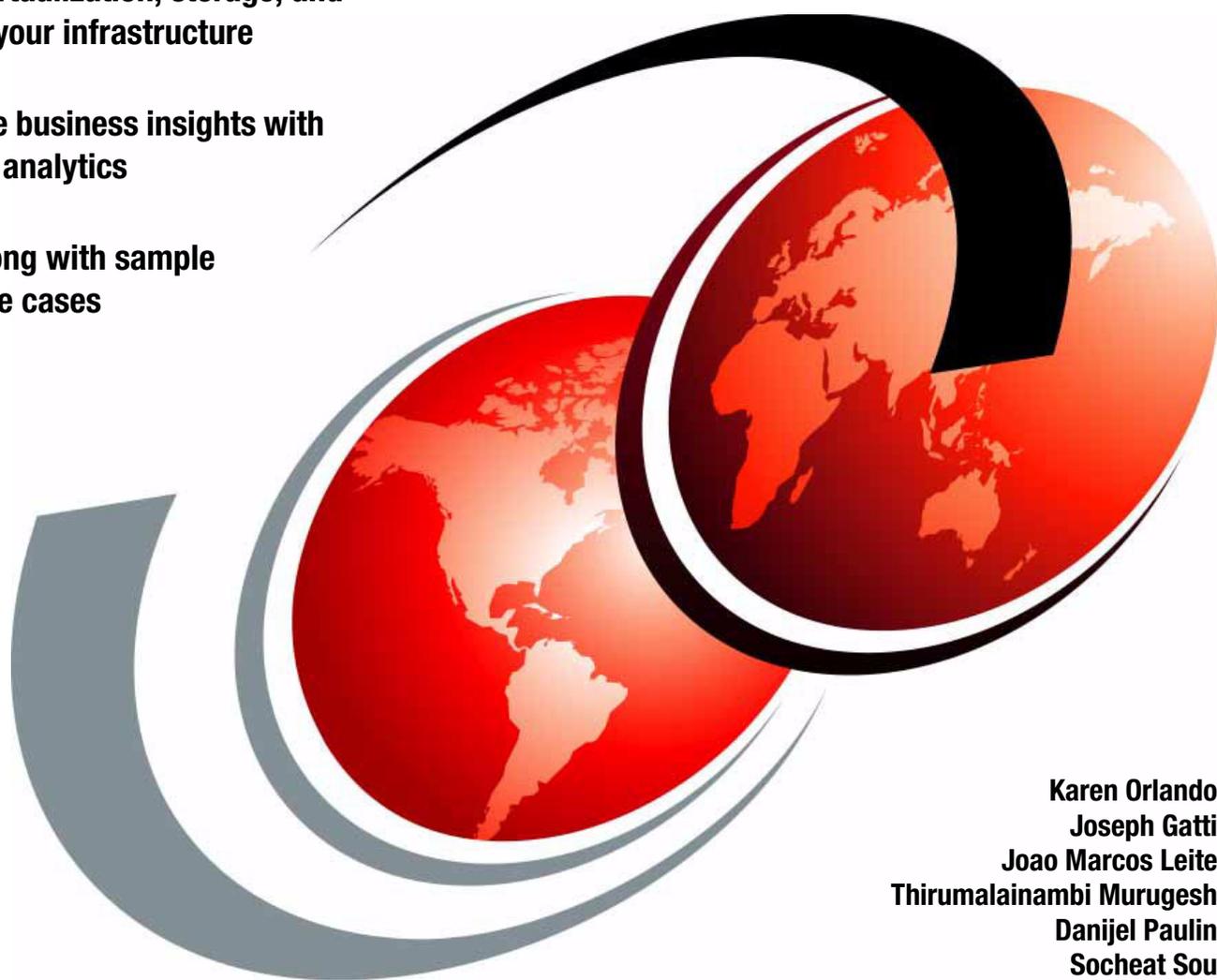


IBM SmartCloud Virtual Storage Center

Explore virtualization, storage, and cloud for your infrastructure

Accelerate business insights with advanced analytics

Follow along with sample guided use cases



Karen Orlando
Joseph Gatti
Joao Marcos Leite
Thirumalainambi Murugesh
Danijel Paulin
Socheat Sou

Redbooks



International Technical Support Organization

IBM SmartCloud Virtual Storage Center

February 2015

Note: Before using this information and the product it supports, read the information in “Notices” on page vii.

First Edition (February 2015)

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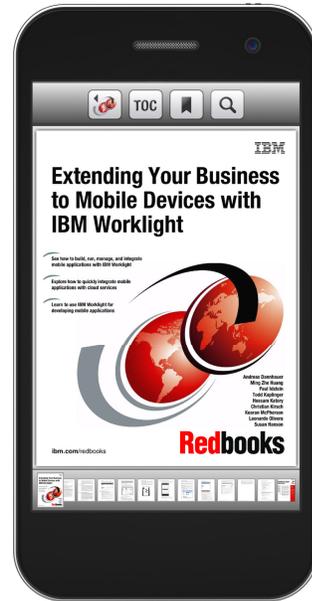
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Preface

IBM® SmartCloud Virtual Storage Center provides efficient virtualization and management of heterogeneous storage systems. It facilitates migration to an agile cloud architecture that can optimize storage availability and performance, while helping to reduce costs.

IBM SmartCloud® Virtual Storage Center (VSC) helps convert existing storage to IBM Smarter Storage, providing more room for data growth and simplified storage administration.

This IBM Redbooks® publication gives an overview of the concepts of software-defined environment (SDE) and software-defined storage (SDS), and how they work together with VSC. It explores the architecture, components, and interfaces, providing details of VSC and how to use it.

It also includes practical scenarios and use cases, helpful for client VSC business environments, with a focus on the following topics:

- ▶ **Introductory concepts:** These can help you better understand SDE and SDS in both cloud-based and traditional IT business environments.
- ▶ **VSC components and available integrations:** This topic describes how these can assist you in transforming traditional storage to storage clouds.
- ▶ ***Storage management* component of VSC:** This topic shows you the functionality that the integration of IBM Tivoli® Storage Productivity Center provides.
- ▶ ***Storage virtualization* component of VSC:** This topic gives an overview, comparisons, and describes options with IBM SAN Volume Controller, Storwize® V5000 and V7000.
- ▶ ***Application aware data protection* component of VSC:** This topic gives an overview and use case. Also provided are IBM Tivoli Storage FlashCopy® Manager and DB2® example scripts (*pre-freeze* and *post-thaw*) and the steps for creating customer scripts before running backups.
- ▶ **VSC storage provisioning:** This topic describes how you can simplify the way storage is provisioned in an IT environment.
- ▶ **VSC storage optimization:** Functions and uses cases can help you to optimize your storage environment by improving performance and to better utilize storage resources.

This book is primarily for storage administrators, users who are responsible for maintaining IT and business infrastructures, and anyone who wants to learn more about IBM SmartCloud Virtual Storage Center.

Authors

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, Poughkeepsie Center.



Karen Orlando is a Project Leader at the International Technical Support Organization, Tucson Arizona Center. Karen has over 25 years in the IT industry with extensive experience in open systems management, software development, and hardware test of IBM storage. Karen has lead several projects for Redbooks publications about IBM Tivoli Storage Productivity Center, IBM FlashSystem™, IBM ProtecTIER® products, and storage solutions. She holds a degree in Business Information Systems from the University of Phoenix and is Project Management Professional (PMP), certified since 2005.



Joseph Gatti is a Senior IT Specialist from Austin, Texas hired by IBM in 1999. He has worked in IBM Software Group as a Technical Enablement Specialist and in Advanced Technical Presales and in Global Process Services as the lead IT Architect and Storage Administrator. His areas of expertise are IBM storage hardware and software, Brocade, Cisco, NetApp, VMware vSphere, vCloud Director, Solarwinds Storage Manager, and CloudStack. Joe has been providing pre- and post-sales supported for Tivoli Storage Productivity Center since version 1.2, and has created technical enablement hands-on labs for FlashCopy Manager for VMware and Tivoli Storage Manager for Virtual Environments.



Joao Marcos Leite is an IBM Senior Certified IT Specialist from Brazil who joined IBM in 2000. For more than 13 years in the IBM Systems and Technology Group, his focus has been in the field of storage solutions design for clients. His current role is in Client Technical Sales Support. His areas of expertise include storage virtualization and storage management products. Joao co-authored three previous Redbooks publications for SAN Volume Controller, Tivoli Storage Productivity Center, and SAN Volume Controller with FlashSystem 820. He graduated as a Data Processing Technologist from Universidade Federal do Parana in Curitiba, Brazil, and has 33 years of experience as an IT Specialist. He is a member of the Technology Leadership Council Brazil (TLC-BR) an affiliate of the IBM Academy of Technology, and holds a title of Distinguished IT Specialist by The Open Group.



Thirumalainambi Muruges is an Integration Architect working for the IBM Global Technology Services® (GTS) group in Sydney, Australia. Muruges has over 17 years of experience in IT performing solution design, prototypes development, implementation and integration. His areas of expertise includes design and development of architectures, patterns, assets and tools for high availability server and storage solutions. Muruges has designed infrastructures as a service (IaaS) solution using VMware for servers virtualization, IBM SmartCloud Virtual Storage Center. This includes SAN Volume Controller for storage virtualization, Tivoli Storage Productivity Center for storage management, Tivoli FlashCopy Manager for application aware backups, Tivoli Storage manager for data backups and Symantec Enterprise vault for policy based data archiving. Muruges has a Ph.D in Electrical and Electronic Engineering from the University of Auckland, New Zealand, with a specialty in Secure Network Management with Cryptography.



Danijel Paulin is a Systems Architect at IBM in Croatia, working for the Systems Architectural team, in the IBM South East Europe region. He has 17 years of experience in IT. Before joining IBM in 2003, he worked for two financial companies in Croatia where he was responsible for IBM mainframe and storage administration. He has experience with a wide array of IBM storage products and storage software. His areas of expertise include architecture and design of various high availability, disaster recovery, business continuity, and virtualization solutions for mainframe and open systems.



Socheat Sou is a Staff Software Engineer from Tucson, Arizona. He has been with IBM in several capacities. He worked in the storage technology area for six years, and with the Tivoli Storage Productivity Center and Virtual Storage Center for the past three years. He received a Computer Science Engineering degree from the University of Michigan. His areas of expertise include SONAS, OpenStack, and Linux.

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Markus Standau
IBM Sales & Distribution, STG Sales

Thomas Clark
Brian De Guia
Scott McPeek
Bryan Odom
Harley Puckett
Ben Randall
IBM Software Group, Cloud & Smarter Infrastructure

Tony Pearson
IBM & Technology Group, Client Enablement & Systems Assurance, Master Inventor and Senior Consulting IT Specialist

Toni Ionescu
Global Technology Services, Tivoli Storage Manager Client Product Currency Center of Competency

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IBM Sales & Distribution, Inside Sales, ITSO Tucson Center

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Introductory concepts

This chapter provides the introductory concepts to help you better understand software-defined environments (SDE) and software-defined storage (SDS) in both the cloud-based and traditional IT business environments. We provide an overview of the IBM SmartCloud Virtual Storage Center (VSC) component of this model, describing how this solution enables your organization to deliver IT services in the most efficient way possible.

1.1 Overview

With the evolution of technologies, people through social media and smart devices are generating huge amounts of data, which has led to an information explosion in recent years. In response, organizations are becoming more instrumented, interconnected, and intelligent. While organizations continue to focus on improving and supporting their important traditional IT business workloads like enterprise resource planning (ERP), human resources (HR), customer relationship management (CRM), businesses are also striving to engage customers that use big data, analytics, social media and mobile apps. Figure 1-1 depicts the results of this information explosion.

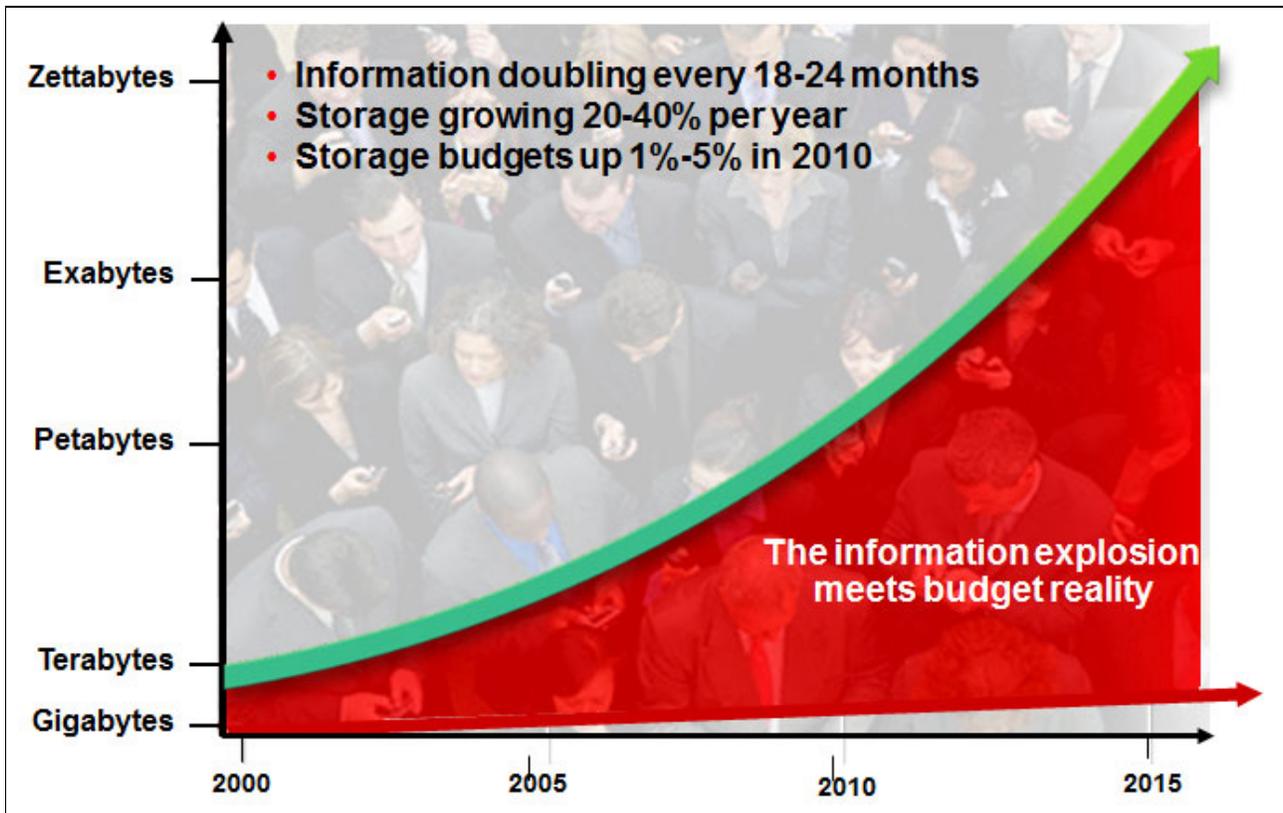


Figure 1-1 The information explosion ¹

The following sections provide an overview and the terminology to help you understand the software-defined environment (SDE) model. The cloud-based model described in this book encompasses IBM software-defined storage (SDS), with IBM SmartCloud Virtual Storage Center (VSC).

We discuss in general how VSC is integrated into this environment, adds value, and delivers a storage cloud-based solution.

¹ Source: Tivoli Storage Talk, SmartCloud Virtual Storage Center (VSC) Sales Enablement

1.2 Software-defined environment (SDE)

Imagine an entire IT infrastructure controlled not by hands and hardware, but by software: one in which workloads like big data and analytics are serviced automatically by the most appropriate resource.

This section briefly describes the SDE concept and the benefits provided to the business. SDE can be described as a programmatic access to the infrastructure resources. The IT industry is shifting from the traditional landscape to an application programming interface (API) driven, cloud-based services consumption model. SDE transforms the old static IT infrastructure resources into dynamic, constantly optimized, workload-aware, virtualized resources.

SDE can be defined as a loosely coupled set of software components which are able to provide, among others, the following basic functions in order to federate hardware resources (such as compute, network, and storage) and make them all available in the form of an integrated IT service:

- ▶ Virtualization and optimization
- ▶ Dynamic cross-domain integration and orchestration
- ▶ Policy-based workload automation

SDEs represent another transformational trend in the optimization journey to better support today's workloads (Figure 1-2).

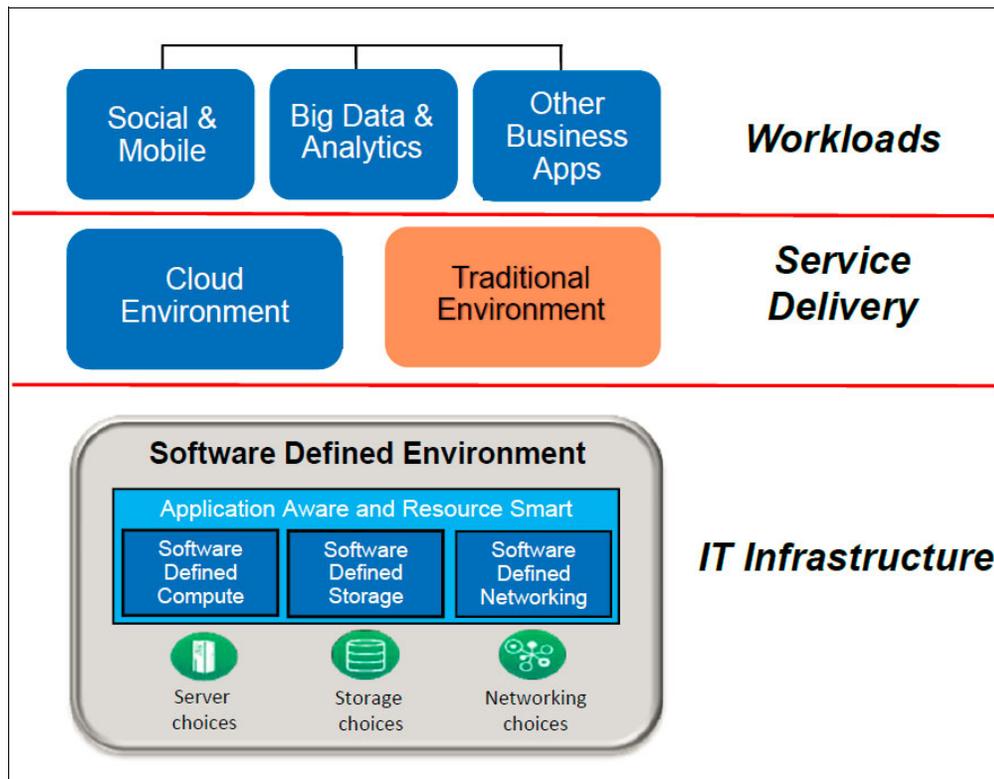


Figure 1-2 SDE reference architecture

The figure shows the following items:

Workloads	SDE improves agility of business applications and accelerates the application lifecycle through rapid change. This layer represents the traditional business applications (ERP, HR, CRM, and others) and the new ones (big data, analytics, social, mobile, and others.). All of them of course can have integration through APIs made available from the API economy.
Service delivery	Cloud and traditional approaches to deliver the IT services to the business applications can generally coexist. This layer represents both as possible ways to claim IT resources from the SDE environment. In cloud, for example, IT services can be requested through a web portal or APIs and automatically generate a deployment workflow; in the traditional approach they can be automated or even deployed manually by operators.
IT infrastructure	This layer represents the IT SDE infrastructure for programmable, open standards-based infrastructure foundation to enable cloud, mobile and other dynamic enterprise solutions. This resource smart infrastructure spans across all domains for maximum agility and efficiency and consists of the following components: Software-defined computing Software-defined networking Software-defined storage

1.2.1 IT SDE infrastructure components

Within the landscape of a software-defined environment, the IT Infrastructure layer spans across all domain for the maximum agility and efficiency and consists of the software-defined computing, software-defined networking, and the software-defined storage components.

Software-defined computing (SDC)

SDC is based on CPU virtualization technologies, which have been available in the market for long time. Several hypervisor technologies exist, covering open and mainframe environments. They are basically able to disconnect the physical hardware from the operating system, setting up virtual machines (VMs) on the physical server to run business workloads.

