ABSTRACT

Another step in moving from a virtualized, shared IT infrastructure to a private cloud, along with infrastructure and service optimization, is service analytics. NetApp’s design approach, technologies, and ecosystem integration build on our storage efficiencies to deliver service-level efficiencies via centralized, policy-based monitoring and analytics. A service-oriented approach enables end-to-end, real-time performance monitoring and optimization, as well as consumption-based metering and dynamic capacity optimization. As a result, enterprises can meet workload service-level requirements while greatly reducing management and resource costs.
# TABLE OF CONTENTS

1 **PRIVATE CLOUD WHITE PAPER SERIES** .................................................................................................3

2 **INTRODUCTION** .................................................................................................................................4
   - WHY SERVICE ANALYTICS IS AN ESSENTIAL ELEMENT OF DELIVERING CLOUD SERVICES ..........4
   - NETAPP’S APPROACH TO SERVICE ANALYTICS ..............................................................................4

3 **ANALYTICS USE CASES AND HOW NETAPP ONCOMMAND HELPS TO ADDRESS THEM** ........6
   - BALANCING AND OPTIMIZING VIRTUAL MACHINES AND STORAGE WORKLOADS IN A VIRTUAL INFRASTRUCTURE ......................................................................................................................6
   - PROVIDING STORAGE SERVICE AVAILABILITY, IMPACT, AND CONFIGURATION COMPLIANCE ..........12
   - FORECASTING CAPACITY MORE ACCURATELY WITH TRENDING AND ENABLING SHOWBACK ..........17

4 **ECOSYSTEM INTEGRATION** ..................................................................................................................20

5 **SUMMARY** ...........................................................................................................................................21
1 PRIVATE CLOUD WHITE PAPER SERIES

Enterprise IT departments are under extreme pressure to reduce capital and operating expenses, driving them to virtualize their infrastructures to improve hardware utilization and scalability and move toward the enhanced operational efficiency and flexibility of cloud computing. Key attributes of a cloud infrastructure include automated on-demand provisioning of resources to make sure that service levels can be achieved, and a pay-as-you-go model that enables resources to be tied to services and associated costs as they are consumed. The cloud landscape includes private clouds, public clouds, and hybrid clouds. A private cloud is a shared virtualized infrastructure that remains within the control of the enterprise's IT organization, behind a firewall. IT departments in a private cloud essentially take on the role of service providers in delivering applications, and storage and server resources to their internal customers as services.

Many organizations have virtualized portions of their infrastructures but aren’t sure how to navigate the next steps toward a fully automated, service-driven model that enables them to further reduce costs, improve efficiency, and deliver IT as a service. The migration to cloud computing is a multiyear and multiphase effort, and most enterprises are still in the early stages of data center transformation. This transformation involves a fundamental shift in focus from the infrastructure optimization provided by virtualization to service optimization necessary for the cloud.

NetApp has helped many industry-leading firms deliver data and applications as a service using our storage solutions as the foundation for their private (as well as public and hybrid) clouds. Based on our experience with countless IT environments, we’ve identified four fundamental elements that organizations should include as they evolve to a private cloud. These elements are captured and explained in the NetApp private cloud white paper series, listed in Table 1. These white papers explain how NetApp helps enterprises transition from a shared virtualized infrastructure to a private cloud. Each one describes the design, deployment, and benefits of one of the four key elements as it relates to a service-oriented infrastructure. An important point: these papers are not focused on NetApp hardware. They instead explore the NetApp management software that enables policy-driven service efficiency as well as many advanced storage efficiency capabilities. They also describe how NetApp APIs integrate with third-party or customized orchestration solutions at each step, enabling organizations to deliver comprehensive storage management as part of their automated, end-to-end service fulfillment capabilities.

The NetApp private cloud white papers do not necessarily have to be read in sequence. In addition, some elements described in the documents might overlap and can be deployed together.

Table 1: NetApp private cloud white papers.

