White Paper

Storage Infrastructure for Cloud Computing
NetApp Is the Technology Partner of Choice

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EXECUTIVE SUMMARY

Cloud computing is rapidly becoming a reality, and forward-thinking IT organizations are moving quickly to evolve existing IT infrastructures to include cloud capabilities that provide IT as a Service (ITaaS). Shared cloud infrastructure has created new requirements for secure multi-tenancy, service automation, data mobility, storage efficiency, and integrated data protection. NetApp is leading the way with proven technologies to help provide these critical capabilities, including NetApp® MultiStore®, NetApp Data Motion™, and SANscreen®. At the same time, NetApp continues to evolve its Data ONTAP® operating environment to deliver the storage capabilities that will power cloud infrastructures both now and in the future.

While technology is a critical component of cloud success, having the right technology partners with the right expertise is just as critical as you contemplate the transition to cloud computing. NetApp has forged close relationships with key virtualization, networking, and cloud technology providers that can smooth your journey. Our NetApp dynamic data center solution is designed to help you assess your situation, provide valuable insights, and create and execute a plan to achieve your cloud goals with the least cost, minimum risk, and disruption to your ongoing operations.

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1   INTRODUCTION

With total IT spending on cloud computing projected to grow at least threefold by 2012, you've likely heard a lot about the potential benefits of cloud computing. Perhaps your company has already begun purchasing some cloud services rather than adding to its existing IT infrastructure every time a new requirement arises.

From an IT standpoint, cloud computing promises to deliver elastic scalability, pay-as-you-grow efficiency, and a predictable cost structure, while at the same time improving access to data. On the business side, this translates into an ability to turn capital expenses into operating expenses and increase productivity and innovation, all while reducing IT expenses and business costs.

Technological maturity is making workable cloud solutions both possible and affordable. You may already be considering ways to make your own data center more "cloud-like" to boost efficiency, cut capital costs, and provide the elastic scaling you need to adapt to rapidly changing business requirements. However, the best ways to accomplish this—especially where storage is concerned—may still be unclear.

This white paper defines cloud computing, discusses the broad requirements for storage capable of meeting the demands created by the cloud, and goes on to explain how NetApp storage satisfies the demands of this emerging paradigm based on its superior technology and proven track record.

2   WHAT IS CLOUD COMPUTING?

There are two schools of thought on how to define cloud computing. Some people define the cloud in terms of technology, with specifications for architectural models and development protocols; others look at cloud computing as a business model.

From NetApp's perspective, it's more productive to look at cloud computing in terms of the problem it attempts to solve. So, when we talk about the cloud, we refer to the ability to deliver computing services on demand: IT as a Service (ITaaS). Cloud computing is simply a business model for delivering IT as a Service. Cloud services are the end deliverable of cloud computing and can be broken down into four categories (Figure 1).

Figure 1) Categories of cloud services.

A cloud can be either private: limited to the ecosystem of end users, partners, and/or customers directly associated with a company; or public: available to essentially anyone with Internet access.
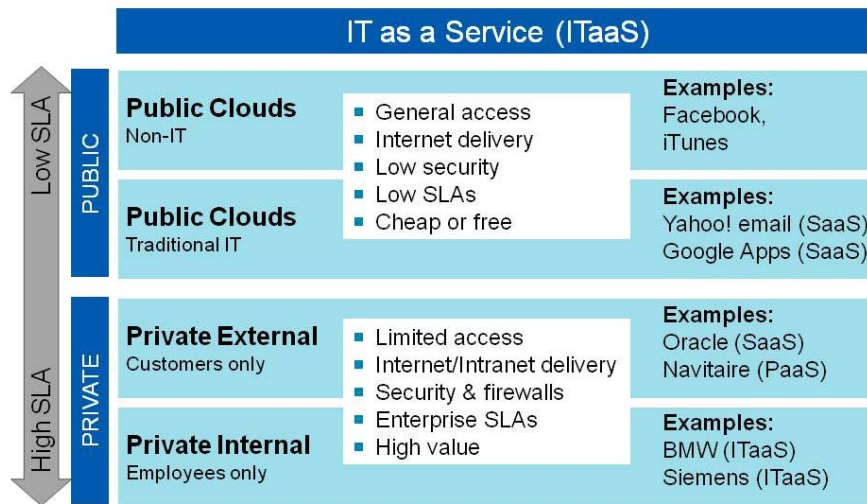
Figure 2) Distinctions between private and public clouds.