In SDC environments, the value of optimization, and agility are achieved through a top-down approach by these methods:

- ▶ Assessing the workload components
- ▶ Using patterns to determine the best ways to configure the components of middleware applications
- ▶ Mapping the workload onto the available virtual resources

Software-defined networking (SDN)

SDN is a network paradigm that separates each network service from its point of attachment to the network, creating a far more dynamic, flexible, automated, and manageable architecture. Administrators can easily move virtual resources throughout the network, create private virtual networks that meet specific performance security needs, and use many other high-value applications. The key to SDN is an innovative approach to controlling how data flows through a network. In a traditional network, data flow is controlled by switches and routers.

Each switch and router contains the following basic elements:

- ▶ **Data plane:** Physically carries data packets from one port to another by following rules that are programmed into the device hardware. The data-forwarding plane operates at the speed of the network (wire speed).
- ▶ **Control plane:** Contains the logic that the device uses to program the data plane, so packets are forwarded correctly throughout the network.
- ▶ **Management plane:** An administrator can log in to the device and configure it for basic activities. Most devices can be configured locally or through a network management tool. Vendors use control plane software to optimize data flow to achieve high performance and a competitive advantage. The switch-based control plane paradigm gives network administrators little opportunity to increase data flow efficiency across the network as a whole.

SDN abstracts the flow of control from individual devices to the network level. Similar to server virtualization, where virtual machines are decoupled from the physical server, network-wide virtualization gives administrators the power to define network flows that meet the connectivity requirements of end stations and address the specific needs of discrete user communities.

Software-defined storage (SDS)

SDS offerings unlock the potential of data and increase business agility and efficiency in ways that were not possible until now. IBM software-defined storage enhances the speed and efficiency of your storage and simplifies migration to new workloads by these methods:

- ▶ Accelerating global access to petabytes of data and billions of files
- ▶ Changing the economics of storage technology with multi-brand virtualization, intelligent tiering, and open API support (OpenStack software, Apache Hadoop, and POSIX)
- ▶ Transforming business models with hybrid cloud storage and data protection for big data analytics
- ▶ Supporting any storage, any data

The primary focus of subsequent topics in this chapter is on the SDS control plane layer, and more specifically the value that VSC adds to cloud-based solutions from within this layer.

1.2.2 Software-defined storage overview

Software-defined storage (SDS) is a *programmatic* approach to storage. SDS is a set of software capabilities that automatically manage data locally and globally, providing breakthrough speed in data access and easier administration. It also provides the ability to scale technology infrastructures quickly and more cost-effectively as data volumes expand. In addition, these advances can work with any company's storage systems to provide automated and virtualized storage.

SDS consists of loosely coupled hardware and software components. They implement a flexible, standard, and secure storage consumption model to programmatically meet your workload requirements in real time. SDS provides SDE with the following capabilities:

- ▶ Optimal workload allocation
- ▶ Transaction integrity
- ▶ Agility and scalability
- ▶ Universal data access

SDS inherent functions are as follows:

- ▶ Storage virtualization
- ▶ Policy automation
- ▶ Analytics and optimization
- ▶ Backup and copy management
- ▶ Integration and API services
- ▶ Security
- ▶ Cloud accessibility

The loosely coupled hardware and software products, with their specific features, of SDS must be orchestrated in order to provide all the capabilities needed by an SDE. This model means that customers do not need to replace their whole storage infrastructures with new products or devices, but can save on their previous investments by integrating their current storage systems into the new SDS environment.

The IBM SDS component model is illustrated in Figure 1-3. VSC is integrated in the *IBM SDS control plane*. VSC incorporates advanced functions and storage management functions of IBM Tivoli Storage Productivity Center, and also storage virtualization, and application-aware data protection that is provided by Tivoli FlashCopy Manager advanced snapshot capabilities. These components are coupled with advanced analytics, including storage optimization and provisioning to provide a cloud-based solution.

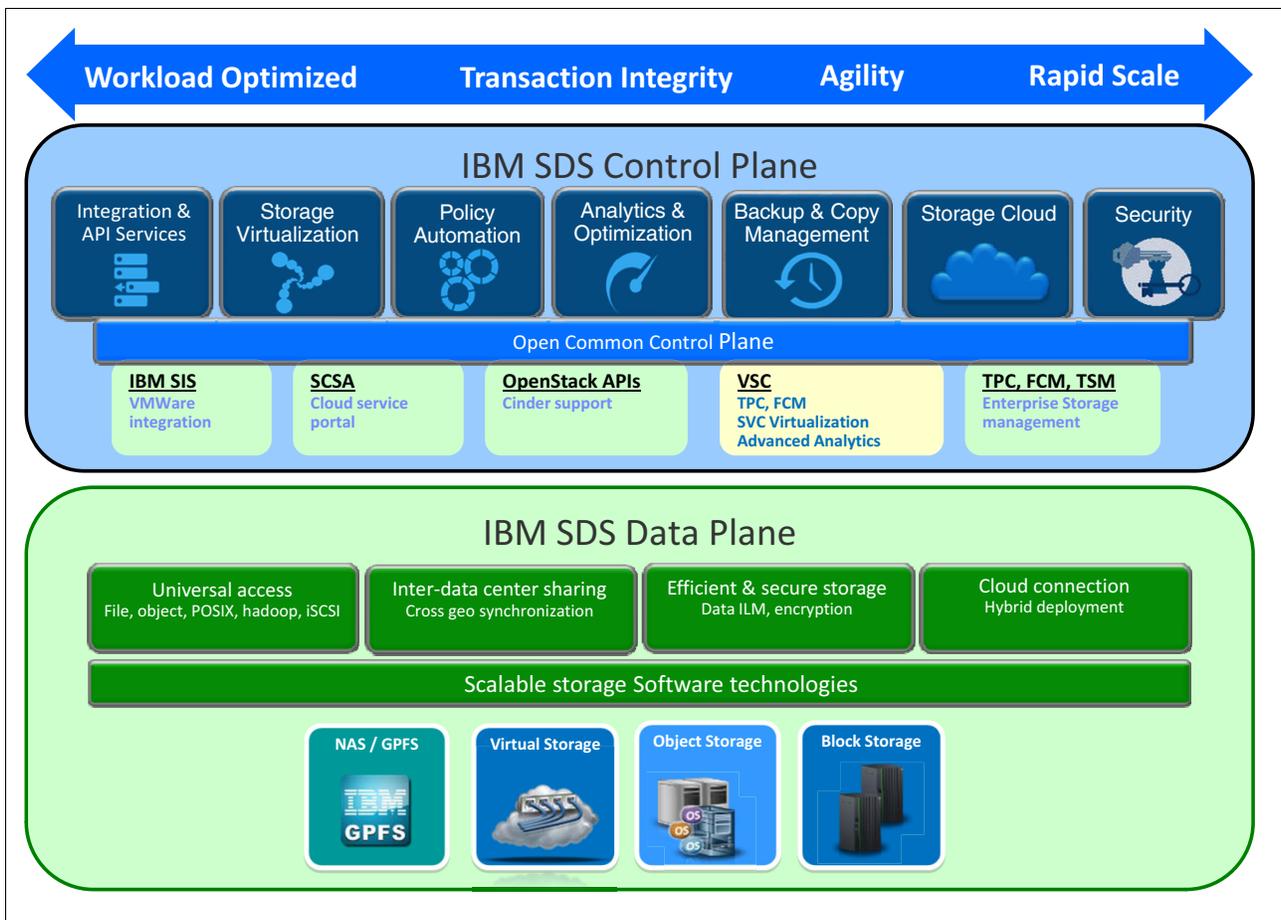


Figure 1-3 SDS component model

The figure shows two planes:

- ▶ **SDS control plane:** The control plane is a software layer that manages the virtualized storage resources. It provides all the high-level functions needed by the customer to run the business workload and enable an optimized, flexible, scalable and fast consumption of the storage infrastructure. These capabilities span across several functions, such as storage virtualization, policy automation, analytics and optimization, backup and copy management, security, integration with the API services, and the possibility to use and provide cloud storage services.
- ▶ **SDS data plane:** The data plane is the infrastructure where the data is processed. It consists of the hardware infrastructure where the data is stored and all the basic storage management functions such as RAID protection, tiering, copy services (remote, local, synchronous, asynchronous, and point-in-time), encryption, and data deduplication, which can be recalled and managed by the above layer. It provides a complete range of data access possibilities, spanning from the traditional access methods like block I/O (for example, iSCSI) or file I/O (for example, POSIX compliant), to the newer methods such as object storage or the Hadoop Distributed File System (HDFS).

IBM SmartCloud Virtual Storage Center (VSC), as shown in Figure 1-3 on page 18, is a key component of the IBM SDS control plane. It provides efficient virtualization and management of heterogeneous storage systems. VSC provides storage virtualization, end-to-end storage management, and data protection through application-aware snapshots. These capabilities are all tightly integrated with advanced analytics functions, such as optimization and provisioning, to deliver a robust storage, cloud-based, solution.

1.2.3 IBM SmartCloud Virtual Storage Center (VSC)

IBM SmartCloud Virtual Storage Center (VSC) provides an integrated storage management environment that can centrally manage a heterogeneous storage environment. VSC can automate a wide variety of storage management tasks (including virtualization and provisioning) that enable storage to easily be integrated into a cloud computing environment.

IBM SmartCloud Virtual Storage Center V5.2 enables easy migration to agile, cloud-based storage environments. This solution comprises the advanced functions available in IBM Tivoli Storage Productivity Center, IBM System Storage® SAN Volume Controller, and IBM Tivoli FlashCopy Manager, and the advanced analytics, provided by the IBM SmartCloud Virtual Storage Center V5.2 license. As an end-to-end storage management solution included in VSC, Tivoli Storage Productivity Center provides a single point of control that helps administrators manage every aspect of the storage infrastructure, between the hosts, through the fabric, and down to the physical disks for multi-site storage environments.

By integrating these products, VSC provides a combined storage virtualization platform and storage management solution. It provides more room for data growth and simplifies the administration of storage. Figure 1-4 on page 20 illustrates how VSC virtualization creates synergy across the heterogeneous storage devices.

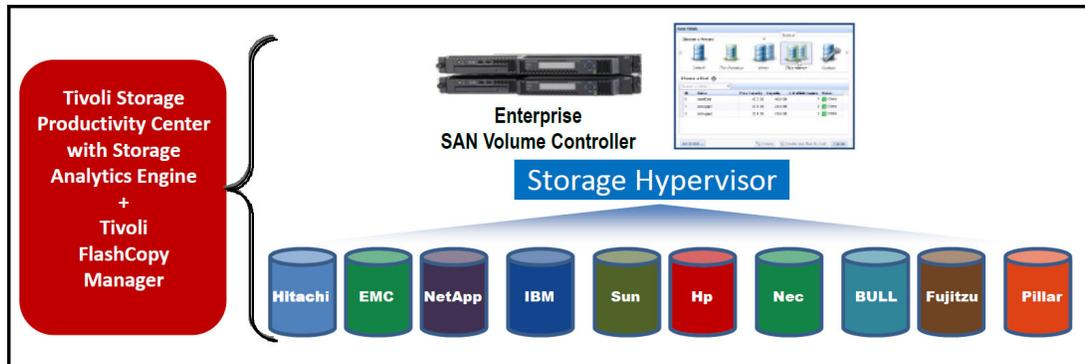


Figure 1-4 VSC virtualization creates synergy across the heterogeneous storage devices

Subsequent chapters in this book offer details of VSC architecture, components, interfaces, and practical scenarios that demonstrate use of VSC advanced analytics. Also included are usage scenarios and discussions of storage provisioning and optimization.

1.3 The changing landscape of IT environments

Today more than ever, clients have a need to reduce their IT operational costs and administration complexity to meet their modern business demands. To support this effort, clients are adding to existing traditional IT environments and moving toward cloud computing, offered in the market as commodity services.

The industry recognizes three primary models in *cloud computing*:

- ▶ Software as a service (SaaS):
 - Software runs on a cloud server.
 - Software is accessible through a web interface.
 - Users are concerned with only the front end (the web browser).
 - Examples are Google Apps, Dropbox, Evernote, and Skydrive.
- ▶ Platform as a service (PaaS):
 - Is primarily for developers.
 - Streamlines development, testing, and deployment.
 - Examples are IBM Bluemix™, IBM managed Cloud Services, Google App Engine.
- ▶ Infrastructure as a service (IaaS):
 - Infrastructure and hardware are provided.
 - Model is pay-per-use.
 - Overhead is much lower.
 - Examples are IBM SoftLayer®, Rackspace, Amazon Elastic Cloud.

With cloud services available to consume for customers, traditional IT environments tend to or will change over time toward a more software-defined structure. The potential savings in capital expenditure (CAPEX) and operational expenditure (OPEX) motivate clients to change the way they approach IT. Changing the way client IT environments work also involves changing business processes and general concepts.

Table 1-1 lists several types of traditional IT with new era IT applications and approaches.

Table 1-1 Traditional IT and new era IT

Traditional IT	New era IT
Banking, finance, insurance, mail	Web applications
ERP (SAP)	Media archives
Traditional Microsoft Office	Sync and share (Dropbox, Office365)
SQL Analytics	Hadoop Analytics
Transactional IT	Web scalability IT

1.4 Cloud computing

The National Institute of Standards and Technology (NIST) provides the following definition for cloud computing²:

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

A company can use cloud services that are provided by third parties (*public cloud*). A company can also build its own cloud (*private cloud*) and provide services from the cloud to internal company users, eventually to selected business partners or customers, or to the world. A company can also use both public and private (*hybrid cloud*).

A cloud service has the following characteristics:

- ▶ Supports self-service provisioning
- ▶ Accessibility through the Internet or corporate intranet
- ▶ Provision resources from a pool, without the user needing any knowledge of it
- ▶ Simple and fast resource elasticity, when users demand changes
- ▶ Resources monitoring capability with a dashboard view of cloud health status
- ▶ Metering capability, enabling a dynamic chargeback model

To provide these characteristics, the infrastructure that enables cloud services takes advantage of two key enablers that, although not part of any formal cloud definition, are proven to be indispensable in delivering the essential cloud service characteristics:

- ▶ **Virtualization:** Allows computing resources to be pooled and allocated on demand and enables pay-per-use billing.
- ▶ **Automation:** Implements the elastic use of available resources, supporting the provisioning and deprovisioning of service instances to support scalability, and allows the moving of workloads where they are available.

Application programming interface (API)

The API plays a key role in software-defined environments. APIs consist of routines, protocols, and tools to allow for software application communication. APIs specify how software components should interact and be used. With an API, developers can use functions of existing computer programs in other applications.

² NIST Special Publication 800-145, P. Mell, T. Grance. *The NIST Definition of Cloud Computing*: <http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf>

1.4.1 Storage cloud

Software-defined storage and storage cloud helps clients to address their top traditional storage-related issues (“pain points”), represented in the data (from 2013 and 2014), as shown in Figure 1-5.

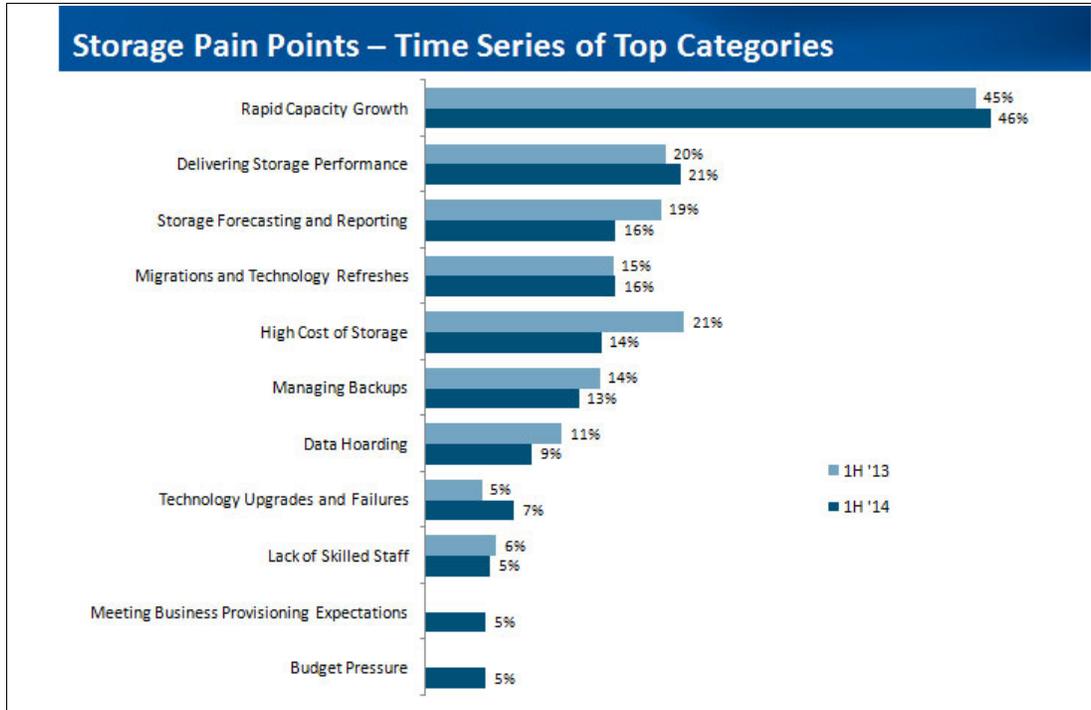


Figure 1-5 Top storage-related issues (2013-2014 data)³

Storage for cloud

Storage for cloud is a general term that is applied to the type of storage environment that is implemented in cloud computing to provision cloud-computing services. For example, when a virtual server machine is created, some storage capacity is required. This storage is provisioned as part of the VM creation process to support the operating system and runtime environment for the instance. It is not delivered by a storage cloud. However, it can be provisioned from the same storage infrastructure as a storage cloud.

A storage cloud can be part of an overall cloud data center, or can provide storage as a service to storage users. It can be delivered in any of the cloud delivery models (public, private, hybrid, or for example the OpenStack community, which is described in 2.5.1, “OpenStack software” on page 41). A storage cloud can be used to support a diverse range of storage needs, including mass data stores, file shares, backup, archive, and more. Several examples of publicly available storage clouds are as follows:

- ▶ IBM SmartCloud solutions, which offers various storage options, including archive, backup, and object storage.
- ▶ Microsoft OneDrive, which can be used to store and share files on the Microsoft public storage cloud service.
- ▶ Email services such as Gmail and Yahoo, which are services that store user email and attachments in their storage clouds.
- ▶ Facebook and YouTube, which allow users to store and share photos and videos.

³ Source is from InfoPro: *Storage Study: Wave 18 - 451 Research/The InfoPro*

Storage cloud capability can also be offered in the form of storage as a service, where fees are paid based on the amount of storage space that is used. There are various ways a storage cloud can be used, based on your organization's specific requirements.

1.4.2 Benefits of storage cloud

The storage cloud model can be helpful for businesses that have seasonal or unpredictable capacity requirements, and for businesses that require rapid deployment or contraction of storage capacity.

When storage cloud is used, clients can focus on their core business, and worry less about supporting a storage infrastructure for their data. Storage cloud provides the following key advantages:

- ▶ Facilitates rapid capacity provisioning, supporting business agility
- ▶ Improves storage usage by avoiding unused capacity
- ▶ Provides support for storage consolidation and storage virtualization functionality
- ▶ Gives chargeback and showback accounting for usage as an incentive to conserve resources.

Can be used to manage IT infrastructure and is based on the user's needs.

- ▶ Offers integrated storage and service management

The storage cloud infrastructure usually includes integrated management software. This software can be used to help manage the complete storage infrastructure from a single console, without having to buy proprietary management software from multiple vendors. This method can save time and help reduce spending on various proprietary management software.

- ▶ Improves efficiency of data management

Consolidation and standardization of storage resources facilitates less infrastructure complexity, which simplifies storage management. Consistent policies and process with integrated management tools support geographically diverse infrastructure requirements that are driven by performance or availability considerations.

- ▶ Provides faster time to market

Automation, self-service portals, rapid deployment, dynamic scaling, and centralized storage management enhance business agility by facilitating significant improvements, such as decreased time-to-market for new products. Businesses can focus on building their core products and competencies rather than worrying about the management of their IT infrastructure.

1.4.3 IBM SmartCloud Virtual Storage Center and storage cloud

IBM SmartCloud Virtual Storage Center (VSC) is the cornerstone of SDS control plane and it provides several capabilities in forming a storage cloud solution. According to the IBM SDS model, the control plane provides the storage management services that can be used by SDEs (either VMware based or Openstack software based), a series of integration APIs (based on REST and Open Service for Lifecycle Collaboration (OSLC) and the possibility of storage provisioning. SDS can also be integrated as an IT infrastructure component of cloud service providers' environments like SoftLayer, or vice versa it can exploit storage resources available in the storage cloud.