<table>
<thead>
<tr>
<th>Service Catalog</th>
<th>Define your services with well-defined policies that automatically map service levels to storage attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Analytics</td>
<td>Optimize your services with centralized monitoring, metering, and chargeback to enhance visibility and both cost and SLA management</td>
</tr>
<tr>
<td>Automation</td>
<td>Rapidly deploy your services by integrating and automating provisioning, protection, and operational processes</td>
</tr>
<tr>
<td>Self-service</td>
<td>Empower IT and your end users by enabling service requests to be fulfilled through a self-service portal</td>
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</table>
2 INTRODUCTION

WHY SERVICE ANALYTICS IS AN ESSENTIAL ELEMENT OF DELIVERING CLOUD SERVICES

IT is undergoing a shift toward virtualized, shared IT infrastructures, which is driving utilization up to 70% to 80% or even higher. Virtualization and automated provisioning are enabling this shift but are also increasing the overall complexity of data center environments. Silo-centric monitoring is no longer sufficient, nor capable of providing the level of service assurance that critical business applications require, particularly in a shared environment. Suddenly, the visibility and insight that can be gained from in-depth, near-real-time analytics become absolutely critical to effectively manage complex infrastructures, maintain service levels at expected rates or commitments, and provide business continuity.

In addition, to encourage users to adopt a shared IT infrastructure model, IT organizations need to provide more visibility and be more transparent in how resources are used to deliver services. One way to do this is to show utilization metrics to users, which is called showback or cost awareness. Showback can help reinforce the users’ level of confidence that they are receiving the same service levels and benefits in the logical silo that they received in the physical silo. Showback also provides a baseline that enables IT staff to guide users to accept and utilize more efficient and lower-cost levels of service. In more advanced deployments of private clouds, some enterprises might implement a chargeback model and charge internal users for their resource consumption.

Organizations moving toward full data center transformation to a private cloud need to go beyond infrastructure optimization and service optimization to service analytics. In the complex and rapidly changing construct of a private cloud, the ability to measure and analyze the entire environment end to end is absolutely necessary to deliver and improve service-level agreements (SLAs) and to realize the full benefits of improved efficiency and lower costs. Analytics goes beyond simple monitoring by enabling IT to:

• Determine service paths and confirm the redundancy of those paths.
• Set policies on service paths for accessibility, performance, and availability.
• Intelligently analyze data to adhere to these policies and provide optimal use of resources.
• More accurately plan for capacity.
• Show usage to users.

Analytics is the key to successfully manage and optimize private cloud storage services.

NETAPP’S APPROACH TO SERVICE ANALYTICS

As IT organizations migrate applications from silos to virtualized, shared IT infrastructures to private clouds, IT managers measure success by the efficiency of the infrastructure in providing end users with flexible and cost-effective services and service levels. NetApp’s objective in offering service analytics is to help enterprises manage the complexity of this transition and provide the tools to efficiently manage private cloud services. The NetApp OnCommand™ suite of products provides:

• Transparency, visibility, and management of the cloud infrastructure
• Information that service levels are being met
• Planning for capacity management and forecasting capabilities
• Service analytics to measure and balance performance for higher service efficiencies

Virtual and storage services are primary components of the private cloud. Storage services play a very large role, not only for application data but also as boot devices and storage for virtualized environments.
This results in additional complexity that encompasses far more than the usual application data use cases. The role of monitoring and analytics is to provide the ability to correlate across these different use cases. NetApp OnCommand products deliver this capability.

NetApp OnCommand products provide a holistic view of virtual and storage infrastructure as a unified set of services (Figure 1). This view is created using analysis, discovery, correlation, service paths, simulation, and root-cause analysis. NetApp OnCommand products also provide the following:

- **Key Performance Indicators**—Some products simply provide a lot of data, but end users and cloud IT administrators really want guidance to help them make the right decisions. OnCommand provides the intelligence to guide management decisions for private cloud deployments.
- **Multivendor**—There are very few true greenfield (those lacking prior constraints) deployments. Even in new data centers, companies typically leverage existing investments. To be effective, any solution must be able to monitor end to end across the assortment of multivendor technologies that make up the infrastructure stack. The solution also needs to interact with the different tools and databases that exist in the management ecosystem.
- **Virtual and Physical**—Private clouds are deployed on a virtual infrastructure. However, certain applications might still need to be hosted on a physical infrastructure. IT needs to enable service levels across the entire infrastructure, both physical and virtual.