If you're working to create a private cloud infrastructure within your company, it is unlikely you will build it from scratch. Instead, you will in all likelihood transform your data center over time, while continuing to leverage existing IT resources. This will lead to a hybrid data center containing both legacy and cloud infrastructure that will need to co-exist. This hybrid data center may require new skill sets and new measurements to enable efficient operation.
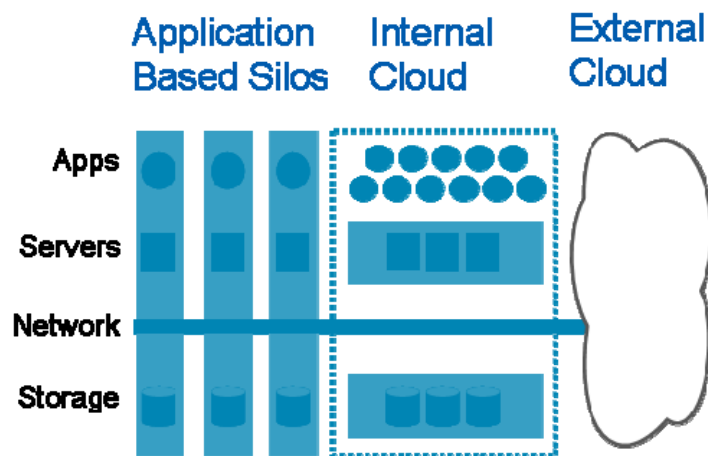
Figure 3) Most enterprises will evolve to a hybrid model in which IT services are provided by a combination of legacy, private-, and public-cloud infrastructure.

3   CLOUD STORAGE INFRASTRUCTURE REQUIREMENTS

Whether a cloud is public or private, the key to success is creating an appropriate server, network, and storage infrastructure in which all resources can be efficiently utilized and shared. Because all data resides on the same storage systems, data storage becomes even more crucial in a shared infrastructure model.

Business needs driving the adoption of cloud technology typically include:

- Pay as you go
- Always on
- Data security and privacy
- Self-service
- Instant deliver and capacity elasticity

These business needs translate directly to the following infrastructure requirements:

- Secure multi-tenancy
- Data mobility
- Integrated data protection
- Service automation and management
- Storage efficiency

Of these requirements, the ability to ensure that multiple, distinct applications or customers can securely share the same IT infrastructure—secure multi-tenancy—and the ability to move data without application disruption represent the most dramatic departures from existing IT practices.

It's probably already clear that on the compute side, server virtualization technology provides an appropriate infrastructure for cloud services, because it allows compute resources to be efficiently partitioned and quickly allocated, increased, decreased, or deallocated as needs change. A rapidly maturing set of virtualization management services also helps provide speed, flexibility, and enhanced availability. Leading providers of enterprise cloud services such as T-Systems are already taking this approach, leveraging the latest virtualization technologies[1].

Much less has been written about how to create efficient and effective storage infrastructure for cloud computing. In fact, the first Storage Networking Industry Association (SNIA) work group focusing on cloud storage was just announced at Storage Networking World in April 2009 with the objective "to identify, develop and coordinate system standards and interfaces for cloud storage."

Since there are no approved or de facto standards in place for cloud storage, there are a few questions you should ask yourself when evaluating new or existing storage solutions for suitability to meet your cloud needs and enhance the service levels you are able to offer:

- **Can you establish multi-tenancy and guarantee data is secure?** Allowing multiple business units or separate companies to securely share the same storage hardware is a necessity for efficient cloud storage.

- **Can you automate management processes and align them with services?** The more you can automate regular practices—such as provisioning, backup, and replication—and integrate those practices as part of your cloud services, the better your environment will scale. You must also have the ability to report on and be able to bill based on resource usage.

- **Can you move data freely to create an always-on infrastructure?** Consistent business continuity and disaster recovery processes that cover every service you provide are essential. The concept of "planned downtime" is no longer viable; all maintenance must be performed without interrupting applications. If your data is tied to inflexible storage, achieving these goals will be impossible.