If you answer “yes” to any of the following questions, consider storage cloud for your storage environment.

- ▶ Do you have a need to consolidate mixed-vendor storage devices under a single point of control?
- ▶ Is determining how much storage is available for your applications difficult? What about how the storage is being used?
- ▶ Is storage affecting availability of your applications?
- ▶ Do you find that limitations imposed by your storage are controlling how you deploy new applications?
- ▶ Are you concerned with how fast your storage environment is growing? Are you concerned with how well-utilized your storage is?
- ▶ Is forecasting and planning for storage purchases difficult?
- ▶ Do you need to reduce storage acquisition and storage management costs while at the same time increase availability of your storage resources?
- ▶ Do you lack tools for analytics, trending, problem determination, and asset reporting that enable you to maximize the reliability of your SAN?
- ▶ Would you like a way to dynamically identify hotspots on your storage systems and then migrate data from one location to another location without any disruption to your service level and users?
- ▶ Are you concerned about the amount of time required by administration staff to manage your growing storage?

Figure 1-6 shows how the SDS control plane can be implemented by IBM SmartCloud Virtual Storage Center.

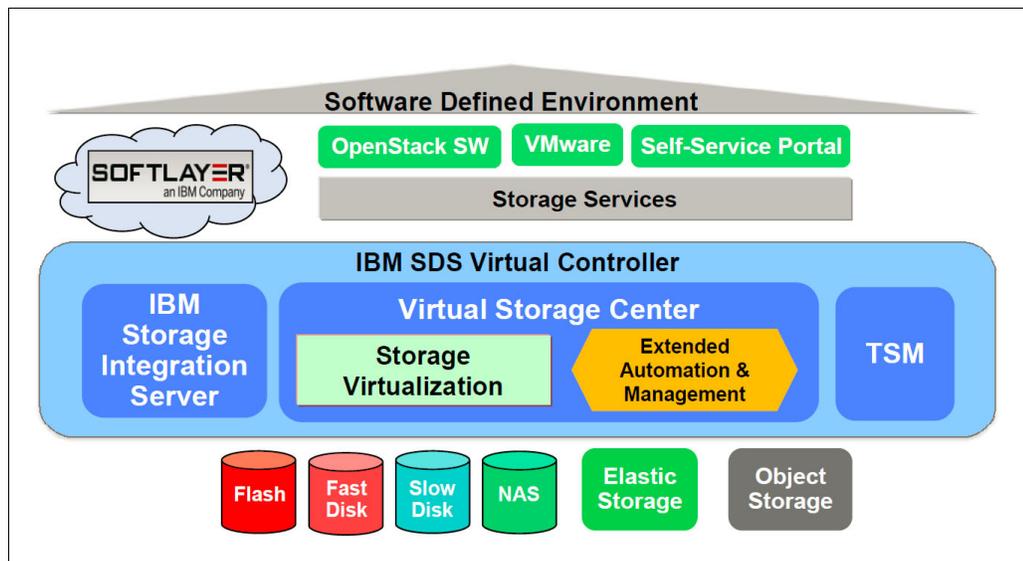


Figure 1-6 IBM SmartCloud VSC in SDS control plane to form a storage cloud solution

IBM VSC offers the following features in forming a storage cloud solution:

- ▶ **Virtualization:** VSC virtualizes heterogeneous storage at a block I/O level regardless of the vendors.
- ▶ **Optimization:** VSC optimizes the use of the block storage, creating a unique physical pool from which the customers can create their own tiers of storage.
- ▶ **Analytics:** VSC provides advanced storage analytics capabilities to discover, monitor, and report about the disk capacity usage and performances, and implement the chargeback; it simplifies the root cause analysis of performance issues.
- ▶ **Policy automation:** With VSC, customers can implement standardized storage provisioning by automation, with policies.
- ▶ **Copy Management:** Clients can use VSC to produce and manage multiple point-in-time copies of the data for backup, which can be sent to Tivoli Storage Manger for backup to media.
- ▶ **Improved storage utilization:** Make better use of existing storage and controlling storage growth expenditures.
- ▶ **Improved application availability and simplified data migrations:** Clients can make changes to storage and move data without taking applications down.
- ▶ **Simplified storage management:** VSC offers greater efficiency and productivity for storage management staff.
- ▶ **Network-based replication and software architectural advantages:** Helps enable greater choice (lower cost) when buying storage and lowers software costs.
- ▶ **Reduction in storage management and administration cost:** A core group of administrators can control multiple assets across a distributed storage environment (efficiency is improved by 50%).
- ▶ **Improved storage utilization:** Improves capacity utilization of existing storage assets.
- ▶ **Controls future spending:** Controls the growth of future spending (improves use by 30%).
- ▶ **Reduced cost of storage:** Capitalize on being able to purchase the lowest cost storage resources (growth is controlled, on average, by 20%).
- ▶ **Improved customer and user availability to data-driven applications:** Minimizes downtime associated with migrating data between storage assets

IBM SmartCloud Virtual Storage Center components and integration is described in Chapter 2, "Virtual Storage Center (VSC)" on page 27.



Virtual Storage Center (VSC)

This chapter describes the components of IBM SmartCloud Virtual Storage Center (VSC). At a high level, this chapter describes features of the components and available integrations to help you in transforming traditional storage to storage cloud.

Also described in this chapter are the VSC offerings and licensing model overview.

2.1 IBM SmartCloud Virtual Storage Center overview

IBM SmartCloud Virtual Storage Center (VSC) 5.2 provides efficient virtualization, management and data protection for heterogeneous storage environments. VSC helps IT storage managers migrate to an agile cloud-based storage environment and manage it effectively without having to replace existing storage systems. This powerful offering removes the physicality of storage, and also the complexity that is associated with managing multivendor infrastructures.

VSC V5.2 offers a storage virtualization platform, capabilities for storage virtualization management, and instant copy management. VSC V5.2 delivers to customers, under one licensed software product, the complete set of functions available in the IBM Tivoli Storage Productivity Center, the functions and capabilities that are associated with the IBM System Storage SAN Volume Controller (including copy services), and the capabilities of the IBM Tivoli Storage FlashCopy Manager. With VSC, you can now get all of the advanced capabilities of what was previously Tivoli Storage Productivity Center Standard Edition; and with the IBM SmartCloud VSC 5.2 license you get all of the advanced analytics functions. This powerful solution enables organizations to optimize provisioning, capacity, availability, reporting, and management for virtual storage.

2.2 Storage hypervisor

This topic introduces *server hypervisor* and *storage hypervisor*. It also has an overview of the IBM Storage Hypervisor, which is integrated with the IBM SmartCloud Virtual Storage Center V5.2.

Server hypervisor

In cloud computing, *server hypervisor* is a well understood term, with the following key attributes, in providing effective resource utilization, cost savings, and flexibility to the business:

- ▶ Pooled physical resources are consumed by virtual machines resulting in high asset utilization.
- ▶ Virtual machines are mobile, giving administrators their choice of physical server and location.
- ▶ A common set of value capabilities and centralized management are provided for virtual machines, regardless of what physical server they are running on.

Storage hypervisor

Storage hypervisor is a rapidly emerging way of describing the same value aspects, but in a storage context:

- ▶ Consolidation and cost: Storage pooling increases utilization and decrease costs.
- ▶ Business availability: Data mobility of virtual volumes can improve availability.
- ▶ Application support: Tiered storage optimization aligns storage costs with required application service levels.

IBM Storage Hypervisor

The IBM Storage Hypervisor offers the following features (shown in Figure 2-1):

- ▶ Virtualizes storage resources from multiple arrays, vendors, and data centers, which are pooled together and accessed anywhere.
- ▶ Standardized storage services are selected from a service catalog.
- ▶ Mobility of storage volumes move dynamically based on workload balancing policies.
- ▶ Self-service provisioning uses automation to allocate capacity.
- ▶ Pay-per-use storage resources so users are aware of the impact of their consumption, service level choices.



Figure 2-1 IBM Storage Hypervisor

IBM Storage Hypervisor is part of the IBM SmartCloud Virtual Storage Center 5.2 (VSC) which includes storage virtualization, storage virtualization management, and storage snapshot management that are tightly integrated with advanced analytics to deliver a robust storage cloud solution. This solution ultimately helps businesses to optimize provisioning, capacity, availability, data protection, reporting, and management for virtualized storage.

2.3 IBM SmartCloud Virtual Storage Center component model

As shown in Figure 2-2, IBM SmartCloud Virtual Storage Center 5.2 includes core functionality, from three IBM offerings; Storage management through IBM Tivoli Storage Productivity Center, storage virtualization with IBM System Storage SAN Volume Controller, and application-aware data protection with IBM Tivoli Storage FlashCopy Manager.

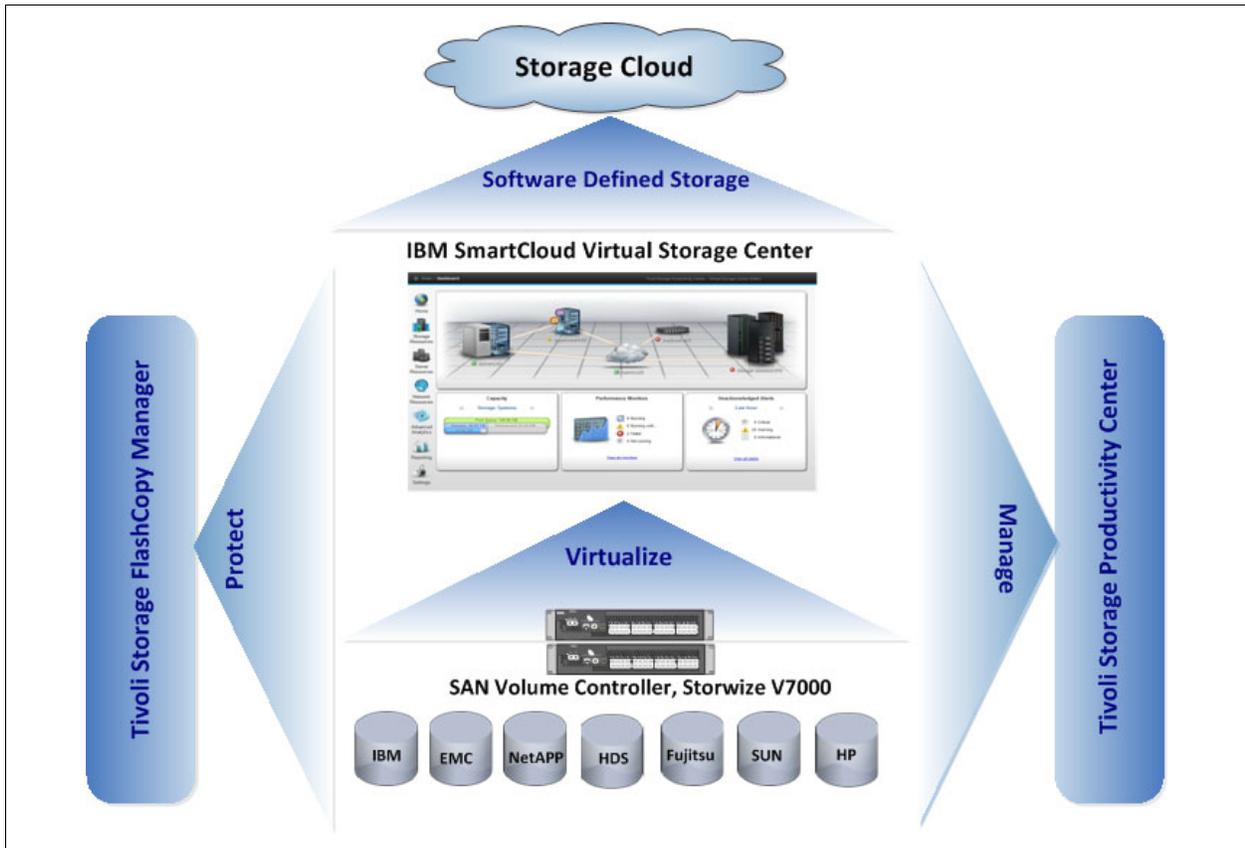


Figure 2-2 Overview diagram of IBM SmartCloud Virtual Storage Center

2.3.1 Storage management

The storage management component in IBM SmartCloud VSC V5.2 provides an advanced storage infrastructure and data management capabilities. The Tivoli Storage Productivity Center component available in VSC includes all the capabilities of Tivoli Storage Productivity Center V5.2. It uniquely provides all the advanced functions that were available in the past as part of Tivoli Storage Productivity Center Standard Edition and Tivoli Storage Productivity Center for Replication. Unique to the VSC V5.2 Storage Analytics Engine is data management with file system and database scanning and analysis, data placement, user quotas, and an advanced management GUI to help simplify virtual storage administration.

The storage management component of the VSC solution is designed to improve visibility, control, and automation for data and storage infrastructures, including storage systems, devices, and SAN fabrics and integrated with SAN Volume Controller functionality for auto-tiering and workload-aware placement across the data center.

Tivoli Storage Productivity Center, the storage management component of VSC, helps simplify provisioning, performance management, and data replication processes (Figure 2-3).

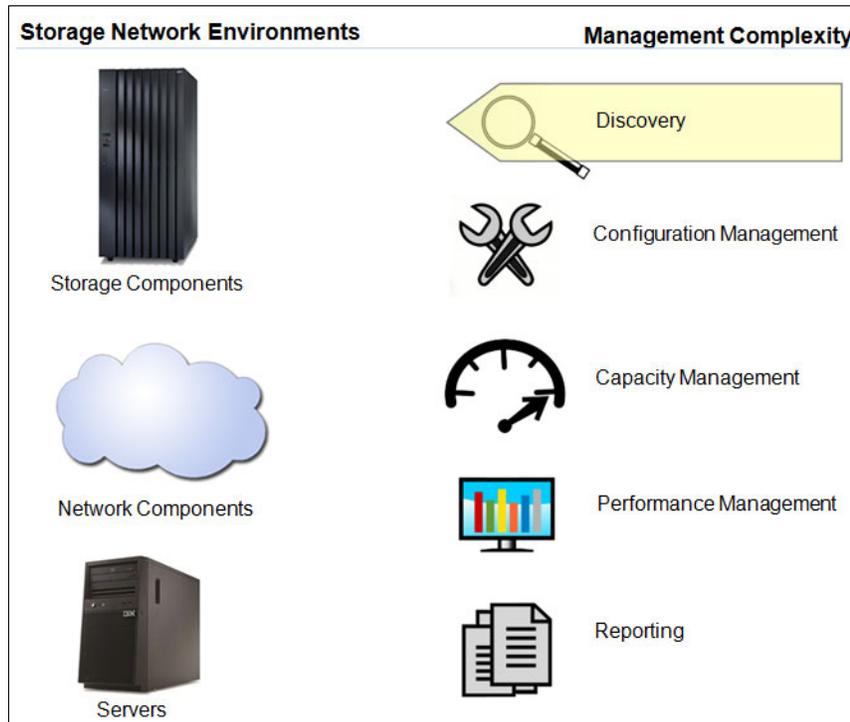


Figure 2-3 VSC storage management and Tivoli Storage Productivity Center

IBM Tivoli Storage Productivity Center provides these capabilities, all from a single GUI:

- ▶ Database, host, file system, and file level capacity analytics
- ▶ Storage performance management
- ▶ Tiered storage analysis
- ▶ Trend analysis
- ▶ SAN planning and provisioning
- ▶ Performance optimization
- ▶ SAN fabric performance management

Note: For details about VSC offerings and licensing, see 2.6, “IBM Virtual Storage Center offerings” on page 51.

Tivoli Storage Productivity Center can generate threshold alerts and forward them to SNMP Receivers. Tivoli Storage Productivity Center provides many ready-to-use reports as shown in Figure 2-4.



Figure 2-4 Tivoli Storage Productivity Center reports that are ready to use

These reports can be scheduled to run periodically. Additional custom reports can be created with IBM Cognos®.

For more information about IBM Cognos reports, see the “Enhanced reporting with IBM Cognos” topic in *IBM Tivoli Storage Productivity Center V5.1 Technical Guide*, SG24-8053.

Additional capabilities of Tivoli Storage Productivity Center are described in Chapter 3, “Storage management” on page 57.

2.3.2 Storage virtualization

The IBM SAN Volume Controller virtualization engine moves the storage control function into the storage network, allowing disk storage to be managed as a single virtual pool, supporting a large number of disk vendors (Figure 2-5).

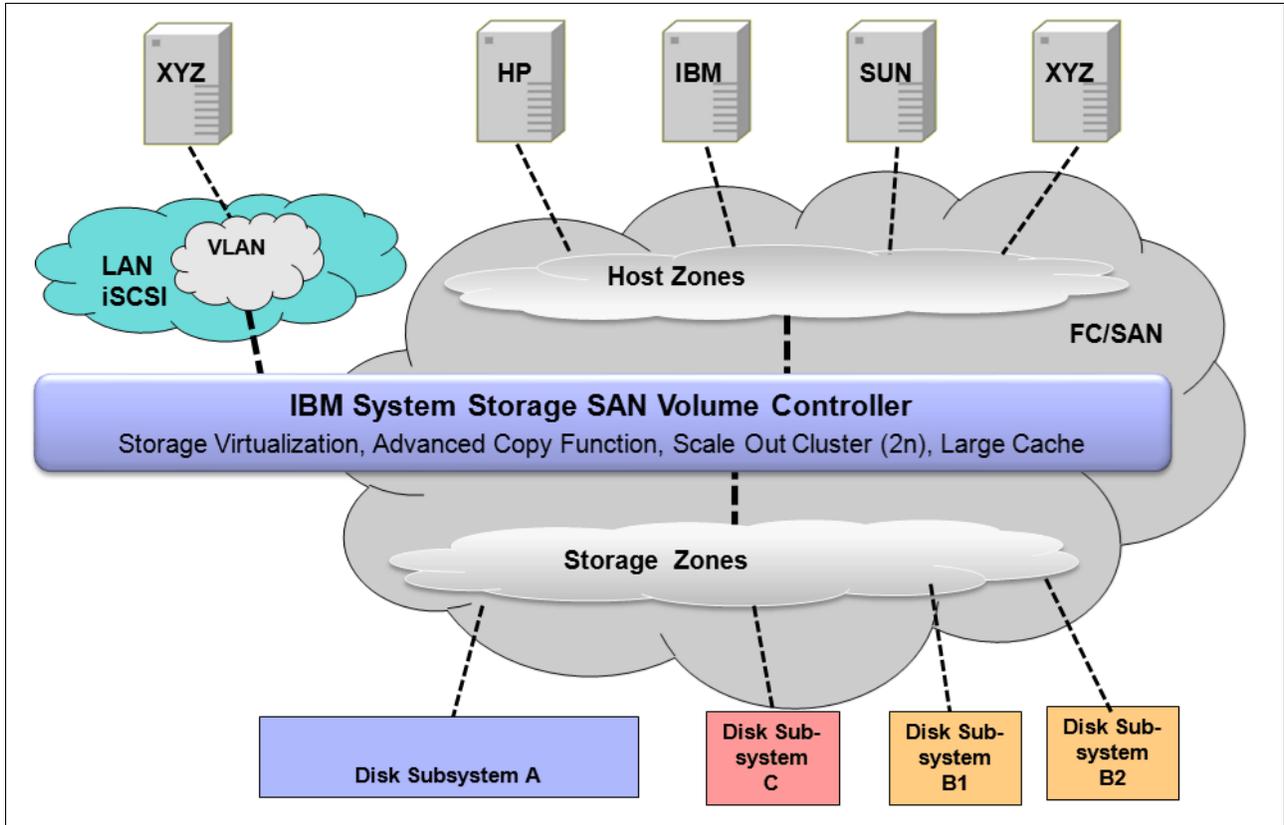


Figure 2-5 SAN Volume Controller conceptual and topology overview

SAN Volume Controller can pool storage volumes into a reservoir of capacity for centralized management. Virtualization with SAN Volume Controller eliminates the boundaries among disk and flash systems, which simplifies management and enables IT Operations to focus on managing storage as a resource to meet business requirements rather than as a set of boxes. The RAID array from an external storage system or from internal disks (Storwize V7000, as shown in our example in Figure 2-5) is presented to an SAN Volume Controller or Storwize V7000 as *Managed Disks* or *MDisks*. A set of MDisks forms a storage pool from which extents are taken to create the volumes, which can be identified by logical unit numbers (LUNs). The volumes, now in virtualized mode, are presented to the hosts. In this sense, the hosts no longer see the back-end disks directly, and the SAN Volume Controller or Storwize V7000 behaves like a controller that is provisioning LUNs to the hosts.