**Figure 1** NetApp OnCommand analytic capabilities.
3 ANALYTICS USE CASES AND HOW NETAPP ONCOMMAND HELPS TO ADDRESS THEM

An effective way to illustrate how NetApp OnCommand provides value in private cloud deployments is to discuss how it can be used to address a number of common private cloud use cases and the subtasks within these use cases:

• Balance and optimize virtual machines (VMs) and storage workloads in a virtual infrastructure
• Provide storage service availability, impact, and configuration compliance
• Forecast capacity more accurately with trending and enable showback

BALANCING AND OPTIMIZING VIRTUAL MACHINES AND STORAGE WORKLOADS IN A VIRTUAL INFRASTRUCTURE

ANALYZING SERVICE HEALTH

OnCommand automatically and agentlessly collects and analyzes performance data from an application's IT infrastructure, including virtual and physical servers, storage area networks (SANs), and storage. It collects data directly from the storage arrays to provide I/O as well as utilization statistics and alerts on the appliance side of the datastore that other products cannot provide. A logical data path topology can be automatically constructed that includes all of the infrastructure resources that each application uses and shares with other applications. Dynamic performance analysis can then determine if there are any hot spots or bottlenecks, and, if so, which applications they are and to what extent each application might be contending for critical resources.

The visual topology is color-coded red/yellow/green to quickly find and resolve any cross-domain resource hot spot and contention issues. OnCommand makes it easy to find and analyze deeply buried contention that domain-centric tools simply cannot discover.

With topology views and their red alert icons and paths, you can quickly see how the critical device is connected through the infrastructure. A red does not mean down or unavailable. It simply means that there is an issue affecting performance. If the device is an application workload or VM, you can easily see the associated host server and storage, or vice versa, and select detailed information about the problem, as illustrated in Figure 2.
Figure 2) Topology view showing a performance issue with the guest and the associated host, server, and storage.

![Topology view showing a performance issue with the guest and the associated host, server, and storage.](image)

**PREDICTING AND RESOLVING PERFORMANCE ISSUES BEFORE THEY IMPACT SERVICES**

OnCommand provides performance and capacity guidance for workloads and independent resources through Key Performance Indicators, such as Infrastructure Response Time (IRT), shown in Figure 2, and Abnormality Analysis. Once service-level requirements are established, OnCommand provides information on service health by monitoring each cloud application workload and alerting when performance falls outside its expected levels.

Figure 3) Infrastructure Response Time indicates the performance delivered to an application by all of the IT resources assigned to it.

![Infrastructure Response Time](image)
OnCommand’s Abnormality Analysis automatically calculates and updates a *normal* IRT profile over time that can be used as a predictive dynamic threshold for service-level management (Figure 3). For example, moving an application to the cloud, particularly if consolidating multiple independent workloads, might result in unexpected application behavior or performance. Abnormality Analysis provides visibility of these abnormal occurrences, enabling you to quickly address them before they affect the performance of other applications. It also provides the ability to project a violation, enabling you to respond proactively.  

Figure 4) Abnormality Analysis shows normal forecasted response time and actual response time.

OnCommand provides more extensive monitoring for all the components in the infrastructure. Other Key Performance Indicators, the Disk Utilization analytic and Predictor alerting features, prevent issues that could impact the business. The Disk Utilization graph tracks cumulative utilization for all workloads using the disk group. Disk Utilization warns against increasing loads on a disk group and is represented as a percentage of total possible disk activity, with 0% for no activity and 100% for full load. The load is based on throughput, response time, and queue depth, and is monitored and graphed for each disk group and array. You can use this information to monitor and track utilization at the disk group level and see how much remaining performance capacity is available. When disk utilization reaches its configured threshold, it’s marked on the display with a red dot (Figure 4) and the predictor sends an e-mail or an SNMP trap with all of the details.
The Predictor e-mail provides a clear description of the problem, the business impact, the victim servers experiencing slower response times, the root cause (bully) servers that are causing the problem, and hyperlinks for a full analysis and detailed drill-downs of the individual server workloads. The predictor eliminates guess work and time-consuming troubleshooting of failures because you are provided with the detailed root cause of developing problems before they result in a failure. Rather than simply reporting metrics, as in the case of many other tools, the Predictor analyzes metrics and helps isolate the problem for you.

IDENTIFYING AND RESOLVING BOTTLENECKS QUICKLY

For VMs and host servers, OnCommand provides another Key Performance Indicator called the Performance Index, which monitors the servers’ CPU, memory, and I/O and determines how quickly work is performed, as well as how much capacity remains. By plotting the Optimal Point, always represented as 100, and the current Performance Index, you can quickly see if the server is exceeding its performance capacity and whether the bottleneck is CPU or I/O, as shown in Figure 5. For storage arrays and disk groups, you can also leverage the array controller and Disk Utilization analytics. Using this information, you can quickly determine if the storage is a bottleneck, if the issue is at the controller or the disk group, or if the problem originated with a specific workload that is overwhelming the storage configuration.