- **Can you raise storage efficiency?** Your storage infrastructure must allow you to increase storage utilization, boost overall efficiency, and reduce costs. Thin provisioning, efficient cloning, and deduplication of both primary and secondary data sets can all significantly decrease the amount of storage you need. Deduplication or efficient cloning is particularly important in virtual environments with inherently high data duplication.

- **Is data protection integrated with storage?** As your storage environment becomes more shared, it is essential to have data protection closely coupled with storage.

Beyond these core questions, there are a few more issues you may wish to consider:

- **Can you scale storage resources elastically?** You should be able to allocate, increase, decrease, or deallocate storage resources at a moment's notice to deliver both appropriate levels of capacity *and* performance.

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[1] http://www.vmware.com/company/news/releases/vcloud_vmworld08.html

- **Does your storage environment support server virtualization?** Assuming that server virtualization will be a key component of your cloud infrastructure, you will obviously want storage that integrates closely with any virtualization solutions you use now or are likely to adopt in the future.
- **Can you do everything on a single network fabric?** Consolidating your SANs and LANs on a single Ethernet fabric can decrease cost and increase flexibility.

4   NETAPP STORAGE TECHNOLOGY ENABLES CLOUD COMPUTING

When it comes to storage for cloud computing, NetApp is a preferred technology partner, whether you are building your own cloud infrastructure, working with a system integrator, or outsourcing to cloud service providers. NetApp offers superior technology to meet cloud requirements combined with established solutions and partnerships.

SUPERIOR STORAGE TECHNOLOGY FOR THE CLOUD

The traditional approach to storage forces you to buy different types of storage systems to accommodate different needs. You might have to purchase one storage system for high-end SAN, another for NAS, and another for archive and compliance. The result is complexity and poor storage utilization; capacity and performance cannot be easily shared or reallocated. Clearly, this is not what you want in a cloud computing environment.

NetApp's unified storage approach can eliminate these problems. The entire NetApp FAS storage family runs a single operating environment: Data ONTAP. All your storage needs are met with the same hardware, software, people, and processes, achieving a level of efficiency that is not easily achievable with other storage vendors—and efficiency is what cloud computing is all about. The ease of management inherent in NetApp storage can actually reduces operator errors, which are now a major cause of system downtime.

Data ONTAP is the foundation for all storage capabilities required for cloud computing. The unified, virtualized architecture of today's Data ONTAP continues to evolve to provide an efficient scale-out architecture with elastic scalability, transparent data movement to enable an always-on infrastructure, full integration with virtualization solutions, and even greater self-service data management and automation capabilities. The next major release, Data ONTAP 8, focuses on delivering the technologies that are critical in a shared infrastructure to existing NetApp platforms by enhancing current capabilities and adding new ones.

SECURE MULTI-TENANCY

Traditionally, providing the highest level of data isolation and security has meant independent storage hardware. Security in both private and public clouds must be as tight as possible without sacrificing efficiency. NetApp MultiStore software lets you create multiple, separate, and private virtual storage controllers (vFiler units) on a single storage system, so you can share storage with minimum impact to privacy or data security. The result is secure, multi-tenant cloud storage with increased storage utilization.
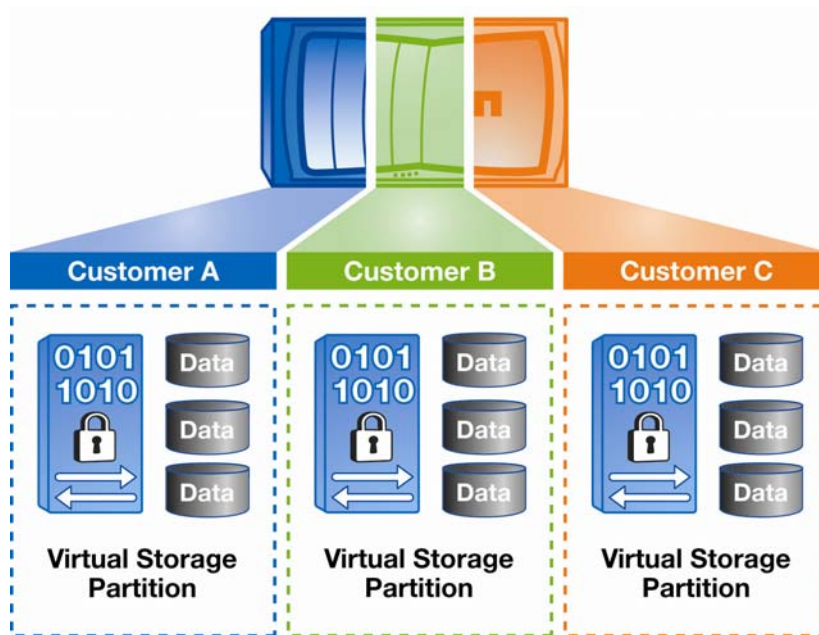
Figure 4) Multi-tenancy with NetApp MultiStore. Multiple customers can each be allocated a "virtual storage controller" on a single physical storage system. Each virtual controller can be used just as if it were a physical storage system.