To achieve multitenancy over the same physical SAN infrastructure, storage pools can be created that are specific to each tenant from a specific set of managed disks and assign them to the specific tenant hosts, as depicted in Figure 2-6.

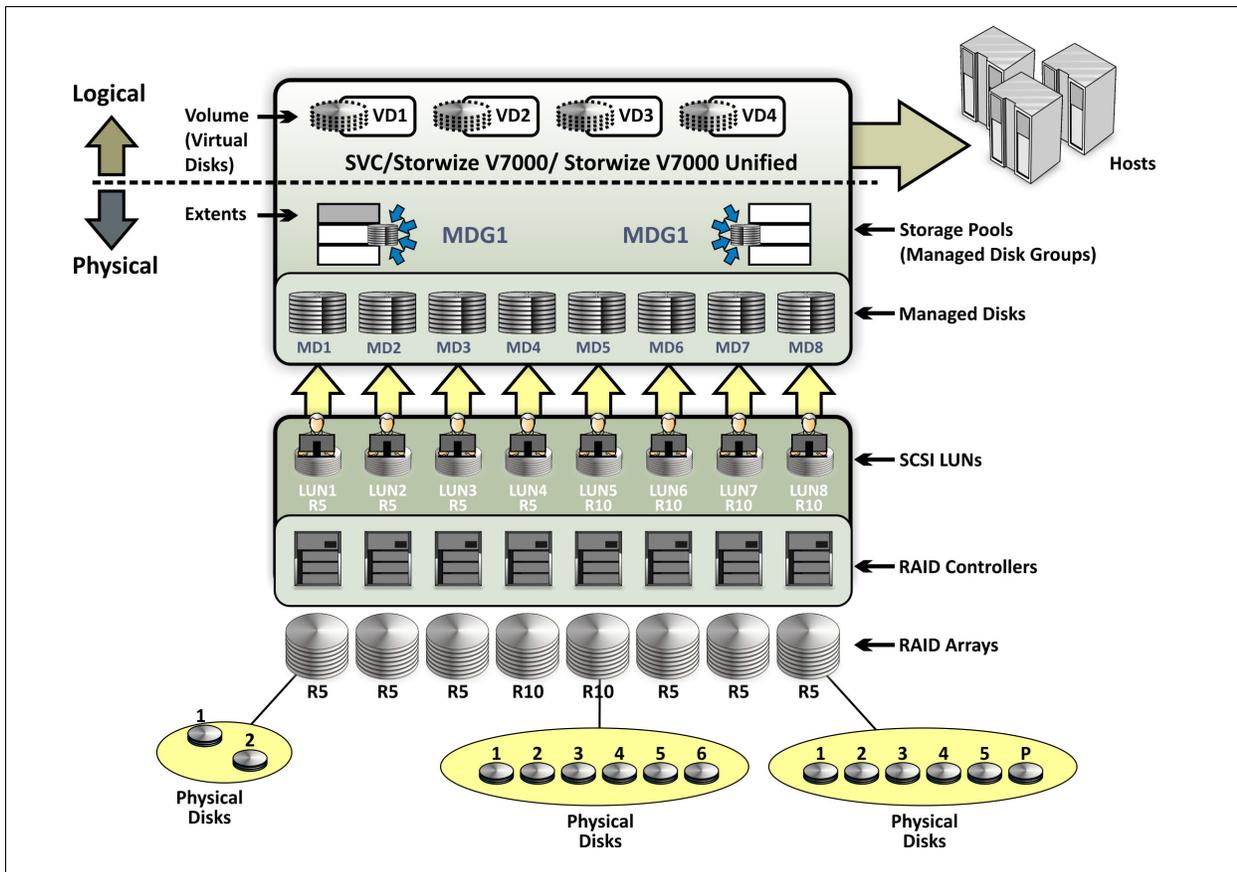


Figure 2-6 SAN Volume Controller storage virtualization concepts summary

The SAN Volume Controller component of VSC reduces labor, reduces and removes planned migration outages, and improves utilization. Storage virtualization with IBM SAN Volume Controller supports a heterogeneous, multivendor environment, with common management and services. SAN Volume Controller allows for nondisruptive changes to the storage environment without impacting host applications. SAN Volume Controller with Infrastructure Lifecycle Management (ILM) intelligent storage analytics provides policy-based automated data placement and tier movement.

The key characteristics of SAN Volume Controller are as follows:

- ▶ Highly scalable: A SAN Volume Controller *cluster* scales horizontally through the addition of node pairs to a maximum of four node pairs (or eight nodes) per cluster.
- ▶ Host-independent: Supports multiple operating systems Windows, Linux, IBM AIX®, HP-UX and so on.
- ▶ Storage controller-independent: Supports storage from multiple vendors including IBM, EMC, HDS, Oracle, Hewlett-Packard, and others.

SAN Volume Controller offers the following services:

- ▶ Creation and management of a storage pools attached to the SAN.
- ▶ Block level virtualization.
- ▶ Provision of advanced functions across the SAN such as advanced copy services (point-in-time copy, instant copy, synchronous remote copy, Metro Mirror and asynchronous remote copy, Global Mirror).
- ▶ Thin provisioning.
- ▶ Real-time compression: The IBM Real-time Compression™ option can be added as a separate priced license. For more details about this topic see 2.6, “IBM Virtual Storage Center offerings” on page 51.
- ▶ Data migration: Move volumes within or between storage controllers (within the same physical virtualization boundary).
- ▶ Growing or shrinking volumes.
- ▶ IBM Easy Tier® helps administrators control storage growth more effectively by balancing MDisks within a pool, and by moving low-activity or inactive data into a hierarchy of lower-cost storage. Administrators can free disk space on higher-value storage for more important, active data.

For more details about SAN Volume Controller Easy Tier functionality, see the following publications:

- *Implementing IBM FlashSystem 840*, SG24-8189 (see Chapter 8, “Product integration” and Chapter 9, “Use cases and solutions”)
- *IBM SAN Volume Controller 2145-DH8 Introduction and Implementation*, SG24-8229 (see Chapter 5, “SAN Volume Controller Easy Tier”)
- *IBM System Storage SAN Volume Controller Best Practices and Performance Guidelines*, SG24-7521 (see Chapter 11, “IBM System Storage Easy Tier function”)
- *IBM DS8000 Easy Tier*, REDP-4667

Additional capabilities of SAN Volume Controller and the IBM Storwize product family are discussed in Chapter 4, “Storage virtualization” on page 89.

2.3.3 Application-aware data protection

With the Tivoli Storage FlashCopy Manager component of VSC, the data backup and restore component in IBM SmartCloud VSC V5.2 provides fast application-aware backups and restores, leveraging advanced snapshot technologies available with IBM storage systems (Figure 2-7).

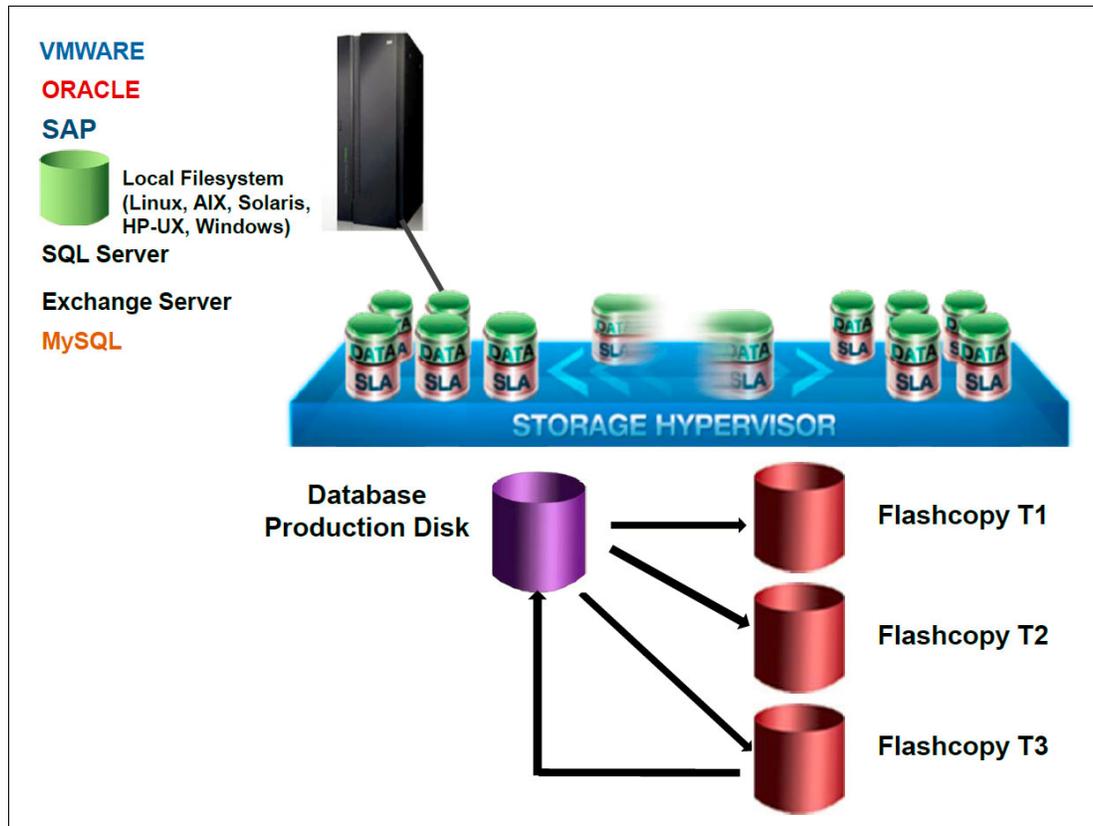


Figure 2-7 High level overview of Tivoli Storage FlashCopy Manager application-aware copies solution

FlashCopy Manager uses advanced IBM storage hardware snapshot technology to help create a high performance, low impact application data protection solution. The Storage FlashCopy function operates at the level of virtual volumes (VDisks). That is, it copies whole volumes. The FlashCopy function is intended to create copies of data that may be used for purposes such as disk-to-disk backups, parallel processing (multiple applications processing different copies of the same data), testing by using a copy of production data, and so on. The copy created by the FlashCopy function is available to be used almost immediately. SAN Volume Controller can perform a background copy of all data from the source to the target or it can copy data only when an update occurs. It delivers high levels of data protection for business-critical applications through integrated application snapshot backup and restore capabilities.

Storage administrators can control the speed of the background copy to limit the impact that the copy has on other SAN Volume Controller activities. The first time that FlashCopy is used, the copy takes place as *normal*, which means that a full copy of data occurs from the source to the target VDisk. When changes are made, only the changes are copied to the target. A total of 256 copies can be made from the same source VDisk, which can be incremental or non-incremental, or a mix of both.

It integrates with IBM System Storage DS8000®, FlashSystem V840, IBM SAN Volume Controller, IBM Storwize V7000 and V5000, and IBM XIV® Storage System products. For Microsoft Windows environments, Tivoli Storage FlashCopy Manager also supports other hardware that is capable of Microsoft Volume Shadow Copy Services (VSS) functions, such as IBM N Series, System Storage DS3000, DS4000®, and DS5000™.

The FlashCopy Manager solution is explained (see Figure 2-7 on page 36) as follows:

1. Starting at the left, the Application system, which is also called the Production system, has the production database on it. More important, this is the data that you want to protect. The applications can be Oracle, SQL, DB2, SAP, Exchange, Files Systems, or VMware. FlashCopy Manager also provides the interfaces for custom applications to take snapshots the data.
2. Following the black arrow, you see that the application data resides on the LUN that sits on the SAN Volume Controller and on its back-end storage. Using FlashCopy Manager, when you take the backup of the database, you have local snapshot versions that represent the application data at some point in time. When you want to restore the data, use FlashCopy Manager to restore from any one of these snapshot versions including the latest to a point-in-time snapshot. If you have Tivoli Storage Manager. You can then offload your backups to Tivoli Storage Manager and manage your data through that and FlashCopy Manager.

Additional capabilities of FlashCopy Manager are discussed in Chapter 5, “Application-aware data protection” on page 103.

2.4 IBM SmartCloud Virtual Storage Center features

IBM SmartCloud Virtual Storage Center helps reduce storage administration complexity and costs by these ways:

- ▶ Improving storage utilization
- ▶ Making better use of existing storage and controlling storage growth expenditures
- ▶ Improving application availability and simplified data migrations
- ▶ Making changes to storage and move data without taking applications down
- ▶ Simplifying storage management
- ▶ Improving efficiency and productivity for storage management staff
- ▶ Providing advantages with software-defined storage architecture model
- ▶ Enabling greater choice (lower cost) when buying storage and lowers software costs
- ▶ Improving application recovery time and recovery point objectives (RTO and RPO)
- ▶ Providing application-aware hardware-based snapshots
- ▶ Providing network-based replication

The outstanding features of IBM SAN Volume Controller are as follows:

- ▶ Efficient by design
- ▶ Self-optimizing
- ▶ Cloud agility

2.4.1 Efficient by design

Organizations need to spend less of their IT budgets on storage and storage administration so that they can spend more on new, revenue-generating initiatives. IBM SmartCloud Virtual Storage Center has built-in efficiency features that help users avoid purchasing add-ons or additional licenses or deal with complicated integration issues.

It has these advanced efficiency features:

- ▶ **Storage virtualization**

This is a foundational technology for clouds and software-defined environments. Without virtualization, storage capacity utilization averages about 50%, but virtualized storage enables up to 90% utilization by enabling online data migration for load balancing. With IBM SmartCloud Virtual Storage Center, you can virtualize your storage resources from multiple storage systems and vendors. Pooling storage devices enables you to access capacity from any storage system, a significant advantage over the limitations inherent in traditional storage.
- ▶ **Simplified user experience**

IBM SmartCloud Virtual Storage Center provides an advanced GUI and a VMware vCenter plug-in to reduce administration complexity. Administrators can do common tasks consistently, over multiple storage systems, even those from different vendors. The IBM storage GUI enables simplified storage provisioning with intelligent presets and embedded best practices, and integrates context-sensitive performance management throughout.
- ▶ **Near-instant, application-aware backup and restore**

To reduce downtime in high-availability virtual environments, critical applications such as email and databases require near-instant backups that have little or no impact on application performance. Application-aware snapshot backups can be performed frequently throughout the day to reduce the risk of data loss. IBM SmartCloud Virtual Storage Center simplifies administration and recovery from snapshot backups.

2.4.2 Self-optimizing

Self-optimizing storage adapts automatically to workload changes to optimize application performance, eliminating most manual tuning efforts. IBM SmartCloud VSC includes these self-optimizing features:

- ▶ **IBM Tiered Storage Optimizer**

IBM SmartCloud Virtual Storage Center uses performance metrics, advanced analytics, and automation to enable storage optimization on a large scale. It can optimize storage volumes across different storage systems and virtual machine vendors and brands. The Tiered Storage Optimizer feature can reduce the unit cost of storage by as much as 50%, based on deployment in a large IBM data center.
- ▶ **IBM Easy Tier**

IBM SmartCloud Virtual Storage Center helps optimize flash storage with automated tiering for critical workloads. Easy Tier helps make the best use of available storage resources by automatically moving the most active data to the fastest storage tier, which helps applications and virtual desktop environments run up to three times faster.
- ▶ **Thin provisioning and efficient remote mirroring**

Thin provisioning helps automate provisioning and improve productivity by enabling administrators to focus on overall storage deployment and utilization, and also on longer term strategic requirements without being distracted by routine storage-provisioning requests. IBM Metro Mirror and Global Mirror functions automatically copy data to remote sites as it changes, enabling fast failover and recovery. These capabilities are integrated into the advanced GUI, so that they become easier to deploy.

2.4.3 Cloud agility

Cloud computing is all about agility. Storage for clouds must be as flexible and service-oriented as the applications it supports. IBM SmartCloud Virtual Storage Center can convert existing storage into a private storage cloud with no “rip and replace” required. The solution enables you to adapt to the dynamic storage needs of cloud applications by providing storage virtualization, automation, and integration for cloud environments.

Features are as follows:

- ▶ OpenStack cloud application provisioning

IBM SmartCloud Virtual Storage Center includes an OpenStack Cinder volume driver that enables automated provisioning using any of the storage systems controlled by IBM SmartCloud Virtual Storage Center. OpenStack cloud applications can access multiple storage tiers and services, without added complexity.

- ▶ Self-service portal

IBM SmartCloud Virtual Storage Center can provide provisioning automation for self-service storage portals (such as IBM SmartCloud Storage Access), which enable immediate responses to service requests while eliminating manual administration tasks.

- ▶ Pay-per-use invoicing

IBM SmartCloud Virtual Storage Center integrates with IBM SmartCloud Cost Manager and other chargeback systems to enable flexible usage accounting for storage resources. IBM SmartCloud Virtual Storage Center can become the single source for usage metrics across storage area networks (SANs), network-attached storage, and direct-attached storage.

2.5 IBM SmartCloud Virtual Storage Center interfaces

IBM focuses on supporting four software-defined environments (SDE), shown in Figure 2-8.

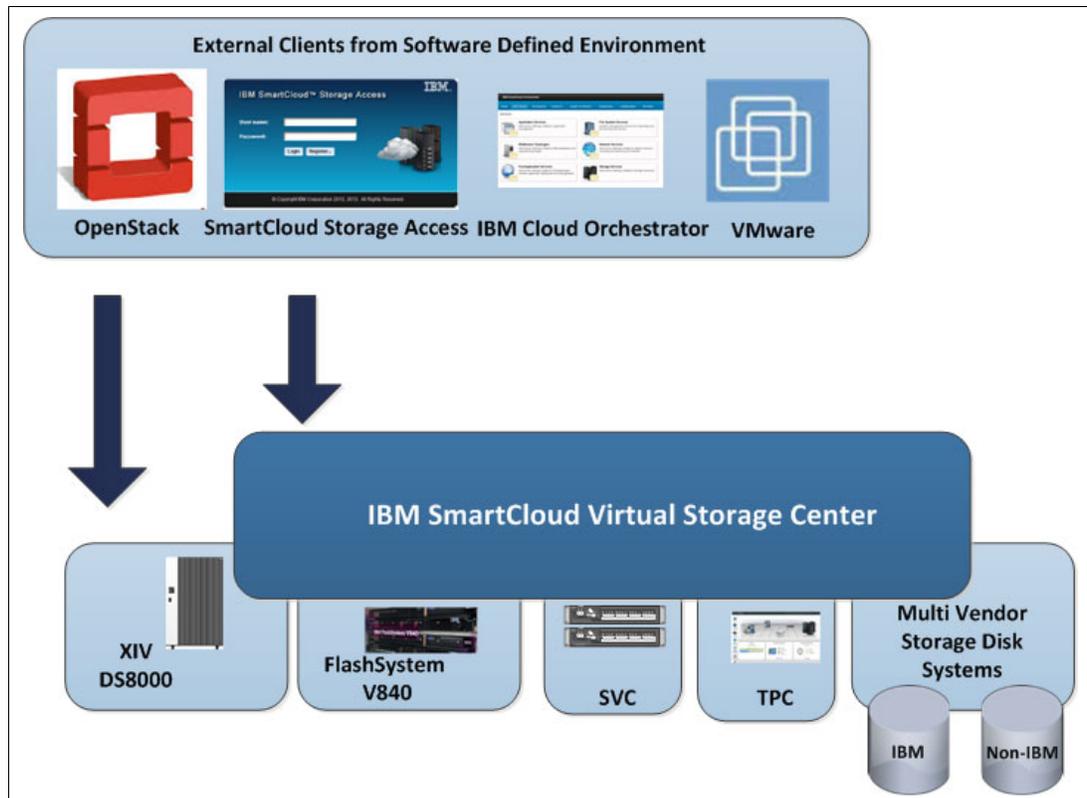


Figure 2-8 Interfaces to IBM SmartCloud Virtual Storage Center

The four SDEs are as follows:

- ▶ OpenStack open source code can manage compute, network and storage resources.
- ▶ IBM SmartCloud is based on OpenStack with value-added IBM proprietary features.
- ▶ IBM Cloud Orchestrator is for storage provisioning, orchestration, and automation.
- ▶ VMware runs primarily on x86-based servers.

The interface features are summarized in Table 2-1.