To make it even easier to identify business impact, OnCommand provides a performance health panel showing the most critical issues, as illustrated in Figure 6.
OnCommand also provides performance analysis and load balance information that can help you quickly identify disk contention, performance patterns, congestion, and topology issues, as shown in Figure 7.

**OPTIMIZING THE INFRASTRUCTURE**

Effective storage service delivery relies not only on capacity, but also on having enough performance to satisfy the needs of the applications running in the cloud. Tracking and understanding performance are critical to maintaining and improving service quality. In the past, a method of trial and error might have been acceptable because you had more time to deliver a service. In the fast-paced environment of a private cloud, you need accurate and timely reports and alerts to adequately assign resources to workloads. You also need a strong understanding of the actual (not perceived) performance requirements of workloads in order to assign the correct tier of storage.
OnCommand provides visibility into a wide range of performance characteristics of the critical storage paths through Fibre Channel (FC) switches and into arrays. This visibility can help you balance storage and increase application availability. OnCommand discovers performance data such as access patterns and maps it to the service path, which enables you to detect, troubleshoot, and address infrastructure congestion (bottlenecks), array contention (hot spots), or low access. Using the detailed traffic visibility into storage usage provided by OnCommand (Figure 8), you can implement a cost-effective tiering plan that also allows you to repurpose or decommission expensive storage.

Figure 9) Performance view into your critical storage paths through FC switches and arrays.

CALCULATING HEADROOM

When consolidating workloads for the cloud, the Performance Index provides a unique view of how much performance capacity remains for a specific set of infrastructures (Figure 9). Using the Performance Index, you can more accurately determine if an existing VM, virtual host, and/or storage can support additional workloads without negatively affecting performance.

Figure 10) Calculating headroom using current and optimal operating points.
ENABLING THE PATH TO PRIVATE CLOUD: SERVICE ANALYTICS

PROVIDING STORAGE SERVICE AVAILABILITY, IMPACT, AND CONFIGURATION COMPLIANCE

SETTING AND CONFORMING TO POLICIES TO ENABLE ACCESS, AVAILABILITY, AND PERFORMANCE OF SERVICE PATHS

To deliver cost-effective, efficient services, you need complete visibility into how storage resources are connected to your users of storage. You can only accomplish this by discovering and correlating components between end points. When one resource is correlated to another, it’s possible to measure performance and perform impact analysis and capacity planning. OnCommand enables you to gain end-to-end visibility into heterogeneous storage infrastructure availability, performance, and utilization service levels in the context of applications and business units. OnCommand does this with a comprehensive view of physical and virtual infrastructure. In addition, through VMware® vCenter™, OnCommand can identify orphaned volumes that are too often attached to unused VMs as a result of VM sprawl, which leads to lower utilization. These volumes can then be reclaimed and added into the pool of available storage.

OnCommand continuously discovers the physical and logical configuration of devices and then helps you to build a policy-based service model of how the interaction of these devices delivers a service to an application, resulting in a service path. Service paths provide visibility into multivendor storage connected to physical, logical, and virtual server environments, including VM-to-host-to-fabric-to-storage access paths, as illustrated in Figure 10. They also provide visibility into storage availability and change management.

Figure 11) Automatic discovery of your service path including VM-to-host-to-fabric-to-storage paths.
For example, you might want to define a service path and policies from a logical unit number (LUN) to a vCenter datastore. You specify these two end points and then OnCommand discovers all of the logical and physical components that intersect the path between the end points. In this case, the LUN might be connected to a storage controller in an array, then to a SAN switch, and then to an FC port on the vCenter server. The discovery process collects data on all of these components. Data collected for the storage controller exposes volumes, LUNs, interfaces, and performance metrics. Data for the FC switch includes switch port data such as the worldwide name. All of this data is correlated to form a service path. OnCommand can then help you to define a set of global application, host, or path-based policies and best practices to help provide the expected levels of access, performance, and availability of the service.

Another example is to discover the path and define policies between a Network File System (NFS) export and a vCenter NFS datastore. Within the NFS datastore, you can correlate to a granular level to specific VM files on that datastore, for instance, VMDK, configuration files, and so on.