MultiStore is an embedded feature of Data ONTAP; over 16,000 licenses have been sold to Fortune 1000 service providers and enterprise customers. With MultiStore, storage can be provisioned, moved, and protected based on the boundaries you define; virtual storage controllers allow you to apply policies appropriate to each container, which could correspond to a particular application or client of a cloud service.

SERVICE AUTOMATION AND MANAGEMENT

NetApp provides a suite of management products that simplify storage operations by automating all tasks associated with storage so you can manage more capacity with fewer resources while increasing operational efficiency. Policy-based automation maps end-user requirements to specific levels of service. Once policies are established, new storage consumers (a new application, a business unit, etc.) can request and receive storage and automatically get the appropriate level of data protection and other services without manual intervention. Through API and Web services, NetApp data management solutions can be integrated into orchestration systems to create end-to-end cloud management solutions.

Self-service operations make it possible for the users or consumers of services to perform common operations for themselves without the assistance of a storage administrator. For instance, the NetApp SnapManager® suite of products makes it simple for users of popular applications to perform file or data recoveries as necessary.

NetApp SANscreen® provides real-time, end-to-end visibility across a heterogeneous storage environment with automatic mapping of infrastructure elements to business services and monitoring and alerting on availability, performance, or policy problems. A configuration management database and business intelligence engine provide metering, capacity management, and other functions. By automatically correlating your end-to-end storage infrastructure against business services, SANscreen allows you to monitor service-level agreements, meter usage for chargeback, and proactively manage capacity to maintain optimal utilization of storage resources.

Usable Capacity TB	Time Frame							
	9/2008	10/2008	11/2008	12/2008	1/2009	2/2009	3/2009	4/2009
Application Name								
Marketing - Sales CRM	0.98	0.91	0.90	0.88	0.82	0.70	0.59	0.57
Marketing Backup	0.98	0.91	0.90	0.88	0.82	0.70	0.59	0.57
Marketing DB	0.98	1.08	1.25	1.49	1.70	2.04	2.49	2.87
Marketing Exchange	0.98	0.91	0.90	0.88	0.82	0.70	0.59	0.57
SAP	0.20	0.21	0.21	0.26	0.27	0.31	0.32	0.33
Users	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01

Figure 5) Screenshot showing the ability of NetApp SANscreen to report on capacity usage for chargeback or other purposes.

DATA MOBILITY

In a dynamic cloud environment, you need to be able to move data without interrupting running applications. NetApp Data Motion allows virtual storage controllers within NetApp MultiStore to be transparently migrated from one storage system to another, in a manner analogous to VMware® VMotion, XenServer XenMotion, or Hyper-V™ Quick Migration. This feature helps you avoid the need for planned downtime, as well as optimize operations by moving virtual storage controllers to balance load or achieve other objectives.

The ability to continue operations without deferring necessary maintenance enhances the service-level agreements (SLAs) you can offer to your customers.

ALWAYS-ON INFRASTRUCTURE

In a cloud environment, you must be able to seamlessly add new storage capacity and storage performance, provide instantaneous failover for business continuance and disaster recovery, and perform all maintenance activities (on both hardware and software) without disruption. These capabilities further enhance your ability to deliver high SLAs to your customers.

As we've already seen, NetApp Data Motion enables the nondisruptive movement of storage resources to eliminate planned downtime. To help avoid unplanned downtime, NetApp combines the proven reliability of its base hardware with innovative solutions to continue operations in the face of hardware failures or disasters that affect a site or region.