Table 2-1 Comparison of virtual storage interfaces to software-defined environment

OpenStack software	IBM SmartCloud and IBM Orchestrator	VMware
IBM is a platinum sponsor of OpenStack Foundation.	IBM Cloud Manager with OpenStack is based on OpenStack open source code, with value-added proprietary features from IBM.	VMware is entirely proprietary, but has large market share for x86-based server infrastructure.
OpenStack open source code can manage IBM compute, network and storage resources.	IBM Cloud Manager with OpenStack and IBM Cloud Orchestrator support various server hypervisors and interfaces.	IBM was VMware's first OEM and joint development partner (since 1998). IBM continues strong partnership. IBM Global Services is one of VMware's largest customers, using VMware in many of their client solutions.
IBM offers Cinder interfaces on most of its major storage products for Block storage access and supports Swift interfaces for object storage access.	IBM SmartCloud Storage Access and IBM Cloud Orchestrator provide self-provisioning and orchestration capabilities.	VMware vStorage API for data protection (VADP), VMware Site Recovery Manager (SRM), VMware vSphere storage APIs: Array integration (VAAI), VMware vCenter.

An overview of each VSC interface is provided in the following sections.

2.5.1 OpenStack software

The OpenStack environment is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a data center, all managed through a dashboard that gives administrators control while empowering users to provision resources through a web interface. OpenStack Icehouse is the ninth release of the open source software for building public, private, and hybrid clouds, has nearly 350 new features to support software development, managing data and application infrastructure at scale.

The OpenStack community continues to attract the best developers and experts in their disciplines with over 1,200 individuals employed by more than 120 organizations contributing to the Icehouse release.

Because OpenStack design and development is done in the open, public documentation is available regarding the development status of the current release and decisions made at each Design Summit. To review details of this information, see the Icehouse Release Notes:

<https://wiki.openstack.org/wiki/ReleaseNotes/Icehouse>

OpenStack Cinder support

The Tivoli Storage Productivity Center OpenStack Cinder driver enables your OpenStack-powered cloud to use your Tivoli Storage Productivity Center installation for block storage provisioning.

Tivoli Storage Productivity Center provides block storage provisioning capabilities that the storage administrator can employ to define the properties and characteristics of storage

volumes within a particular service class. For example, a block storage service class may define RAID levels, tiers of storage, and various other storage characteristics.

The Tivoli Storage Productivity Center Cinder driver enables your OpenStack cloud to use these defined service classes, which are exposed directly into your Cinder environment as Cinder volume types. For each block storage service class, a Cinder volume type is created. This enables your cloud users to create and use volumes of this type.

Figure 2-9 shows the interaction between the OpenStack components (Horizon, Nova, and Cinder) and Tivoli Storage Productivity Center. When an OpenStack cloud user requests a new volume for a virtual machine through the Horizon dashboard, the Cinder node sends Tivoli Storage Productivity Center all the necessary information through the Cinder driver, which includes service class information. With that information, Tivoli Storage Productivity Center chooses the most appropriate storage system to use and creates a volume and all the necessary connections. Tivoli Storage Productivity Center then passes that information back to the Cinder node through the same driver. From there, the Cinder node assigns the volume to the virtual machine.

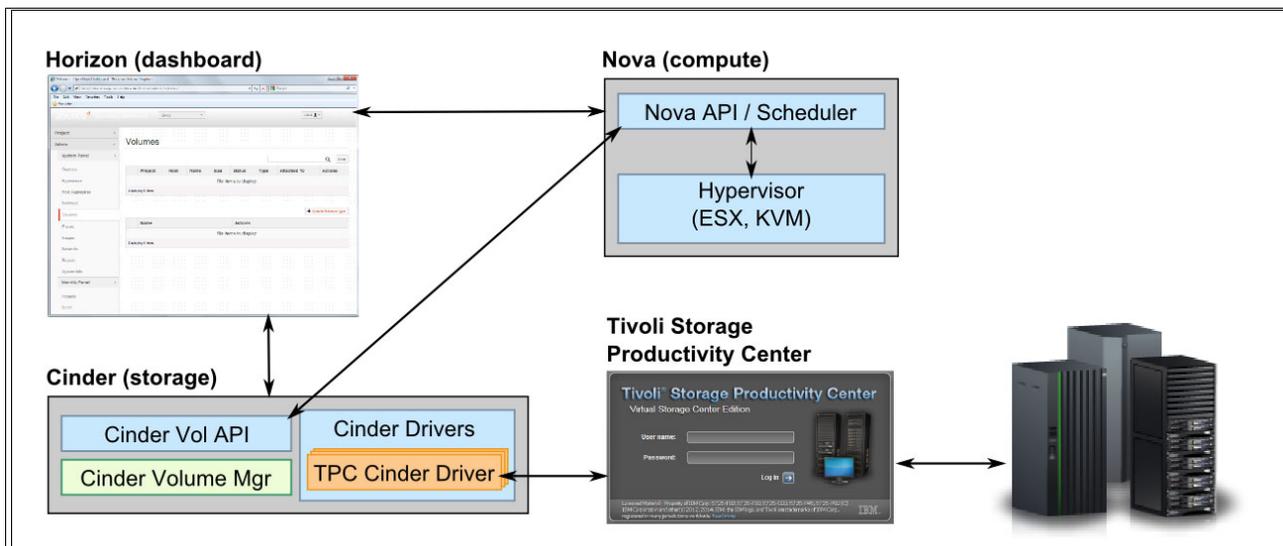


Figure 2-9 Tivoli Storage Productivity Center Cinder driver components

2.5.2 IBM SmartCloud Storage Access

IBM SmartCloud Storage Access is a software appliance that provides cloud services to block and file storage environments. IBM SmartCloud Storage Access Version 1.2 or later supports the following storage devices:

- ▶ IBM Scale Out Network Attached Storage (SONAS)
- ▶ IBM Storwize V7000 Unified
- ▶ IBM Storwize V7000
- ▶ IBM Storwize V5000
- ▶ IBM FlashSystem V840
- ▶ IBM System Storage SAN Volume Controller
- ▶ IBM XIV Storage System

IBM SmartCloud Storage Access provides an environment where the users can serve themselves. The cloud administrators, through IBM SmartCloud Storage Access, can define policies and automate tasks for provisioning resources.

The following list includes some of the key storage cloud operations that are enabled through IBM SmartCloud Storage Access:

- ▶ Creating and managing file storage and Fibre Channel block storage
- ▶ Creating working environments to give team-specific access to file and block storage
- ▶ Providing request and approval work flow support
- ▶ Providing access to file space through Network File System (NFS) and Common Internet File System (CIFS)
- ▶ Setting automatic mail notifications according to policy
- ▶ Providing support for expiration of storage resources
- ▶ Providing support to federated authentication
- ▶ Providing a Storage Cloud API for third-party integration
- ▶ Providing globalization support

IBM SmartCloud Storage Access deployment with VSC architecture

This section describes a deployment architecture for a private storage cloud with IBM SmartCloud Storage Access. As shown in Figure 2-10 on page 44, IBM SmartCloud Storage Access works with various external systems or services to achieve the functionality required for a private storage cloud.

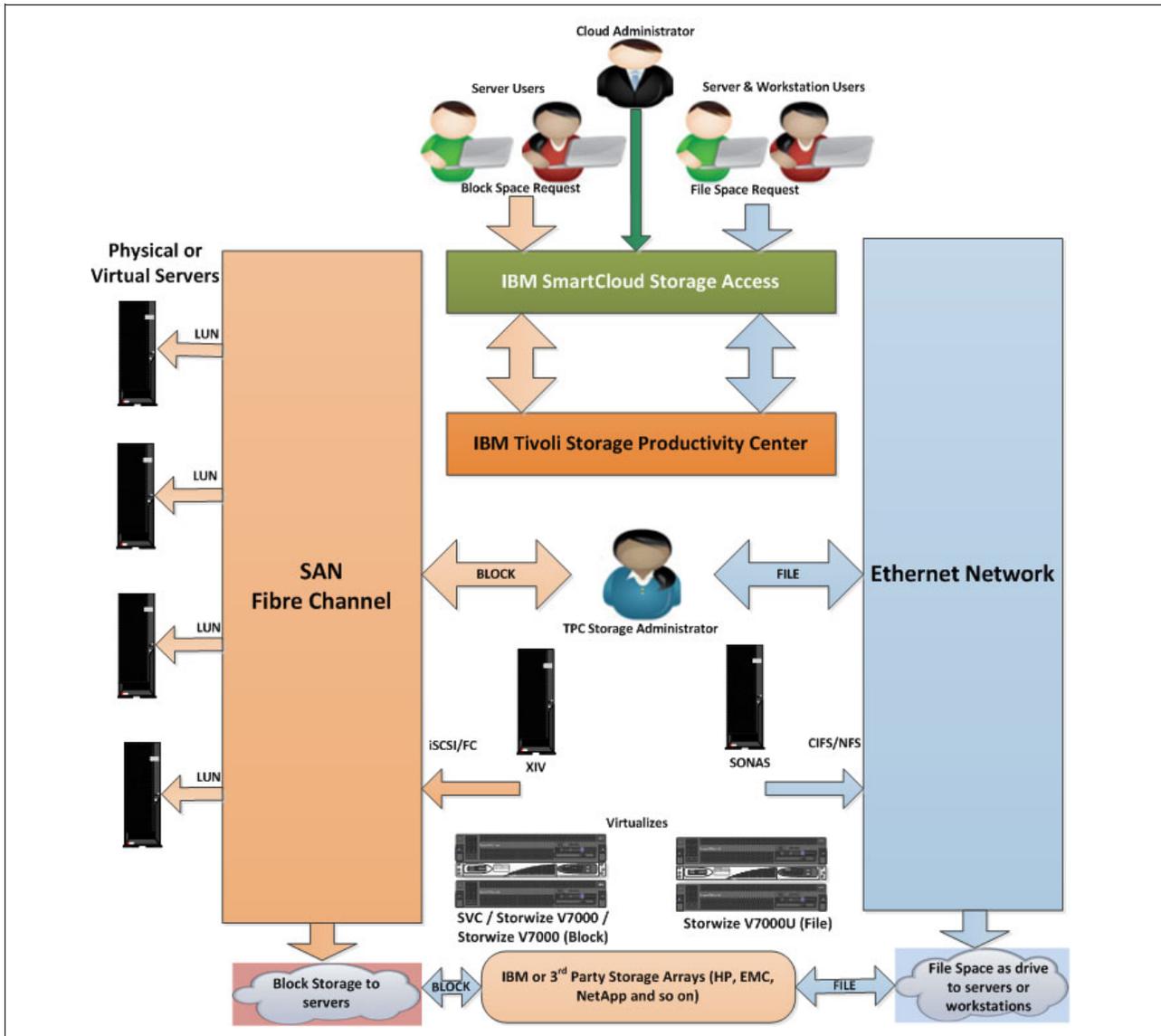


Figure 2-10 IBM SmartCloud Storage Access deployment architecture diagram

Three words that matter the most to any enterprise are *reduce*, *reuse*, and *recycle*. These are true for private cloud deployment based on IBM SmartCloud Storage Access, because the enterprises can achieve the following goals:

- ▶ Reduce administrator resource usage, operational costs, and provisioning turnaround time.
- ▶ Reuse existing infrastructure components, such as NTP server, DNS, SMTP server, and storage systems.
- ▶ Recycle unused or underused storage space, and therefore ensure optimal use.

The deployment architecture as shown in Figure 2-10, has IBM SmartCloud Storage Access working with Tivoli Storage Productivity Center, which is the storage manager to provision and deprovision network drives. Tivoli Storage Productivity Center plays a major role in understanding the resource request from IBM SmartCloud Storage Access and completing the resource provisioning.

2.5.3 IBM Cloud Orchestrator

IBM Cloud Orchestrator is built on a foundation of open standards, including OpenStack and community-provided best practices, and provides common cloud services for compute, storage, and network resources, while also supporting multiple hypervisors and multivendor platforms. It is designed to simplify and speed the creation of process workflows that can help shorten deployment and change processes in the cloud.

With IBM Cloud Orchestrator, cloud administrators can use a single interface to design and deploy services, monitor capacity and performance, control updates and migrations, and recover unused resources as needed. It also helps IT staff deliver resources to users more quickly and consistently.

Managing workloads across the lifecycle requires orchestration. IBM Cloud Orchestrator performs Resource Orchestration, Workload Orchestration, and Service Orchestration, as shown in Figure 2-11). A Cloud Orchestrator administrator can create a process that will onboard a VM, provision and manage the CPU, storage and network, and place the new system based on existing workloads. The process can optimize the performance and operation of the server. Finally, the entire lifecycle of the business application is managed, ensuring that patches are applied in a timely manner and that service tickets are opened when required.

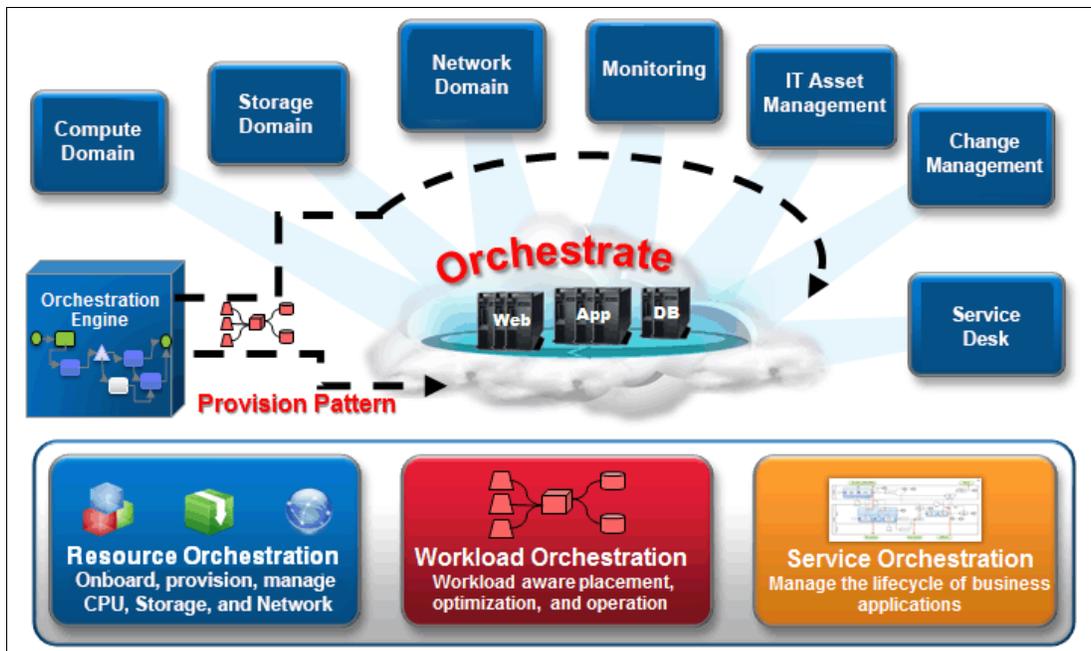


Figure 2-11 IBM Cloud Orchestrator

Assets are built, monitored, and managed from a single product. Individual software titles or bundles are available to extend the base virtual image as necessary. Patterns are available for use to deploy complex applications or environments and may generate entire systems. For example, a pattern might include a web component on one system, a database on a second system and a file server on a third. The number and type of systems that can be built using a pattern is determined by the software bundles that are available and the number of resources available.

The orchestration processes tie in the customizations that are required for environments, including specific user interfaces (perhaps a custom web front end), user interface widgets, and the business processes that handle the email notification to requesters, and the defined approval processes. The orchestration component can also perform the steps to decommission the virtual machine or environment either manually or based on an end date that is provided at the time the virtual machine or environment was requested.

In summary IBM Cloud Orchestrator provides the following features:

- ▶ Standardizes and automates cloud services through a flexible orchestration engine and a self-service portal.
- ▶ Provides reusable workload patterns to enable dynamic cloud service delivery.
- ▶ Is built on open standards, including OpenStack cloud software, for unparalleled interoperability.
- ▶ Use of open technologies such as OpenStack cloud software to build an interoperable infrastructure foundation to provision workloads, provide multitenancy, and enable administration.
- ▶ Offers infrastructure and workload orchestration for VMware and Microsoft virtualization infrastructures, and adopts OpenStack technology.
- ▶ Supports deployments on public clouds such as Amazon Elastic Compute Cloud, allowing the implementation of a hybrid cloud model.

Standardization and automation of cloud services with IBM Cloud Orchestrator provide the following benefits:

- ▶ Coordinate services and tasks such as compute and storage provisioning, configuration of network devices, integration with service request and change management systems, and integration with data center tools and processes.
- ▶ Allow cloud administrators to expose cloud services in a simpler self-service portal for user consumption.
- ▶ Control image sprawl, manage image drift, and reduce security vulnerability through analytics, image versioning, and federated image library features.
- ▶ Include monitoring and capacity analytics capabilities to help consolidate and balance workloads.
- ▶ Facilitate measuring the cost of cloud services with metering and charge-back capabilities.

2.5.4 VMware

VMware provides servers virtualization on Intel based architecture. The core components of the VMware solution are as follows:

- ▶ VMware ESX and ESXi based hypervisor
- ▶ VMware vSphere vCenter for providing management capabilities
- ▶ vSphere vMotion to combat planned downtime
- ▶ VMware vCenter Site Recovery Manager to automate end-to-end recovery processes for virtual applications

Figure 2-12 on page 47 shows the vSphere suite in a more comprehensive way. vSphere is a product suite similar to Microsoft Office suite, which contains Microsoft Office Word, Excel, Access, PowerPoint, and so on. VMware vSphere suite includes an ESXi hypervisor, vCenter, and vSphere client. ESXi is a hypervisor installed on a physical machine. The vSphere client is installed on the VMware administrator's notebook or desktop computer and is used to access the ESXi server to install and manage virtual machines on ESXi server. The vCenter

server is installed as virtual machine on top of ESXi server. vCenter server is a vSphere component which is mostly used in large environment where there are many ESXi servers and several virtual machines. The vCenter server can also be accessed by vSphere client for management purpose. So, vSphere client is used to access ESXi server directly in a small environment; in larger environment, vSphere client is used again to access the vCenter server, which ultimately manages the ESXi server.

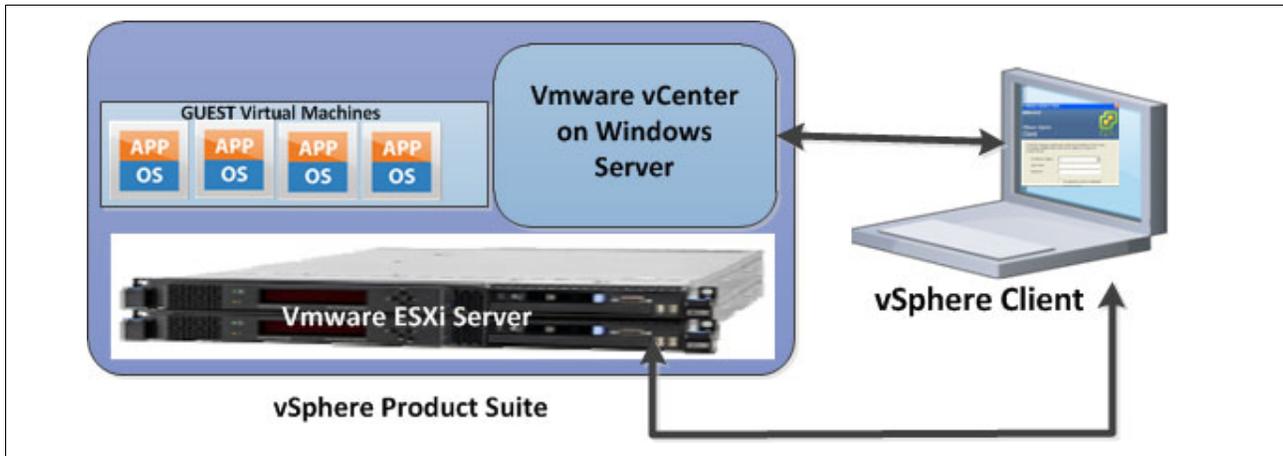


Figure 2-12 VMware vSphere Suite overview

VMware servers hypervisor

VMware ESX and VMware ESXi are hypervisors that allow you to abstract processor, memory, storage, and networking resources into multiple virtual machines (VMs) that can run unmodified operating systems and applications. VMware ESX and VMware ESXi are designed to reduce server sprawl by running applications on virtual machines that consist of fewer physical servers. VMware ESX and VMware ESXi hosts can be organized into clusters. This configuration allows ESX to provide flexibility in terms of what virtual machines are running on what physical infrastructure.

