster recovery, and even delegate important storage tasks to other functions with policy-based management. The result is complete compatibility that allows you to do more and manage more data with fewer resources.

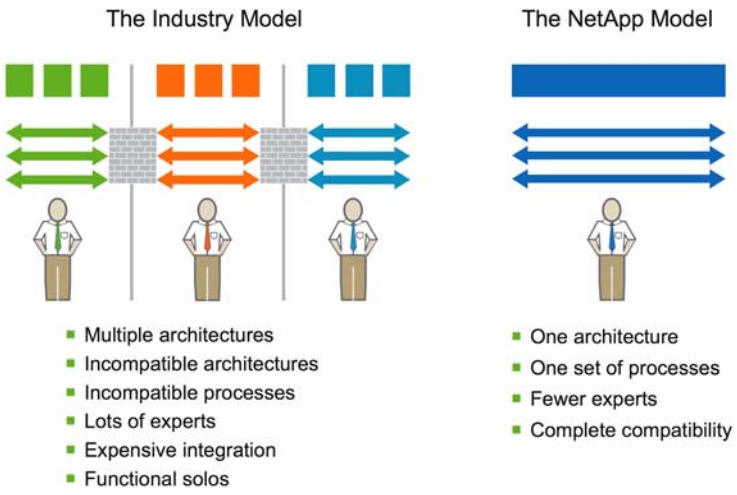

Figure 5) Unified storage architecture: summary of the NetApp advantage.