Based on data from over 15,000 customer systems (the data has been audited and validated by IDC), NetApp storage systems in active-active controller configurations are delivering uptime greater than 99.999% on average. This translates to less than five minutes of downtime per year.

To achieve continuous operation, NetApp combines synchronous mirroring with clustering at the storage level to create a continuously available storage environment capable of spanning distances up to 100 kilometers. Unlike solutions from other vendors, MetroCluster does not rely on host-based clustering mechanisms. (Such mechanisms can be used in conjunction with MetroCluster to provide server availability, but are not required for MetroCluster operation.) The result is a much more cost-effective solution: MetroCluster has up to 50% less complexity and comes at approximately up to 50% less cost than its competition.

For protection against regional disasters, you need a solution that reaches beyond the metropolitan distances spanned by MetroCluster. NetApp SnapMirror® software uses an asynchronous mirroring methodology that effectively spans huge geographic distances. SnapMirror efficiently identifies and replicates only changed blocks. Other common replication methods use time-consuming and resource-intensive file system walks to identify and then replicate changed files. SnapMirror delivers faster, more efficient replication, so synchronization can be performed at a higher frequency. Unlike competing solutions, with NetApp SnapMirror you can leverage your replicated data sets for other purposes including backup, development and test activities, data mining, etc.

SUPERIOR STORAGE EFFICIENCY

Raising storage efficiency can significantly reduce your total storage requirements; this translates into direct reductions in expenditures on storage, as well as additional savings on power, cooling, and floor space. Efficient storage allows you to offer higher SLAs to your internal or external customers at a lower price.

NetApp offers a suite of hardware and software capabilities to help increase storage efficiency, many of which are a standard part of Data ONTAP with the potential for no additional licensing costs.

Table 1) NetApp efficiency technologies.

Technology	Benefits
Raid 6	The double-parity protection of RAID-DP® protects you if two disks fail at once, saving 46% versus data mirroring.
Deduplication	NetApp deduplication identifies and eliminates redundancy at the block level. Space savings range from 25% to 55% for most data sets, up to 95% for full backups stored on disk, from 70% to 95% for virtual server and desktop environments, and up to 70% for engineering environments.
Thin Provisioning	With NetApp thin provisioning, storage is treated as a shared resource and capacity is consumed only as it is needed. Thin provisioning can reduce your storage capacity requirement by 20% to 30%.
Snapshot Technology	Space-efficient, nondisruptive Snapshot™ technology offers up to 80% space savings over competing products.
Thin Replication	Replication is an effective way to enable business continuity. NetApp SnapMirror and SnapVault® software perform only incremental block transfers—thin transfers—after an initial baseline, saving bandwidth and reducing the storage required for disk-based backups. Source and target storage systems need not be the same configuration.
Cloning	NetApp FlexClone® technology lets you create a "virtual copy" of a data set in seconds and only consume additional storage space as changes are made—making it an ideal technology for virtual environments that maintain many identical copies of the same operating systems. Space savings can be as high as 80%.

Because of the flexible provisioning enabled by NetApp FlexVol® technology, NetApp customers routinely achieve storage utilization rates of 60% or higher, whereas the industry average is less than 40%. NetApp offers a range of additional technologies to further enhance storage utilization. Individually, each of these technologies can increase your storage utilization; by combining the full set of NetApp efficiency technologies you can realize tremendous savings.
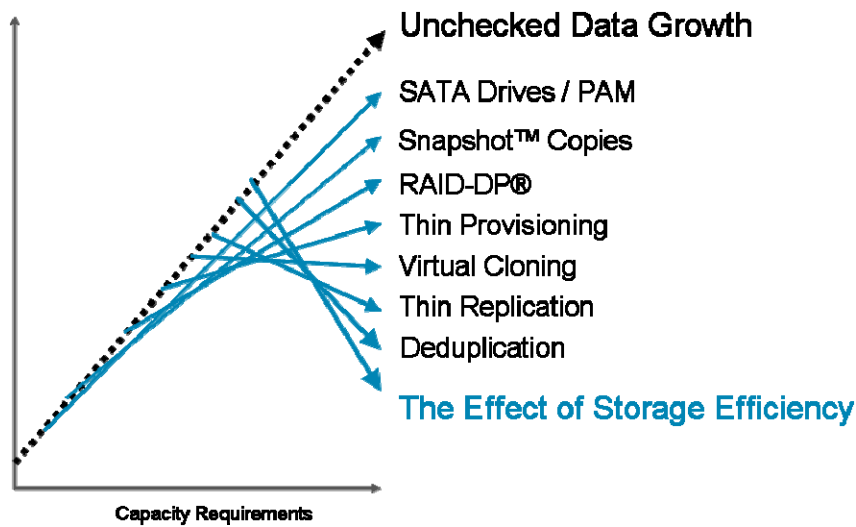
Figure 6) Impact of applying NetApp storage efficiency technologies.