VMware vCenter

vCenter is the management software suite that is used to manage the virtual machines inside an ESX or ESXi host. When you allocate resources such as memory, storage, networking, or processors to a virtual machine, a vCenter server manages how these resources are allocated and maintained. vCenter can manage single ESX or ESXi hosts and clusters of hosts. VMware vcenter has several features that allow for mobility of VMs between ESX hosts and storage. These features can add to the availability of the VMs running in a cluster.

VMware vMotion

vMotion is a technology that is designed to combat planned downtime. vMotion is used to move VMs between host and data stores to allow scheduled maintenance procedures to proceed without affecting VM availability or performance. It is included in the Enterprise and Enterprise Plus versions of VMware vSphere. It is shown in Figure 2-13.

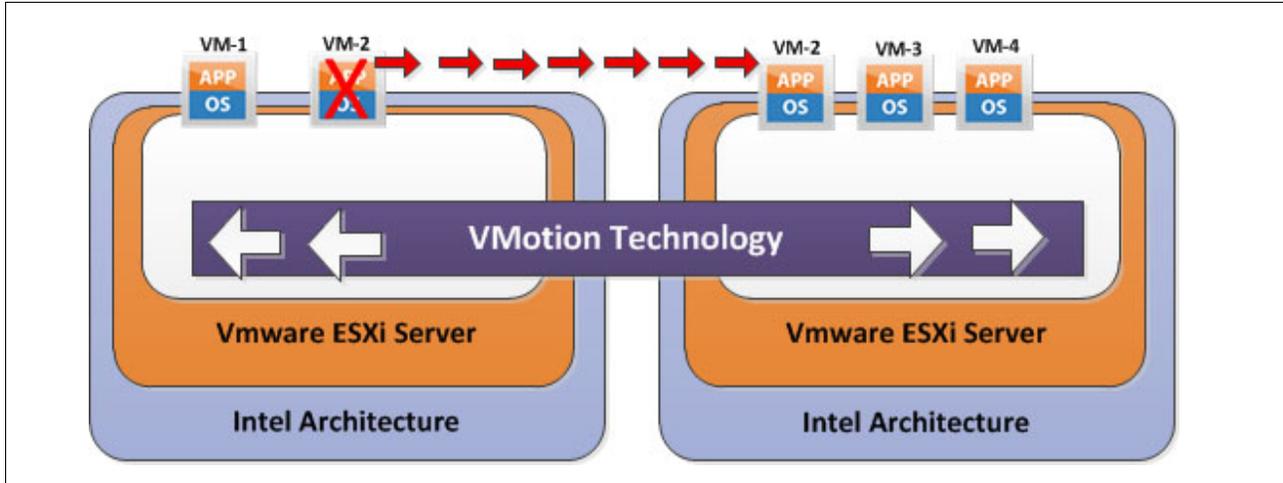


Figure 2-13 VMware vMotion

VMware Host vMotion

Host vMotion eliminates the need to schedule application downtime for planned server maintenance. It does so through live migration of virtual machines across servers with no disruption to users or loss of service.

This process is managed from a vCenter server, which maintains client or application access to a VM while it is moving between physical servers. In a SAN Volume Controller stretched cluster solution, this feature is useful for moving VMs between two failure domains. You might need to move VMs to load-balance across failure domains or because a failure domain needs an outage for maintenance.

VMware Storage vMotion

Storage vMotion eliminates the need to schedule application downtime because of planned storage maintenance or during storage migrations. It does so by enabling live migration of virtual machine disks (VMDK) with no disruption to users or loss of service. The vCenter server manages the copy of data from one data store to another. With vStorage APIs for Array Integration (VAAI), this process can be off loaded to the storage system, saving resources on both the vCenter host and data network.

Figure 2-14 illustrates use of VMware Storage vMotion in a SAN Volume Controller stretched cluster solution.

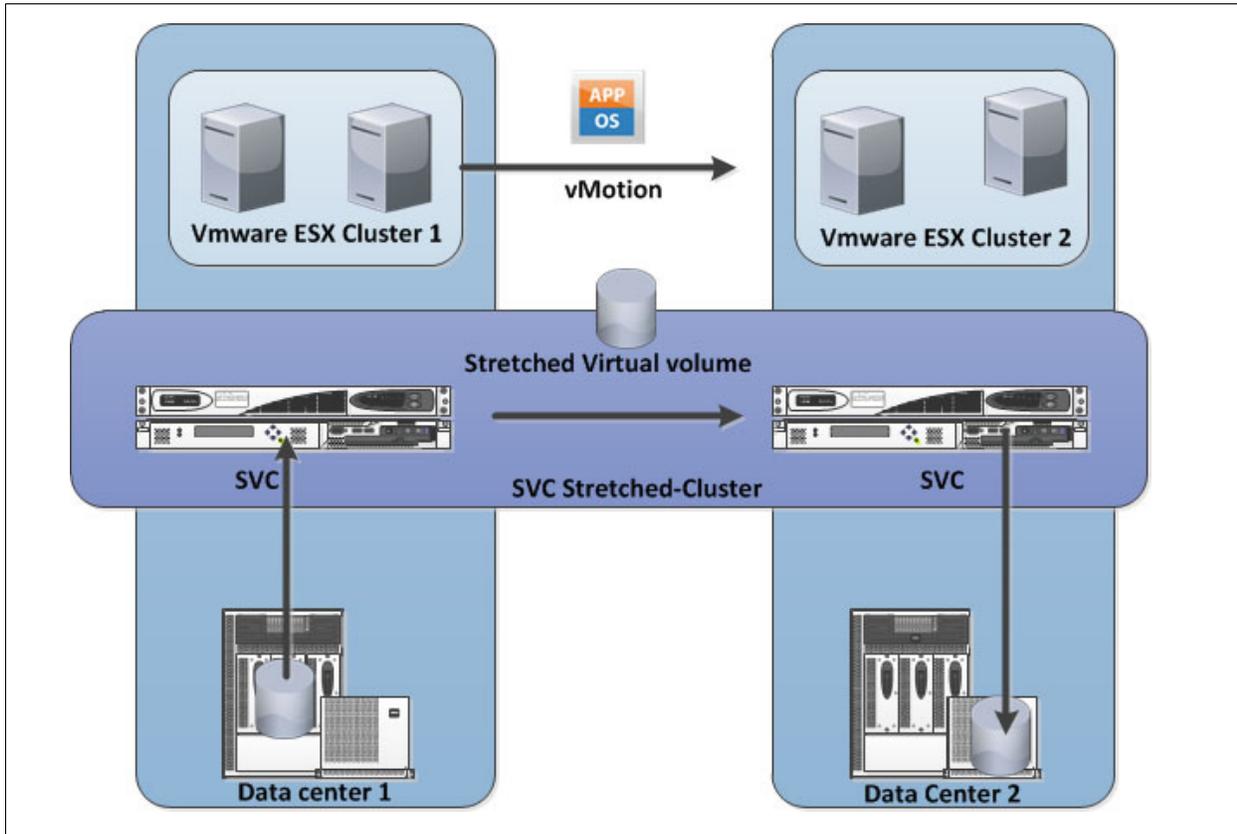


Figure 2-14 VMware Storage vMotion

In a SAN Volume Controller stretched cluster solution, this feature is useful for moving a virtual machine's VMDK file between two systems. You might move this file to ensure that it is on the same failure domain as the VM, or to migrate off a storage device that is becoming obsolete or is undergoing maintenance, as shown in Figure 2-14.

For more information about Storage vMotion, see the following web page:

<http://www.vmware.com/files/pdf/VMware-Storage-VMotion-DS-EN.pdf>

VMware vCenter Site Recovery Manager

Site Recovery Manager integrates with VMware vCenter server, and underlying storage replication products, to automate end-to-end recovery processes for virtual applications. It provides a simple interface for setting up recovery plans that are coordinated across all infrastructure layers. Recovery plans can be tested nondisruptively as frequently as required to ensure that the plan will meet availability objectives. At the time of a failure domain failover or migration, Site Recovery Manager automates both the fail over and fail back processes. It ensures fast and highly predictable RPOs and RTOs.

For more information about vCenter Site Recovery Manager, see the following web page:

<http://www.vmware.com/products/site-recovery-manager/overview.html>

VMware Distributed Resource Scheduler

Distributed Resource Scheduler (DRS) dynamically balances computing capacity across a collection of hardware resources that are aggregated into logical resource pools. It continuously monitors utilization across resource pools and intelligently allocates available resources among the VMs that are based on predefined rules that reflect business needs and changing priorities. When a VM experiences an increased load, VMware DRS automatically allocates more resources by redistributing VMs among the physical servers in the resource pool.

VMware DRS migrates and allocates resources by using a set of user-defined rules and policies. These rules and policies can be used to prioritize critical or high performing VMs, ensure that particular VMs never run on the same storage or host, or save on power and cooling costs by powering off ESX servers that are not currently needed.

For more information about Distributed Resource Manager, see the following web page:

http://www.vmware.com/pdf/vmware_drs_wp.pdf

VSC and VMware integration

VSC and VMware are integrated by using Tivoli Storage Productivity Center plug-ins, as shown in Figure 2-15.

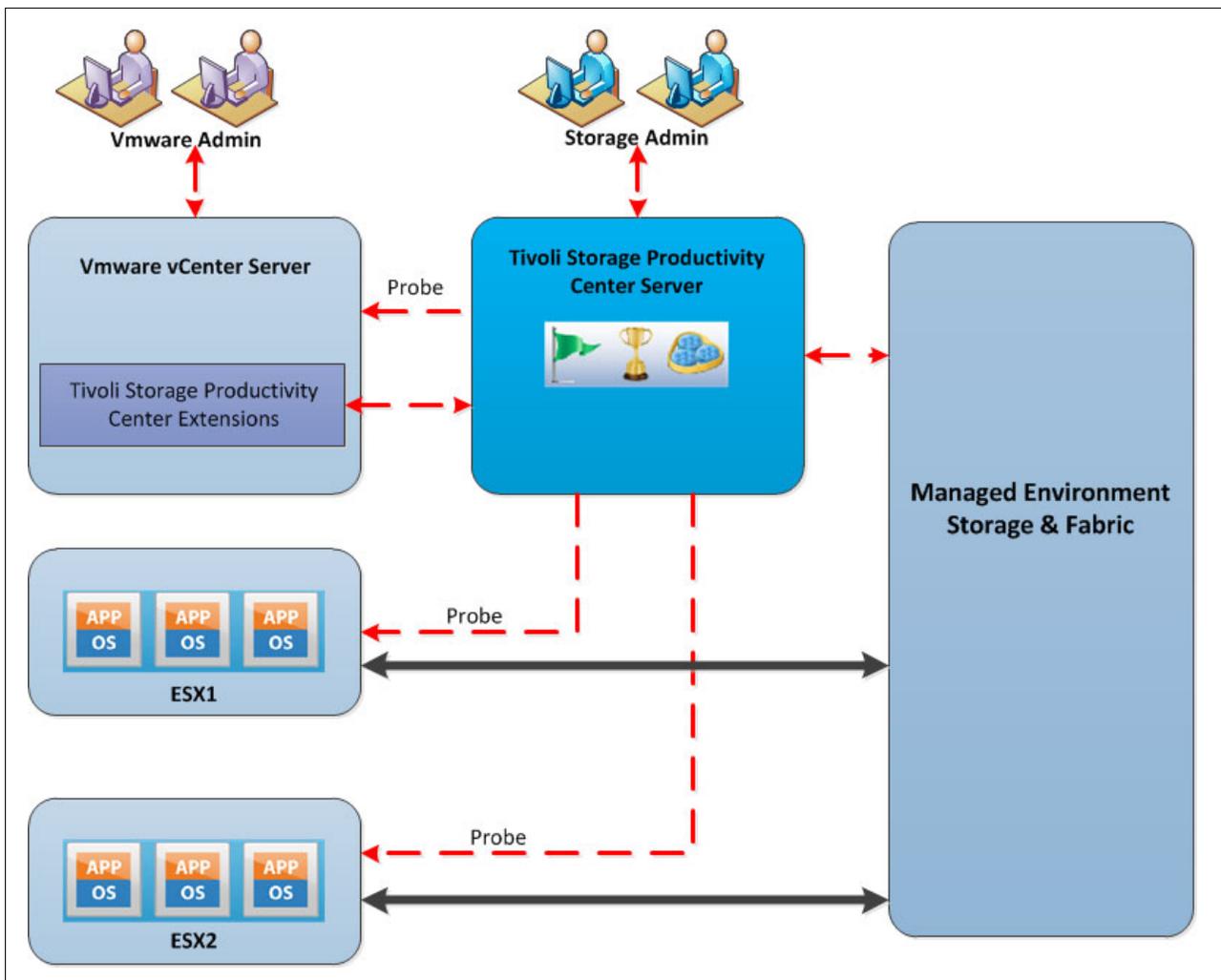


Figure 2-15 VSC and VMware integration topology

VMware vCenter web client extension provides the following features to VMware administrators:

- ▶ Visualization of connections:
 - End-to-end from storage volume to VM
 - Storage details like pools, volumes, attributes
 - Performance charts
- ▶ Automated policy-based storage provisioning, based on storage services catalog:
 - Block volumes
 - File shares
 - Service class characteristics (storage tier, data protection, compression, encryption, and so on)
- ▶ vSphere API for Storage Awareness (VASA):
 - Alerts for performance, errors and capacity thresholds
 - Availability of volumes, pools, storage systems, paths
 - Tivoli Storage Productivity Center service classes can be used as VASA capabilities
- ▶ Additional storage reports are available in vCenter admin GUI:
 - Fabric connectivity
 - Storage performance
 - Storage mappings

2.6 IBM Virtual Storage Center offerings

IBM SmartCloud Virtual Storage Center V5.2 has the following offerings:

- ▶ IBM SmartCloud Virtual Storage Center V5.2
- ▶ IBM SmartCloud Virtual Storage Center Entry V5.2
- ▶ IBM SmartCloud Virtual Storage Center for Storwize Family V5.2

The *IBM SmartCloud VSC V5.2* license is an offering to be used with the System Storage SAN Volume Controller and is a software entitlement to run both the external virtualization, FlashCopy and remote copy services features. The only feature of the SAN Volume Controller that is not included in the IBM SmartCloud VSC V5.2 license entitlement is the Real-Time Compression option, which can be added as a separately priced license. This license does not include the hardware nodes that are required for a complete SAN Volume Controller implementation.

IBM SmartCloud VSC Entry V5.2 provides external virtualization, FlashCopy, and remote copy services software entitlement in smaller SAN Volume Controller configurations. Also, for deployment in midrange environments, a Storwize V5000 or V7000 can be used as the virtualization engine in a VSC configuration, and in this case the offering to be used is the *IBM SmartCloud Virtual Storage Center for Storwize Family V5.2*.

The versions of code that are available through IBM SmartCloud VSC 5.2 for download for the System Storage SAN Volume Controller and the Tivoli Storage FlashCopy Manager are exactly the same as the versions available for download if these products were downloaded independently of IBM SmartCloud VSC 5.2. In the case of Tivoli Storage Productivity Center, the code is the same as the independent product, but the VSC license enables the Storage Advanced Engine functions to be used.

2.6.1 License model overview

IBM Virtual Storage Center can help customers to easily migrate their storage to a virtual environment and manage storage efficiently. IBM VSC licensing charges are based on the entire managed capacity. This contrasts with SAN Volume Controller, where FlashCopy and Metro Mirror or Global Mirror can be licensed on virtual capacity for those functions only. The managed capacity model avoids over-provisioning, which can become expensive with SAN Volume Controller. Table 2-2 compares the current IBM VSC and IBM Tivoli Storage Productivity Center licensing options and features. The sections after the tables have more details about each of the IBM Virtual Storage Center licenses.

Table 2-2 Current 5.x VSC and Tivoli Storage Productivity Center licensing by offerings

Product name	Licensing usage	Tivoli Storage Productivity Center license	FlashCopy Manager license	SAN Volume Controller license ^a	Storwize license ^b
VSC	Per terabyte (greater than 250 TB or greater than two I/O groups) For example, with the VSC license, you can have 100 TB and grow to 300 TB. This is not possible with VSC Entry, which is limited to less than 250 TB)	Tivoli Storage Productivity Center Advanced	✓	✓	
VSC Entry	Per terabyte (less than 250 TB and less than two I/O groups)	Tivoli Storage Productivity Center Advanced	✓	✓	
VSC for Storwize Family	Per enclosure	Tivoli Storage Productivity Center Advanced	✓		✓
Tivoli Storage Productivity Center	Per terabyte	Tivoli Storage Productivity Center			
Tivoli Storage Productivity Center Select	Per enclosure	Tivoli Storage Productivity Center Select			

a. SAN Volume Controller License includes Base, and FlashCopy and Remote Copy (Metro Mirror and Global Mirror) license.

b. Storwize license included in VSC for Storwize Family is for external virtualization only. The base virtualization license must be configured for each Storwize enclosure as usual.

For customers who might be migrating from an older IBM Tivoli Storage Productivity Center to a current IBM Virtual Storage Center or IBM Tivoli Storage Productivity Center license, Table 2-3 compares functional features of the various licenses.

Table 2-3 Comparison of licenses by feature

Feature	Tivoli Storage Productivity Center 4.2.x					Tivoli Storage Productivity Center (TPC) or VSC 5.x		
	Basic	Disk	Data	Rep ^a	Std ^b	TPC and TPC Select	VSC and VSC Entry	VSC for Storwize Family
Discovery, topology, monitoring, capacity management, alerting, basic capacity reporting	✓	✓	✓		✓	✓	✓	✓
Disk performance reporting		✓	✓		✓	✓	✓	✓
2-site replication management				✓		✓	✓	✓
3-site replication management				✓		✓	✓	✓
Advanced NAS functions		✓			✓		✓	✓
File System & DB scans, reports, quotas, script integration		✓			✓		✓	✓
Fabric performance reporting					✓	✓	✓	✓
Storage Optimizer					✓		✓	✓
SAN Storage Planner with policy based provisioning					✓		✓	✓
VMWare Hypervisor reports					✓	✓	✓	✓
Storage tier reports					✓		✓	✓
Web GUI and Cognos						✓	✓	✓
Cloud API (Tivoli Storage Productivity Center internal)							✓	✓
SAN Volume Controller: Base, FlashCopy and Remote Copy (Metro Mirror and Global Mirror) license							✓	

Feature	Tivoli Storage Productivity Center 4.2.x					Tivoli Storage Productivity Center (TPC) or VSC 5.x		
	Basic	Disk	Data	Rep ^a	Std ^b	TPC and TPC Select	VSC and VSC Entry	VSC for Storwize Family
Storwize: External Virtualization, FlashCopy and Remote Copy (Metro Mirror and Global Mirror) license								✓
FlashCopy Manager							✓	✓

- a. Replication
- b. Standard

Note: VSC for the Storwize Family (5608-ACL) can also be used for the FlashSystem V840 internal storage enclosures. You must use VSC Standard (5608-AE1) for V840 externally virtualized storage. If VSC is not required, you can continue to license FlashSystem V840 external virtualization (5639-FV7) per enclosure for externally virtualized storage.

2.6.2 VSC License: Enterprise deployment

Do you have a medium to large storage configuration (250 TB or *greater*), possibly with a variety of storage systems to manage? And, is high performance on that virtualized storage mandated? Consider using the Standard VSC license.

License: Standard VSC

This license offers these features:

- ▶ Per terabyte price metric with tiered capacity pricing
- ▶ No restrictions on terabyte and number of SAN Volume Controller I/O groups
- ▶ SAN Volume Controller is the storage engine of choice
- ▶ Includes all features of standard VSC license (virtualization, FlashCopy, mirroring, Advanced Analytics)

Choose this VSC license when you are using an SAN Volume Controller as your storage virtualization engine, your managed capacity is 250 TB (or greater), or you are using more than two SAN Volume Controller I/O groups.

2.6.3 VSC Entry License

Are you managing a smaller storage configuration (*less than 250 TB*), possibly with a variety of storage systems to manage. And, is high performance on that virtualized storage mandated? Consider using the VSC Entry license.

License: VSC Entry

This license offers these features:

- ▶ Per TB price metric
- ▶ Restricted to 250 TB¹ and two SAN Volume Controller I/O groups
- ▶ SAN Volume Controller is the storage engine of choice
- ▶ Includes all features of standard VSC license (virtualization, FlashCopy, mirroring, Advanced Analytics)

Choose the VSC Entry license when you are using a SAN Volume Controller as your storage virtualization engine, your managed capacity is less than 250 TB, and you are using two or fewer SAN Volume Controller I/O groups.