**SETTING ASSURANCE POLICIES FOR MONITORING**

OnCommand enables you to set policies designed to meet performance service-level objectives (SLOs) at each touch point along the service path. For example, you might set a minimum threshold for input/output operations per second (IOPS) on a storage controller port. If the controller port is not meeting the threshold, then it’s violating the service-level objective for that service path. This capability keeps cloud services operating at expected performance levels. You can also set the policy to alert for deviations outside of normal performance to identify trends that might eventually violate the SLO if you don’t identify and rectify the issue soon.

**SETTING SMART THRESHOLDS AND ALERTS FOR THIN PROVISIONING**

Thin provisioning and deduplication are frequently implemented in private cloud environments to extract the most utilization from existing and new storage resources. Thin provisioning is highly efficient because only consumed storage is actually allocated. The downside of this model is that, eventually, if everyone requests more capacity on the same day, you might not have the capacity to respond. Intelligent monitoring can provide the safety net needed to help you always honor existing requests and maximize efficiency.

OnCommand provides real-time information about available resources to accelerate application provisioning with an accurate, repeatable, and end-to-end provisioning process that minimizes rework. With OnCommand, you can set thresholds and proactively monitor (illustrated in Figure 11) and generate exception reporting on configurations and usage of thin provisioning and deduplication technologies. To enable accurate monitoring and risk mitigation, you can set parameters specifying the percentage of storage pool overcommit, free space, and so on, from the device, storage pool, and business-level perspective. In addition, OnCommand provides what-if monitoring, detailed storage efficiency reporting, and reporting about thin provisioning to help you proactively manage the virtual environment.
ENABLING CONFORMANCE

Measuring adherence to process and policy is critical to delivering a high quality of service and achieving efficiency in a private cloud. OnCommand helps keep your private cloud infrastructure in conformance by comparing all real-time storage paths and changes with the established policies for those service paths and sending alerts on all violations. This information can also be used in support of corporate compliance initiatives.

Because OnCommand audits and logs all changes, when a change occurs that affects a service path OnCommand automatically sends an alert and provides root-cause analytics around the problem. For example, a root cause might be:

- Active path conflict—misconfigured virtual hosts in an active-passive configuration
- Inconsistent LUNs—LUNs that are not equally assigned to members of the same cluster (which could cause an application to go down if a failover occurs)
- Missing redundancy—service paths that violate the minimum number of redundant paths required for an application (illustrated in Figure 12)
- Missing virtual cluster path—when there is a missing path to storage from one of the members of a virtual cluster (which could cause the application to go down if a failover occurs)
- Path outage—when a component of a service path becomes unavailable and disrupts the flow of data
In addition, OnCommand can report on violations by event. In general, most violations are caused by events, such as an outage, or changes that often trigger multiple violations, as shown in Figure 13. By reporting on an event, OnCommand enables you to identify and fix one issue, and thus clear multiple violations at the same time.

Figure 14) Report on violations by event so you can take immediate, corrective action.
In a private cloud, where storage is allocated only when needed, it’s more important than ever for users to understand how much storage they use. OnCommand can send user alerts (e-mail) to all users who exceed their disk or file quota limits. In addition, the provisioning policy in OnCommand contains two threshold parameters—nearly full threshold and full threshold—that are defaulted to 80% and 90%, respectively. When these thresholds are reached, warnings and errors display in OnCommand and the NetApp Management Console.

OnCommand helps enable provisioned datasets to be in conformance with storage service levels. For example, if a SnapVault® action is not occurring, then the dataset is out of conformance, because the primary storage is not being backed up. In this case, Unified Manager will detect this violation and alert the user.

MAKING CHANGES WITH CONFIDENCE

In a siloed environment, changes to hardware, firmware, or software affect only the application running on that system. In a private cloud environment, in which many applications share resources, one change has the potential to cripple your business. You need the ability to make changes quickly to respond to increasing demands and reap the benefits of cloud computing, but you also must determine that changes do not have an adverse affect on the environment as a whole. OnCommand provides tools to help you plan, simulate, analyze, validate, and implement changes, so you deliver private cloud services with confidence.

OnCommand change management tools enable you to plan minor or major changes in your environment and test them so you can correct any potential issues before implementation. This can be something as simple as upgrading firmware in a switch or as complex as moving all application storage from one array to another. OnCommand provides what-if scenarios to simulate planned configuration changes and accurately determine the service impact on applications, so you can eliminate the risk of violations and catastrophic human errors during the actual changes and accelerate the time it takes to complete them.