INTEGRATED DATA PROTECTION

The traditional approach to data protection is expensive and inflexible. Many data centers keep two full data copies plus incremental backups stored in backup formats that are only useful for recovery. NetApp takes a different approach to data protection—one that is more efficient and leaves data in a format in which it can be leveraged for other purposes. With NetApp integrated data protection, footprint and network traffic are reduced up to 95%. Greater efficiency yields up to 75% savings on capital and operating expenses.

NetApp provides fully integrated and comprehensive data protection and disaster recovery based on mature technologies that include NetApp Snapshot, SnapVault, the SnapManager Suite, SnapMirror, MetroCluster, and Protection Manager. These technologies offload the burden of data protection from servers to storage, providing a consistent approach to data protection across a cloud infrastructure while allowing utilization of backup and disaster recovery data for development or other activities. The result is an efficient data protection infrastructure that protects availability and reduces risk. A policy-based management framework, application-specific data protection for popular applications, and full coverage for both NetApp and non-NetApp data complete the offering.

NetApp integrated data protection allows you to offer a range of SLAs to meet varying requirements, including compliance regulations. You can flexibly adjust the recovery point objectives (RPOs) for different data sets to meet any RPO goal up to and including continuous data availability.

ELASTIC SCALABILITY

NetApp's flexible volume and thin provisioning technology (FlexVol) abstracts storage volumes from underlying disks. Any storage container (LUN or volume), regardless of size, is automatically spread across a large number of disks for optimal performance, and can grow or shrink nondisruptively. NetApp has already deployed tens of petabytes of storage in shared storage environments, in which customers routinely scale volumes up and down as needs change.

The next generation of Data ONTAP will further extend these capabilities with a global namespace, granular scale-out, and the ability to spread storage volumes across multiple storage systems to meet both performance and availability goals.

SUPPORT FOR SERVER VIRTUALIZATION

NetApp offers unique advantages for virtual environments, including close relationships with VMware, Microsoft, and Citrix to provide product integration and support for vSphere, Hyper-V, and XenServer, respectively. NetApp Data Motion complements the ability to move virtual machines between servers in these environments, as discussed previously. NetApp deduplication technology and/or NetApp FlexClone can be used to eliminate the redundancy that results from having dozens of copies of the same operating system.

Although you may have already virtualized your server infrastructure, it's likely that you still have physical servers and will need to support both for some time to come. NetApp provides a single pool of storage that meets the needs of both physical and virtual servers. This pool can span metropolitan distances using MetroCluster and longer distances using SnapMirror. Because NetApp's unified storage architecture supports Fibre Channel, iSCSI, and NAS protocols, this single storage pool can simultaneously meet the storage needs of any physical or virtual environment.

Virtual environments offer features to simplify restarting services at a secondary site. For instance, VMware HA makes it simple to restart failed virtual machines on alternate servers in the same or a different location. A NetApp storage pool that spans locations using synchronous mirroring or replication facilitates this process.

SINGLE NETWORK FABRIC

The development of Fibre Channel over Ethernet (FCoE) makes it possible to move your data centers to a single Ethernet fabric for all storage and networking needs. Having a single network fabric can greatly simplify your network infrastructure and eliminate the costs associated with deploying and maintaining multiple types of networks.

NetApp has been—and continues to be—an Ethernet storage leader, first as a NAS pioneer and then as an early proponent of iSCSI. NetApp is currently the only vendor with native support for FCoE, which is a logical progression of our unified storage approach. By supporting FCoE we provide a simple evolutionary path for existing Fibre Channel SAN users to migrate to a unified network fabric.

5   PARTNERS FOR SUCCESS

Transforming your current IT infrastructure into a shared cloud infrastructure is not without challenges. Implementing new technology always involves risks, and the organizational changes necessary to align with operational changes can also be disruptive if not managed carefully.