2.6.4 VSC for Storwize Family license

Are you managing a small to medium storage configuration (100 TB - 1 PB) where the storage virtualization investment is largely with Storwize V7000 or Storwize V5000, which might manage some variety of storage systems under them? Consider using the VSC for Storwize Family license.

License: VSC for Storwize Family

This license offers these features:

- ▶ Restricted to deployment on Storwize V7000 and V5000 hardware
- ▶ Per Enclosure price metric
- ▶ No restrictions on the number of enclosures
- ▶ Includes all features of VSC (external virtualization, Mirroring, Advanced Analytics);
- ▶ License does not include base software license for Storwize enclosures

Choose the VSC for Storwize Family license if you are using a Storwize V7000 or Storwize

¹ Use Real-Time Compression to extend capacity management beyond 250 TB.



Storage management

This chapter describes the storage management component of IBM SmartCloud Virtual Storage Center (VSC), also known as IBM Tivoli Storage Productivity Center. We discuss how the storage management component is integrated in Virtual Storage center.

As an end-to-end storage management solution included in VSC, Tivoli Storage Productivity Center provides a single point of control that helps administrators to manage every aspect of the storage infrastructure, between the hosts, through the fabric, and down to the physical disks across multi-site storage environments.

In this chapter, the following Tivoli Storage Productivity Center functions are described:

- ▶ End-to-end management of storage infrastructures
- ▶ Management of storage replication
- ▶ Management and administration of SAN-attached storage
- ▶ Optimization, provisioning, and transformation of SAN-attached storage
- ▶ Performance management of SAN-attached devices
- ▶ Monitoring, management, and control of SAN fabric components
- ▶ Capacity utilization and availability management of file systems and databases

We also discuss scenarios and installation considerations, with the primary focus on installing a new Tivoli Storage Productivity Center and upgrading existing Tivoli Storage Productivity Center installations to Tivoli Storage Productivity Center VSC edition.

3.1 Overview

IBM SmartCloud Virtual Storage Center enables IT storage administrators to easily migrate an existing storage environment to an agile, cloud-based, software-defined storage environment, and manage it effectively. By using Tivoli Storage Productivity Center as a storage management solution, storage administrators can manage complete SAN and storage infrastructures, and use advanced storage analytics to optimize, provision, and transform storage efficiently.

Note: Advanced storage analytics functions (cloud configuration, optimization, provisioning and transformation) are licensed only in IBM Tivoli Storage Productivity Center - Virtual Storage Center Edition, apart from the other storage management features, which are also available in standard IBM Tivoli Storage Productivity Center.

Figure 3-1 shows Tivoli Storage Productivity Center environment with its interfaces and examples of monitored objects. The Tivoli Storage Productivity Center server represented at the center of the drawing shows a single server installation on which database, reporting, and the Tivoli Storage Productivity Center server components are installed.

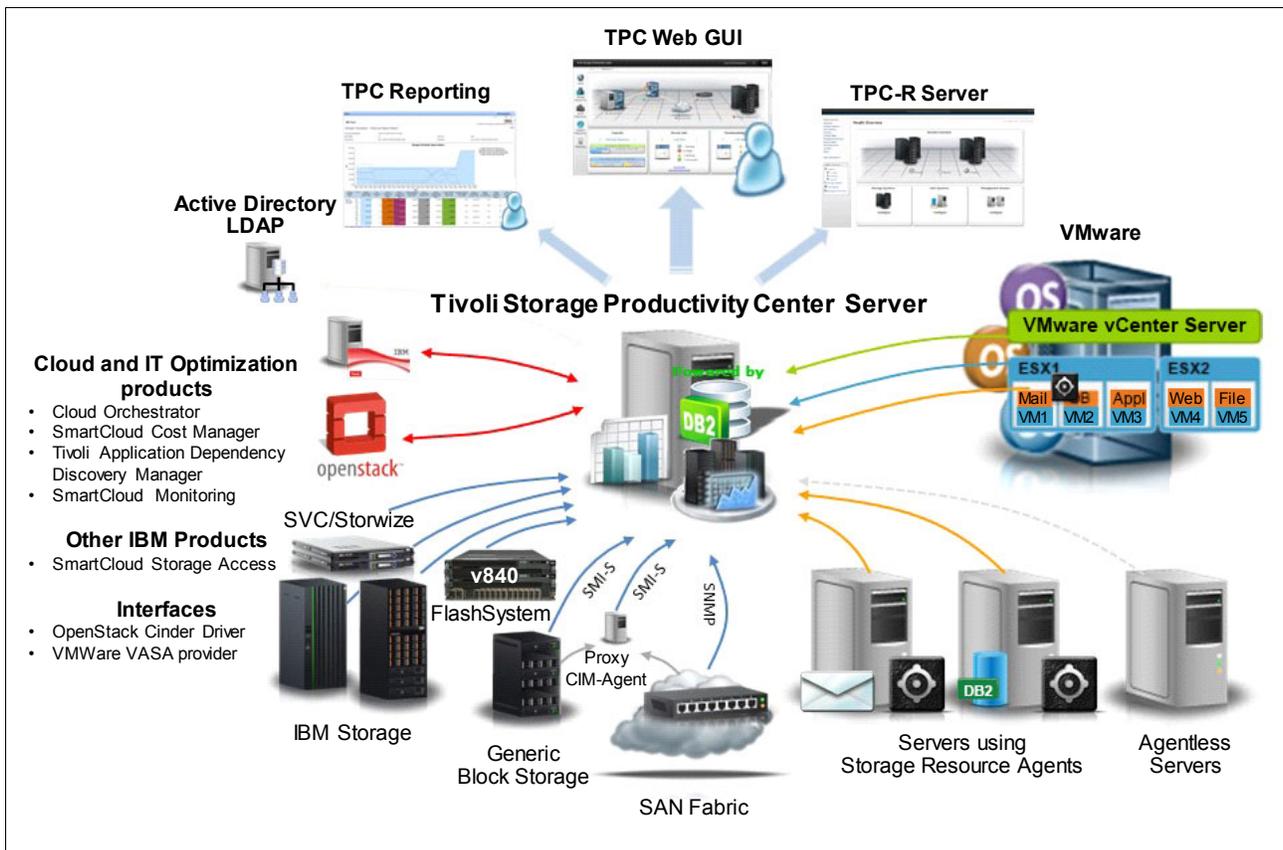


Figure 3-1 Example of Tivoli Storage Productivity Center configuration and components

Simplified administration

Tivoli Storage Productivity Center provides simplified administration through the web-based GUI, which enables consistency and control across complex storage infrastructures. It simplifies many common tasks and enables users to drill down to element managers for advanced tasks. The web GUI enables even non-experts to perform storage provisioning and performance management tasks. Figure 3-2 shows the fully integrated, web-based user interface.

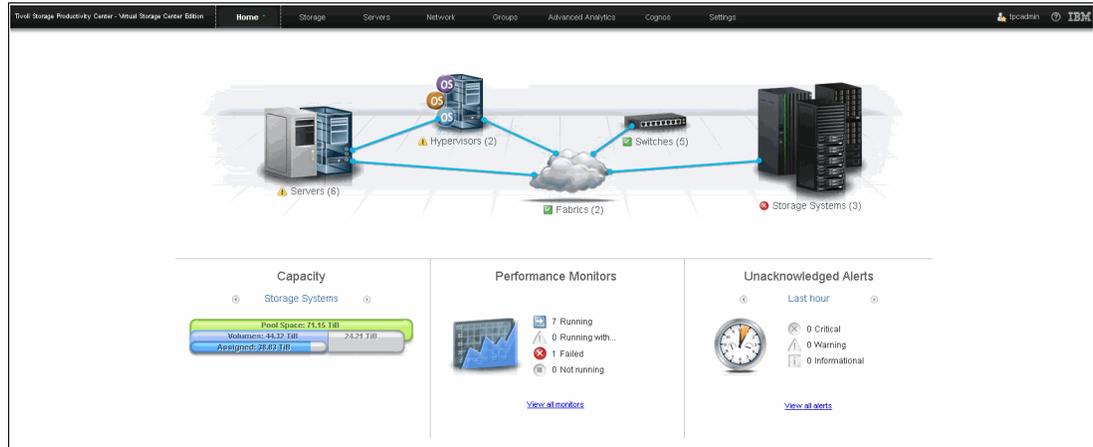


Figure 3-2 Tivoli Storage Productivity Center web GUI

Storage management

Tivoli Storage Productivity Center provides device-level, integrated storage infrastructure management capabilities for managing both IBM and non IBM storage systems. Heterogeneous storage support is offered through the Storage Networking Industry Association (SNIA) Storage Management Initiative Specification (SMI-S). Management capabilities include operational control and provisioning of heterogeneous storage platforms, including storage systems from EMC, NetApp, Hitachi, Oracle Solaris, and HP. In addition, Tivoli Storage Productivity Center includes advanced operational control and performance reporting for IBM storage systems that include DS8000, FlashSystem V840, Storwize family systems, SAN Volume Controller XIV, and IBM GPFS™.

SAN management

Tivoli Storage Productivity Center SAN fabric management capabilities include automatic resource and topology discovery, monitoring and alerts, zone control, and SAN error-prediction capabilities. Adding to this Tivoli Storage Productivity Center also enables performance management at the port and switch levels for SAN platforms from Brocade Communications and Cisco Systems. Figure 3-3 on page 60 shows an example of performance report at the port level.

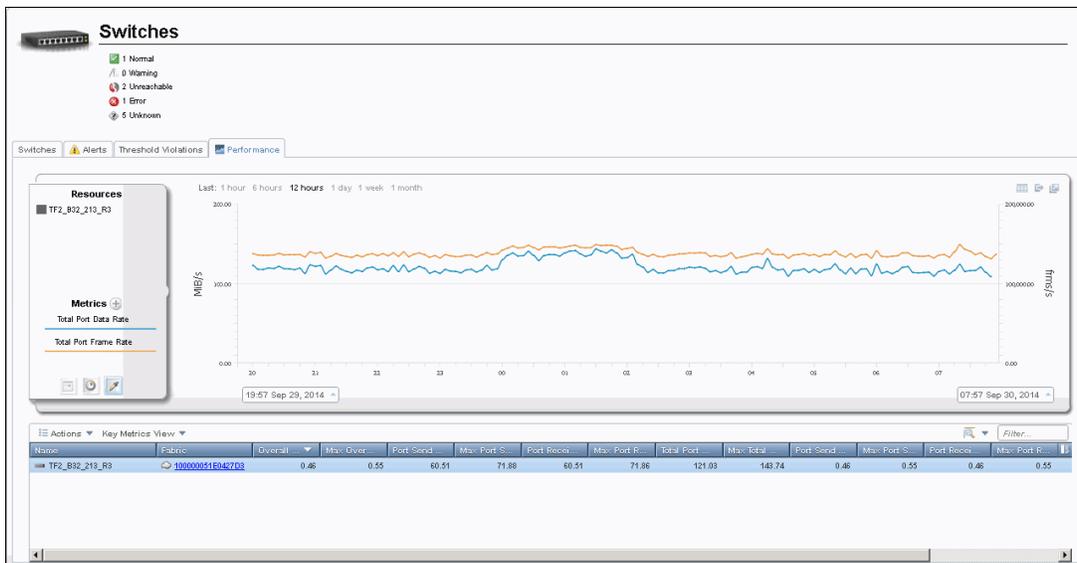


Figure 3-3 Switch port performance

Servers capacity utilization

By using a Storage Resource Agent (SRA), Tivoli Storage Productivity Center provides capacity utilization information including file and file system information about servers (Figure 3-4). Tivoli Storage Productivity Center can also gather information about database managers installed on the server, and NAS device information.

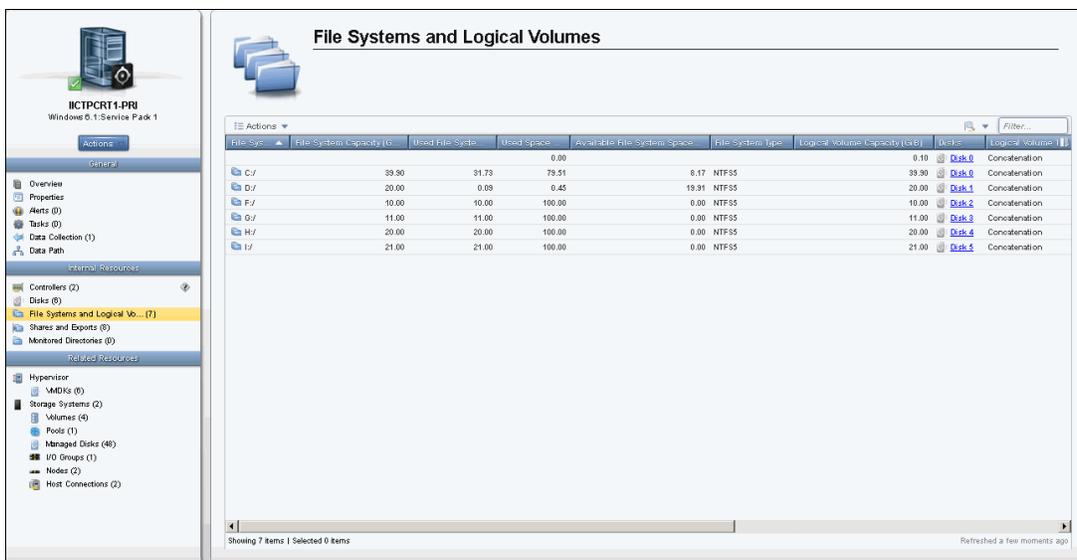


Figure 3-4 Server filesystem information

Tivoli Storage Productivity Center can also monitor servers without using the SRA agent. Agentless server gives you the chance to model a host server, either a physical server or virtual machine, in Tivoli Storage Productivity Center without deploying an SRA. This is useful in those situations where you cannot or do not want to deploy an SRA (either for security restrictions in providing administration credentials or simply to avoid loading a production server with agent code). In Tivoli Storage Productivity Center, you can add servers without deploying Storage Resource agents and still view the overall connectivity and capacity of those servers.

VMware integration

Tivoli Storage Productivity Center includes a VMware vCenter plug-in that can simplify storage administration for VMware administrators. By using this plug-in, users and administrators can provision storage directly from the VMware vSphere client GUI. Tivoli Storage Productivity Center also provides details of storage capabilities to vSphere through VMware APIs for Storage Awareness (VASA), which in turn can be used to define VMware storage profiles. vSphere reports are enhanced with Tivoli Storage Productivity Center data through VASA and vSphere storage report extensions that include the following information:

- ▶ Fabric details, including zones, switch and fabric
- ▶ End-to-end mapping of VMware storage for each virtual disk
- ▶ Storage system performance metrics on the total I/O rate and response times

Performance management

Tivoli Storage Productivity Center integrates built-in, context-sensitive performance management that is accessible to any administrator. It collects information about the performance of storage systems and switches. The information includes key performance metrics and notifications of threshold violations that can help administrators to measure, identify, and troubleshoot performance issues and bottlenecks in storage environment.

Performance management is server-centric so administrators can more easily visualize storage performance problems from the user perspective. Administrators can quickly generate performance graphs from several perspectives and align them with a simple mouse click. Performance scenarios can be cloned, so administrators can review past performance scenarios to better understand how problems first developed. Figure 3-5 shows an example of a performance monitor.



Figure 3-5 Storage pools performance monitor

Replication management

Tivoli Storage Productivity Center replication management capabilities help simplify the data replication process from end to end. It can automate complex replication tasks without scripts, and can scale to support hundreds of replication sessions across thousands of volumes.

Tivoli Storage Productivity Center supports the following replication session types:

- ▶ IBM FlashCopy
- ▶ IBM XIV Storage System snapshots
- ▶ IBM Basic HyperSwap®
- ▶ Metro Mirror
- ▶ Global Mirror
- ▶ Metro/Global Mirror
- ▶ Global Copy

For replication management, Tivoli Storage Productivity Center can use IBM DS8000, XIV, IBM System Storage SAN Volume Controller, IBM Storwize V7000, IBM Storwize V7000 Unified, and IBM Storwize V3700. Figure 3-6 shows Tivoli Storage Productivity Center replication management GUI.

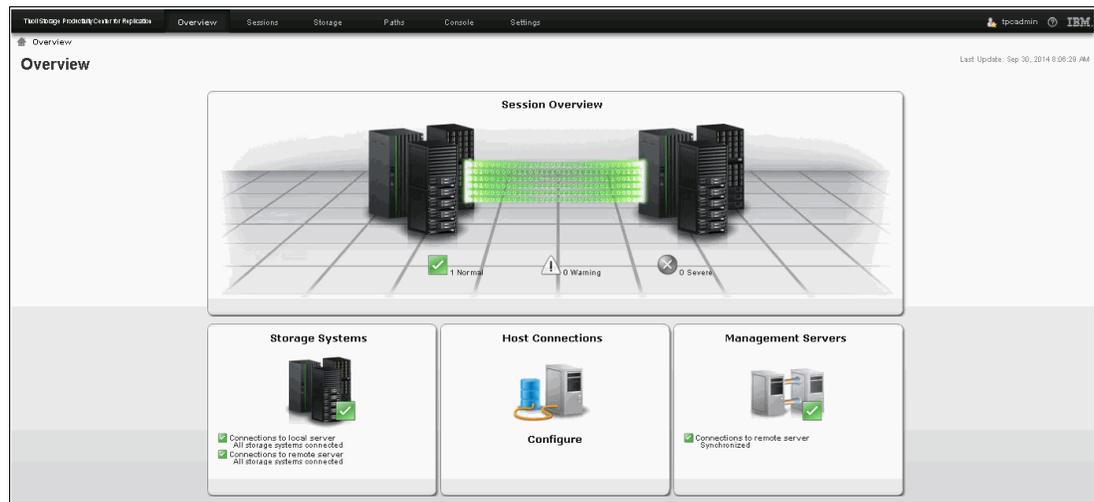


Figure 3-6 Tivoli Storage Productivity Center Replication management GUI

Tivoli Storage Productivity Center uses performance metrics and advanced analytics to perform storage optimization which includes storage pool balancing, storage tier analysis, and volume transformation. Storage optimization task optimizes the resources in your storage environment by redistributing volumes across each tier, and by moving volumes to higher or lower tiers. It also distributes the workload of volumes across pools on the same tier.

For more details about optimization, see Chapter 7, “Storage optimization” on page 171.

Tivoli Storage Productivity Center and SAN Volume Controller integration

The foundation of SmartCloud Virtual Storage Center is the integration between the Tivoli Storage Productivity Center and the SAN Volume Controller. Although the SAN Volume Controller has a capable web-based management interface, some limitations exist in terms of the reporting and visualization of the environment because the scope is limited to a single SAN Volume Controller cluster.

Tivoli Storage Productivity Center is designed as an enterprise class storage management product that reports on all the SAN Volume Controllers. It also reports on the back-end storage being virtualized, the SAN infrastructure providing connectivity to the SAN Volume Controller and the servers that are connected to the virtualized storage. Tivoli Storage Productivity Center has been able to manage and report on SAN Volume Controller since Tivoli Storage Productivity Center V3.1 and every release of Tivoli Storage Productivity

Center since that initial release has incrementally added to the management and reporting capabilities of the SAN Volume Controller. The result is that Tivoli Storage Productivity Center now reports on more than one hundred distinct performance metrics related to the SAN Volume Controller. Additional reports can help customers handle the reporting needs regarding capacity and utilization of the storage space being virtualized, including thin-provisioned volumes. In addition, Tivoli Storage Productivity Center can produce reports based on a collection interval of hourly or daily views. The time span for the report is also under complete control for historical trend analysis.

3.2 Scenarios and installation considerations

IBM SmartCloud Virtual Storage Center (VSC) bundles Tivoli Storage Productivity Center with IBM System Storage SAN Volume Controller and Tivoli Storage FlashCopy Manager. Installation of each component is independent to each other, but all the components, when integrated together, provide a new agile, cloud-based, software-defined storage environment.

Depending on your environment and existing storage infrastructure, the following scenarios are possible ways to install VSC components:

- ▶ Install VSC in a non IBM storage environment

In this scenario, VSC transforms your existing storage environment into a completely virtualized storage environment by using SAN Volume Controller virtualization technology, where Tivoli Storage Productivity Center will provide comprehensive end-to-end management with advanced analytics. By using SAN Volume Controller advanced copy services, FlashCopy Manager can provide fast, application-aware backups and restores.