Once you’re confident that the changes are sound, the tools help you build a detailed, actionable task list that you can use to make the actual changes (Figure 14). During the change window, the change management tools dynamically monitor and validate each change you make in real time, so you gain immediate confidence that you are completing the changes according to plan and without issues.

Figure 15) Task list to implement your tested change.
Along with making changes to the infrastructure, you can also use OnCommand to plan and optimize the alignment of VMs and storage, or further optimize your storage tiers by identifying tiering candidates by more accurately assessing usage over time. With this information you can better predict future storage needs across storage tiers, enabling you to make more intelligent and cost-conscious decisions when purchasing additional hardware. Another excellent use of the change-planning features is to plan, test, and validate applications before you consolidate and migrate them to the private cloud.

**FORECASTING CAPACITY MORE ACCURATELY WITH TRENDING AND ENABLING SHOWBACK**

**CREATING COST AWARENESS**

OnCommand’s reports (Figure 15) are highly configurable, enabling you to view detailed business-level usage reporting by application, business unit, tenant, project, tier, data center, and so on. For example, you can manage capacity on a set basis, say, monthly, so that enough storage is preprovisioned to accommodate growth in the cloud. Imagine a scenario in which your expensive tier-1 array shows 80% full. Just because an array is 80% full does not mean the array is 80% used. Actual utilization is usually significantly lower. Additional analysis shows that the actual traffic through that array is only around 25% utilization. Conducting further analysis on the applications using that array you find that although the applications use a lot of storage, they don’t require the speed for the amount of actual access to that storage. With this information, you can move these applications to tier-2 or tier-3 storage and immediately validate that there is no negative effect on the performance of the applications. Using the reports, you can intelligently and proactively manage the storage service requirements by application, not simply by array type, and provide a more realistic business approach to service delivery. This correlation can now be used to provide business-level metrics for showback/chargeback, and for optimizing/planning storage needs.

Figure 16) Capacity costs by business unit, users, and tiers.
REPORTING ON COSTS

Controlling costs is particularly important in a private cloud in which users and business units share resources. To manage cost against need, you need to be able to show the actual usage of cloud resources. Cost awareness can be used for budgetary reasons to justify your IT budget and requests for new purchases. It can also help end users understand the costs of storage and virtual infrastructure that their applications consume. As mentioned earlier in this paper, in more advanced deployments of private cloud, some enterprises might also implement a chargeback model to charge internal users, departments, business units, and so on for their consumption of resources.

OnCommand contains all of the data about the storage infrastructure that was discovered when defining service paths. OnCommand also has integration with DataFabric® Manager, enabling reporting for chargeback and capacity planning. You can annotate and align this information with business-level elements to provide business-level reporting on usage by application, business unit, and data center. Typical alignment use cases include:

- Aligning application and end users or business units (data owners) with servers and storage
- Establishing and aligning tiers to the loaded cost per gigabyte (GB)
- Aligning VM usage with application and customer or business unit
- Associating and reporting application cost to end user or business unit by multiple levels including tiers, storage devices, storage pools, volumes, storage network, protocols (FC, NFS, iSCSI, FCOE) and VMs

For example, tiers and costs can be aligned with storage usage by business applications at four primary levels: storage array, storage pool, internal volumes, and LUNs. Tier characteristics can be further defined within storage pools and volumes by these characteristics: disk type, disk size, disk speed, RAID protection, and volume types. Top-level graphic reporting automatically consolidates storage and VM usage by application, business units, data centers, and so on. These reports can drill down to show the quarterly cost of each business unit and its applications, tier usage, capacity, and total cost per quarter to provide valuable insight into the cost of the applications within a virtualized private cloud environment. The reports show actual usage by application—including actual utilization of data, Snapshot® copies, thin provisioning, and deduplication—regardless of the underlying virtual technologies. A sample report is shown in Figure 16.
Figure 17) Cost report on usage by application in a virtualized environment.

Cloud Services Chargeback Report
Includes costs of VM + storage usage by each Application and BU

<table>
<thead>
<tr>
<th>Cloud Customer Name</th>
<th>Application</th>
<th>VM</th>
<th>VM Cost</th>
<th>Data Store</th>
<th>Actual Capacity GB</th>
<th>Tier</th>
<th>Tier Cost</th>
<th>Storage Cost</th>
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<td>Dev Test</td>
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Enable Showback

Showback calculations need to include temporary VMs, development and test VMs, labs, and other nonproduction elements, so end users can understand the full cost of services and make business decisions based on all usage, not just production environments. You can also add charges for administration costs, overhead, facilities, and so on to help form a complete cost accounting report.