You need business partners who can help you implement technology in a way that makes sense for your needs while also helping you design the policies and processes that will minimize both transition and organizational risks. Whether you work directly with NetApp or leverage our extensive partnerships, NetApp can put you on a path to success.

THE NETAPP DYNAMIC DATA CENTER

The full benefits of the NetApp architecture for cloud computing are embodied in our dynamic data center solution. This planned and optimized solution is designed to help data centers make the transition from where they are today to the cloud infrastructures of tomorrow.

People and process go hand in hand with technology. Our dedicated Professional Services team and Authorized Professional Service Partners have the expertise to assess your situation, provide valuable insights, and create and execute a plan to achieve your goals with the least cost, minimum risk, and disruption to your ongoing operations. We use a well-defined work breakdown structure; clear project management methodology; and a clear division of labor between NetApp, NetApp partners, and your IT team. A phased approach allows us to rapidly deploy new services in a predictable and repeatable fashion. You can learn more about this approach in the NetApp white paper "Building a Data Center for Cloud Computing."
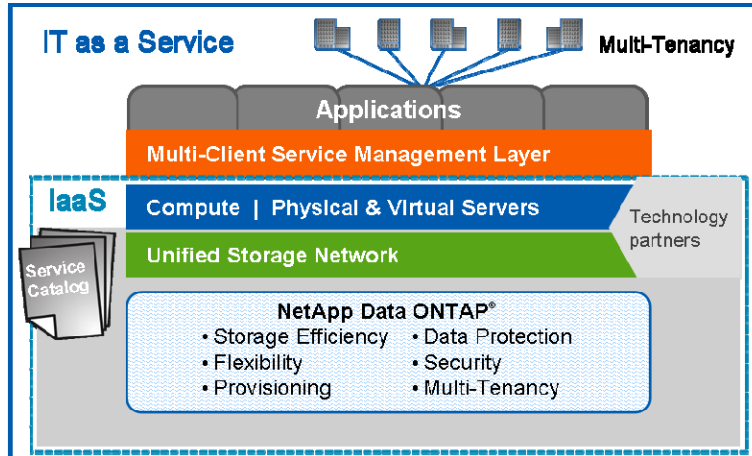
Figure 7) The NetApp dynamic data center solution simplifies the process of making the transition to a cloud infrastructure.

NetApp offers its Fast-Start Workshop to help you begin your journey to complete data center transformation. The NetApp Fast-Start Workshop is a four-day program designed to achieve the following:

- Identify application and infrastructure targets based on capacity, performance, and service-level needs.

- Assess impacts on cost savings, efficiency gains, and performance improvements.

- Identify the top-five process improvements in terms of impact on cost and efficiency, agility and timeliness, and progress toward IT as a Service.

You choose the granularity of transformation that makes sense for your needs, from incremental steps to a single large effort. If you proceed in a step-wise fashion, all planning is done with the end goal in mind, so no effort is wasted. The savings that result from each step can help to fund the next step.

BUILDING A TRANSFORMATION TEAM

No matter whether you plan to build your own cloud, work with a system integrator to help you make the transition, or contract with a service provider for your IT needs, you need a team of trusted experts you can rely on for sound technical expertise and advice. NetApp has an extensive ecosystem of industry partners that you can draw from to build your team. NetApp industry partners include top-tier cloud infrastructure vendors such as Cisco, Microsoft, VMware, and Citrix; global system integrators; and ITaaS providers.

6   CONCLUSION

Forward-thinking companies are already taking advantage of cloud services to meet many non-core IT functions as they evolve to shared infrastructure IT models focusing on service delivery to increase efficiency and flexibility, enhance SLAs, and cut costs.

NetApp supports the critical technologies required by cloud computing, including secure multi-tenancy, advanced automation, data mobility, always-on infrastructure, and integrated data protection. These technologies help you turn your IT infrastructure into a more predictable cost structure with pay-as-you-grow efficiency, elastic scaling, and data access anytime, anywhere.

Choosing NetApp as a key element of your cloud computing infrastructure helps you lower your IT and business costs, increase productivity, and innovate faster to stay ahead of your competition. Start your journey toward complete data center transformation by contacting NetApp today.