There are many showback models that you can report on. Two common models are a simple model and a loaded model. A simple model is one in which you show costs per GB in terms of the raw GB of the storage allocated to an end user. This is based purely on the cost of the storage array divided by the number of GBs and does not include the cost of tiering, protection, configuration, or support overhead. For example, 100GB of raw storage with RAID 1 yields 50GB of allocated storage. The report shows the cost for 100GB of raw storage, but only 50GB is usable because of the protection requested.

With a loaded model, you show the cost of storage per GB but also combine the cost of all support and overhead. The loaded model is typically more realistic and thus used to more accurately report the true cost of storage to end users. OnCommand enables you to easily create automated chargeback or showback reports using the drag and drop features of the data warehouse. You can also create your own customized reports using MySQL queries against the OnCommand data warehouse.

With these reports, and the feedback from your end users, you can make better business-level storage allocation decisions based on the capacity usage and cost of applications as compared to the business value the application provides.
4 ECOSYSTEM INTEGRATION

NetApp realizes that it takes many technologies to implement and manage a successful private cloud and that many organizations would like to utilize their existing applications, or other applications, in this environment. NetApp’s ecosystem integration approach includes open APIs and SDKs to enable you to share data with these applications. NetApp’s differentiator is that we integrate with higher-level management platforms through strategic partnerships with leading infrastructure management providers, such as BMC Software, CA, DynamicOps, Microsoft, and others. Through NetApp’s open interfaces, third-party management platforms or your in-house management tools are allowed the same level of access as NetApp’s management tools. This enables integration at a much higher level of abstraction and empowers you to perform policy-based automation tasks for storage from your existing tools.

OnCommand’s service-centric data repositories are aligned with broader IT service management (ITSM) technologies through a variety of integration techniques. By leveraging OnCommand information, ITSM solutions can integrate storage service data to round out the view of infrastructure for enterprise reporting and analysis. For example, BMC Software implemented a software adapter using NetApp open APIs and SDK that takes full advantage of the Service Catalog to enable full-stack automated provisioning from BMC’s Business Service Management (BSM) product. OnCommand can also be integrated with financial applications to enable actual chargeback to users and business units.

OnCommand is also integrated with VMware vCenter and Microsoft® System Center. This integrated functionality provides VM server and storage administrators with deep visibility across the data center infrastructure into storage and VM environments.

The vCenter plug-in sends OnCommand service path, configuration, performance, and violation information so it can be viewed by VM server teams from within vCenter. This valuable information is not natively available in vCenter. Additionally, all of the VM capacity and performance information is provided back to OnCommand, which provides the storage management team with insight into the performance, capacity, and usage of the VM environment and how it relates to external storage usage. This provides you with complete end-to-end visibility of storage usage for each of the VMs, including arrays, volumes, tiers, capacity, and other information.

Another key NetApp advantage is the ability to integrate with many higher-level orchestration frameworks such as Apache ODE, Oracle® BPEL Process Manager, TIBCO BusinessWorks, and so on. By leveraging the NetApp Manageability SDK and open APIs you can create a self-service portal and use third-party ITSM platforms, virtualization management solutions, your in-house management tools, or third-party analytics to gain the same level of access to NetApp storage technologies as you can directly via NetApp OnCommand.
5 SUMMARY

As you move applications from silos to virtualized, shared IT infrastructures to private clouds, NetApp’s OnCommand suite of products can help optimize the efficiency of the infrastructure in providing the end user with flexible and cost-effective services and service levels. OnCommand Unified Manager provides in-depth monitoring for NetApp systems. OnCommand Insight products provide service analytics for shared, virtualized, heterogeneous IT infrastructures and consist of four modules:

- **Balance**: workload optimization—get service-path visibility into virtual infrastructure environments so you can plan and optimize the alignment of VMs and storage and eliminate capacity and performance concerns
- **Assure**: assurance monitoring—enable storage service availability, impact, and configuration compliance
- **Perform**: storage performance—manage storage infrastructure resource performance
- **Plan**: capacity planning—plan for and enable capacity to meet current and future demands and enable showback and trending

OnCommand provides the Key Performance Indicators, in-depth visibility into complex multivendor and multiprotocol storage services, and powerful analytics to help you fully leverage the promise of private cloud computing.