- ▶ Install VSC in a mixed IBM and non IBM storage environment

In this scenario, VSC transforms your existing IBM and non IBM storage environment into one consolidated, completely virtualized, storage environment by using SAN Volume Controller virtualization technology, where Tivoli Storage Productivity Center will provide comprehensive end-to-end management with advanced analytics. By using SAN Volume Controller advanced copy services, FlashCopy Manager can provide fast, application-aware backups and restores.

- ▶ Install VSC in an IBM environment without virtualization and management

In this scenario, VSC transforms your existing IBM storage environment into a completely virtualized storage environment by using SAN Volume Controller virtualization technology where Tivoli Storage Productivity Center will provide comprehensive end-to-end management with advanced analytics. By using SAN Volume Controller advanced copy services, FlashCopy Manager can provide fast, application-aware backups and restores.

- ▶ Install VSC in an IBM environment with virtualization and management

In this scenario, VSC will improve your existing IBM storage environment. Tivoli Storage Productivity Center will add new advanced analytics functions to existing Tivoli Storage Productivity Center functions and it will enable your environment to optimize and provision storage. By using SAN Volume Controller advanced copy services, FlashCopy Manager can provide fast, application-aware backups and restores.

In this section, we focus only on installing the Tivoli Storage Productivity Center in new environments and in existing environments with an already-installed standard version of Tivoli Storage Productivity Center. Also some suggestions about installing Tivoli Storage Productivity Center on two or three sites for disaster recovery solutions are described.

Details about design considerations for the Tivoli Storage Productivity Center environment are in *IBM Tivoli Storage Productivity Center: Beyond the Basics*, SG24-8236.

3.2.1 Installing new Tivoli Storage Productivity Center

In scenarios where Tivoli Storage Productivity Center is not installed, you must do a fresh installation. The installation procedure includes these steps:

1. Access the software code and documentation
2. Evaluate and prepare hardware configuration
3. Evaluate system configuration and install prerequisite software
4. Install Tivoli Storage Productivity Center

Access the software code and documentation

Tivoli Storage Productivity Center code is available only as a download for registered users. A refresh pack code is available at the IBM Fix Central support website:

<http://www.ibm.com/support/fixcentral/>

Depending on whether you are a customer, an IBM Business Partner, or working for IBM, the way to obtain the code differs. Typically, you use IBM Passport Advantage® or IBM Partner World. For more information about downloading the installation images for Tivoli Storage Productivity Center by using Passport Advantage Online, see the following website:

<http://www.ibm.com/support/docview.wss?uid=swg24038425>

Although several packages exist for download, the three major parts are as follows:

- ▶ Tivoli Storage Productivity Center
- ▶ IBM DB2 Enterprise Server Edition
- ▶ Reporting:
 - Tivoli Common Reporting/Cognos
 - IBM Jazz™ for Service Management
 - Webshere Application Sever

Optional parts which are part of the Tivoli Storage Productivity Center package but are not required to install Tivoli Storage Productivity Center, might be required for added functionality and can be configured later. The optional parts are as follows:

- ▶ Storage Resource Agent (SRA)
- ▶ IBM Tivoli monitoring
- ▶ Tivoli Storage Productivity Center Monitoring Agent for IBM Tivoli Monitoring
- ▶ IBM System Discovery Engine

After you download the code, extract all the compressed files before you begin the installation. The suggestion is to extract Tivoli Storage Productivity Center images into the same single temporary directory; all other parts can be extracted into separate temporary directories for each part or group of parts (DB2, reporting, SRA, IBM Tivoli monitoring, IBM System Discovery Engine).

Requirements for Windows:

- ▶ On the Windows platform, if the installation images are downloaded to a directory that has spaces or unusual special characters in the name, Tivoli Storage Productivity Center does not install correctly. Also, the file path to the temporary directory cannot exceed 90 characters in length.
- ▶ The requirement is for the installation images to be local on the server on which you will install Tivoli Storage Productivity Center. If you mount a network drive with the Tivoli Storage Productivity Center installation images and try to run the setup from there, it will not work.

Table 3-1 lists all required Tivoli Storage Productivity Center 5.2.4 downloadable parts for Windows installation. For optional monitoring parts and also AIX and Linux installation parts, see the following web page:

<http://www.ibm.com/support/docview.wss?uid=swg24038425>

Table 3-1 Tivoli Storage Productivity Center 5.2.4 Windows packages

Part number	File name	Description
CN27PML	VSC_V5.2.4_WINDOWS_Part1.zip	Tivoli Storage Productivity Center Advanced V5.2.4 Windows (1 of 2)
CN27DML	TPC_V5.2.4_WINDOWS_Part2.zip	Tivoli Storage Productivity Center V5.2.4 Windows (2 of 2)
CIZJ2ML	TPC_DB2_10.1.fp3a_WINDOWS.exe	DB2 ESE 10.1 Fix Pack 3a Windows AMD64 and Intel EM64T (X64)
CIXA4ML	ITCR_3.1.0.1_FOR_WINS.zip	Jazz for Service Management 1.1.0.3 for Windows ML (Launchpad, PRS, Jazz Repository, TDI)
CIN3KML	ITCR_3.1.0.1_FOR_CFM_WINS.zip	IBM Tivoli Common Reporting 3.1.0.1 for Windows Multilingual
CIXA8ML	ITCR_3.1.0.2_FOR_WINS.zip	IBM Tivoli Common Reporting 3.1.0.2 for Windows Multilingual
CIFS5ML	WAS_V8.5.0.1_FOR_JAZZSM_WIN_ML.zip	IBM WebSphere® Application Server V8.5.0.1 for Jazz for Service Management for Windows ML
CN27HML	TPC_V5.2.4_STORE_RES_AGENT_FOR_W.zip	Tivoli Storage Productivity Center V5.2.4 Storage Resource Agent for Windows

Evaluate and prepare hardware configuration

Hardware configuration requirements for Tivoli Storage Productivity Center installation depends on the environment to be managed. Tivoli Storage Productivity Center server can require a large amount of memory, disk space, network bandwidth, and processor resources, which must all be planned in advance. In general we can make the following classification whereby the requirements will be defined:

- ▶ Evaluation environments
This can include 10,000 volumes, 5 subsystems, 5 switches, 200 fabric ports, and 300 agentless servers.
- ▶ Medium production environments
This can include 50,000 volumes, 20 subsystems, 15 switches, 800 fabric ports, and 1000 agentless servers.
- ▶ Large environments
This can include 70,000 volumes, 30 subsystems, 20 switches, 1000 fabric ports, and 2000 agentless servers.

Tivoli Storage Productivity Center can be installed in a single server or a multiple-server environment. A multiple-server environment might be suitable for large environments, where one server is not sufficient to manage the Tivoli Storage Productivity Center components. Other considerations to help you decide about a single or multiple server installation are customer policies on server location and database placement.

The preferred practice is single server installation for several reasons:

- ▶ The complexity of the installation and future upgrades is far less in a single server environment.
- ▶ The **service.bat/sh** troubleshooting tool runs on the server where Tivoli Storage Productivity Center is installed. Therefore in a multiple-server environment troubleshooting might not be as easy as if Tivoli Storage Productivity Center is running on a single server, and the **service.bat/sh** tool can collect all of the logfiles.
- ▶ Backing up a Tivoli Storage Productivity Center environment is much simpler if you must only back up one server.

The preferred practice for placement of the DB2 database repository is to place it on the same server where you install the Tivoli Storage Productivity Center.

Details and current information about Tivoli Storage Productivity Center hardware requirements, according to the classification, is at the following web page:

<http://www.ibm.com/support/docview.wss?uid=swg27039550>

Evaluate system configuration and install prerequisite software

Before installing and using Tivoli Storage Productivity Center, you must evaluate system configuration and software prerequisites. This includes supported operating systems, supported web browsers for Tivoli Storage Productivity Center web GUI, supported DB2 database versions, SRA server requirements, CIM agent requirements, supported hypervisor versions, multipath support, and more.

Before you start the Tivoli Storage Productivity Center installation, you must install the DB2 database which is a requirement. If you do start the Tivoli Storage Productivity Center installation program before you install DB2 database, the installer inform you that DB2 database is not installed and that you must install it. Jazz for Service Management and Tivoli Monitoring can be installed during the Tivoli Storage Productivity Center installation if you

immediately plan to use reporting or it can be installed at any time later, after you install Tivoli Storage Productivity Center.

SRAAs can be installed on servers separately after you successfully install Tivoli Storage Productivity Center. You can install an SRA either by using the Tivoli Storage Productivity Center web GUI, or locally on the server by using a command.

CIM agents are used to collect data from third-party storage systems, which does not have native API for Tivoli Storage Productivity Center communication. For all IBM storage systems, we collect data by using the native API. The CIM agents are not required to be installed before Tivoli Storage Productivity Center, but they must be installed and configured before you can collect the data through Tivoli Storage Productivity Center.

Detailed information about the software prerequisites are at the following web page:

<http://www.ibm.com/support/docview.wss?uid=swg27039833>

Install Tivoli Storage Productivity Center

After you evaluate and prepare the hardware and software configuration, you can start the Tivoli Storage Productivity Center installation program from the directory where you extracted Tivoli Storage Productivity Center images. The installation wizard guides you through the installation steps. After you enter all the information in the wizard, the preinstallation summary panel shows a summary before the installation starts. When the installation is complete, in the Installation Complete panel, the links to connect to Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication web user interfaces are shown.

Detailed steps and all information about installing Tivoli Storage Productivity Center are at the following IBM Knowledge Center web page:

http://www.ibm.com/support/knowledgecenter/SSNE44_5.2.4/com.ibm.tpc_v524.doc/fqz0_t_installing_main.html

The Tivoli Storage Productivity Center installation process is also described in *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204.

3.2.2 Upgrading existing Tivoli Storage Productivity Center installation to Tivoli Storage Productivity Center VSC edition

In situations where you want to upgrade an existing Tivoli Storage Productivity Center installation to Tivoli Storage Productivity Center Virtual Storage Center Edition and to use advanced analytics functions (such as optimization and provisioning), you can use the installation wizard or silent mode installation to upgrade to Virtual Storage Center Edition.

Licenses and upgrades

Understand the license and upgrade information.

Determining the license type

To determine the type of license you have (this applies to Tivoli Storage Productivity Center version 5.2), find these files in `TPC_installation_directory/properties/version` directory:

- ▶ `Tivoli_Storage_Productivity_Center.5.2.0.swtag`: Indicates that you have a Tivoli Storage Productivity Center license.
- ▶ `Tivoli_Storage_Productivity_Center_Advanced.5.2.0.swtag`: Indicates that you have IBM SmartCloud Virtual Storage Center Storage Analytics Engine license. Previously, this license was called the Tivoli Storage Productivity Center Advanced license.

- ▶ `Tivoli_Storage_Productivity_Center_Select.5.2.0.swtag`: Indicates that you have a Tivoli Storage Productivity Center Select license.

Depending on the license you purchased, find one of the following license key files in the `license\key` subdirectory, on `disk1`, `part1` of the DVD, or electronic image:

- ▶ `node\lock`: Tivoli Storage Productivity Center license
- ▶ `node\lock.SEL`: Storage Productivity Center Select license
- ▶ `node\lock.AE`: IBM SmartCloud Virtual Storage Center Storage Analytics Engine license

Possible upgrades

Depending on your existing installation, the following upgrades are possible:

- ▶ Upgrade the existing Tivoli Storage Productivity Center 4.2.x and Tivoli Storage Productivity Center 5.1.x installation to Tivoli Storage Productivity Center 5.2 VSC edition, which includes the advanced analytics license.
- ▶ Upgrade the existing Tivoli Storage Productivity Center 5.2 license to Tivoli Storage Productivity Center 5.2 VSC edition license, which enables the advanced analytics.

Considerations for upgrading existing Tivoli Storage Productivity Center 4.2.x and Tivoli Storage Productivity Center 5.1.x installation to Tivoli Storage Productivity Center 5.2 VSC edition are described in these sections.

- ▶ “Considerations for both 4.2.x and 5.1.x upgrades” on page 68
- ▶ “Considerations for only 4.2.x upgrades” on page 69
- ▶ “Considerations for only 5.1.x upgrades” on page 70

However, for more details, see *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204.

Considerations for both 4.2.x and 5.1.x upgrades

These are the considerations for upgrading your Tivoli Storage Productivity Center from a previous version to V5.2.4:

- ▶ Windows 2003 and Windows 2008 32-bit environments are not supported by Tivoli Storage Productivity Center V5.2.4. To upgrade previous Tivoli Storage Productivity Center installations, the operating system must first be migrated to a Windows 64-bit environment.
- ▶ Tivoli Storage Productivity Center V5.2.4 minimum memory requirement is 12 GB. Verify if additional memory is required for your Tivoli Storage Productivity Center server.
- ▶ DB2 9.7 32-bit version is not supported in Tivoli Storage Productivity Center V5.2.x. DB2 must first be upgraded to the 64-bit version. For details about the DB2 upgrade, see *IBM Tivoli Storage Productivity Center Installation Guide*, SC27-4058.
- ▶ The roles that were previously defined in Tivoli Storage Productivity Center were consolidated in two roles: administrator and monitor. Check your user roles and change them accordingly.
- ▶ In Tivoli Storage Productivity Center V5.2.4, IBM Tivoli Integrated Portal is not used. During the Tivoli Storage Productivity Center upgrade process, you can choose to preserve the old Tivoli Integrated Portal instance, for example, if it is being shared with another product. Otherwise, we suggest you uninstall Tivoli Integrated Portal in order to preserve system resources.

- ▶ The LDAP configuration settings are not migrated from Tivoli Integrated Portal to Jazz for Service Management. You must manually configure the Jazz for Service Management with LDAP repository by using the WebSphere Application Server Administrative Console. For details about the Jazz for Service Management configuration with LDAP repository, see *IBM Tivoli Storage Productivity Center Installation Guide*, SC27-4058.

Important: If your DS8000 or SAN Volume Controller storage system is configured to use Single Sign On with Tivoli Storage Productivity Center, then the DS8000 or SAN Volume Controller has the Tivoli Integrated Portal information stored in their configuration. This must be switched back to local authentication during the upgrade of Tivoli Storage Productivity Center, because Tivoli Integrated Portal will no longer be used and must be uninstalled.

To be safe, consider reverting to operating system authentication for the Tivoli Storage Productivity Center and for the duration of the upgrade. Also, see your documentation for the values to re-enable LDAP and Active Directory at a later time.

- ▶ Tivoli Integrated Portal data is not migrated. You must manually migrate the Tivoli Common Reporting reports and any custom Tivoli Common Reporting reports. Consider this information:
 - If you configured Tivoli Common Reporting Version 2.1.1 by using the internal content store, go to the following web page for migration steps:
http://www.ibm.com/support/knowledgecenter/SSEKCU_1.1.0/com.ibm.psc.doc_1.1.0/tcr_original/tcr_upgrading.html
 - If you configured Tivoli Common Reporting Version 2.1.1 by using an external content store such as DB2 and Oracle, go to the following web page for migration steps:
http://www.ibm.com/support/knowledgecenter/SSEKCU_1.1.0/com.ibm.psc.doc_1.1.0/tcr_original/tcr_upgrading_external.html

The migration procedures migrate the existing default reports definitions; they are not overwritten by the new definitions. Therefore reports with duplicated name are shown.

More information:

- ▶ For details about how to customize the export of reports from Tivoli Storage Productivity Center V5.1, see *IBM Tivoli Storage Productivity Center V5.1 Technical Guide*, SG24-8053.
- ▶ For details about exporting BIRT reports, see the *Tivoli Common Reporter User Guide*, SC14-7613.

Considerations for only 4.2.x upgrades

These are additional considerations for upgrading your Tivoli Storage Productivity Center specifically from 4.2.x to V5.2.4:

- ▶ Tivoli Storage Productivity Center V5 does not support CAS based Data or Fabric agents. You must migrate these agents to Storage Resource Agents (SRA). This can be done either before migration (suggested) or after migration. For more information, see *IBM Tivoli Storage Productivity Center Version 5.1 Installation and Configuration Guide*, SC27-4058.
- ▶ The Tivoli Storage Productivity Center V5 database schema changed for performance and configuration history functions. Depending upon on the amount of history data you have, it might take from a few minutes to several hours for the installer to transform this data. The installer will provide a time estimate. You can choose to drop the history data during the installation.

Considerations for only 5.1.x upgrades

This is an additional consideration for upgrading your Tivoli Storage Productivity Center specifically from 5.1.x to V5.2.4:

- ▶ Tivoli Common Reporting 3.1.0.1 uses DB2 as the external content store. Tivoli Common Reporting 2.1.1 uses Derby as the external content store by default. However, some Tivoli Storage Productivity Center users configured Tivoli Common Reporting 2.1.1 to use DB2 as the content store after installation. These users must follow a special procedure to install Tivoli Common Reporting 3.1.0.1, reusing the Tivoli Common Reporting 2.1.1 external content store. The procedure is described in the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/SSEKCU_1.1.0.1/com.ibm.psc.doc_1.1.0.1/tcr_original/tcr_upgrading_external.html

Example: Upgrading 5.2 license to 5.2 VSC edition license

Upgrading the existing Tivoli Storage Productivity Center 5.2 license to Tivoli Storage Productivity Center 5.2 VSC edition license is described in this example.

Figure 3-7 shows the existing Tivoli Storage Productivity Center installation, which has a basic license and which does not support optimization and provisioning.

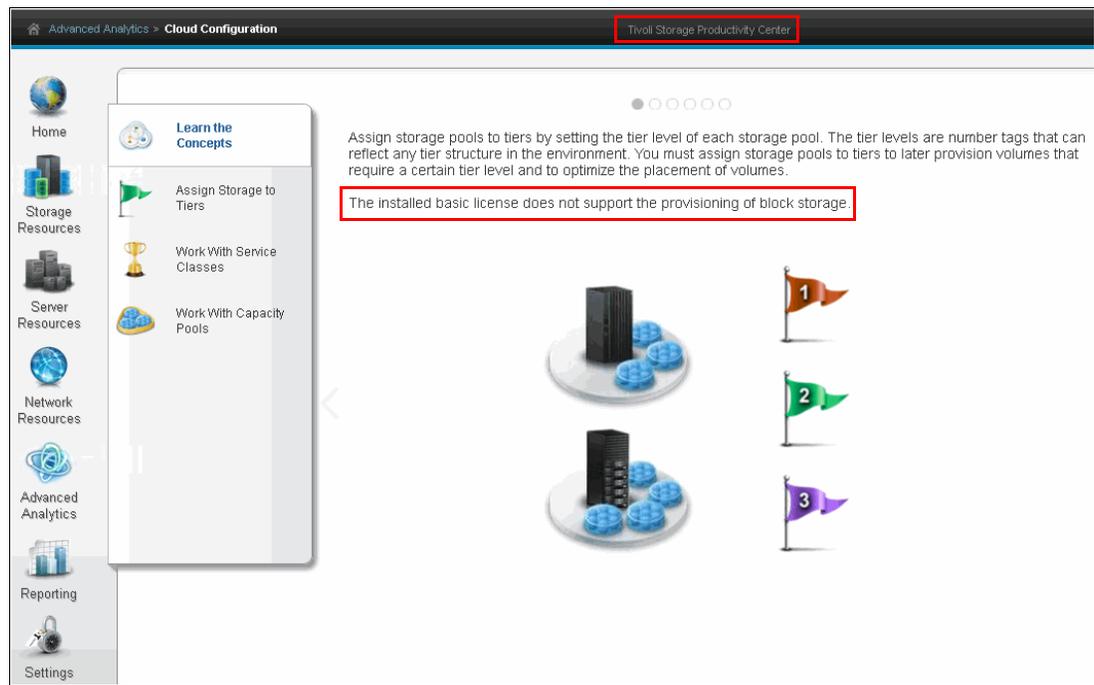


Figure 3-7 Tivoli Storage Productivity Center without advanced analytics functions

To start the license upgrade of your existing Tivoli Storage Productivity Center installation, complete the following steps:

1. Log on to your Tivoli Storage Productivity Center system with the appropriate user privileges.
2. From the Install directory (for example C:\Install\TPC) where you extracted the VSC package, start the installation program by right-clicking **Setup**, and selecting **Run as administrator**.

3. On the installation wizard page, select a language and click **OK**. The language that you select is used to install the license.
4. On the Choose Installation Location and Type page (Figure 3-8), select **License upgrade** and click **Next**.

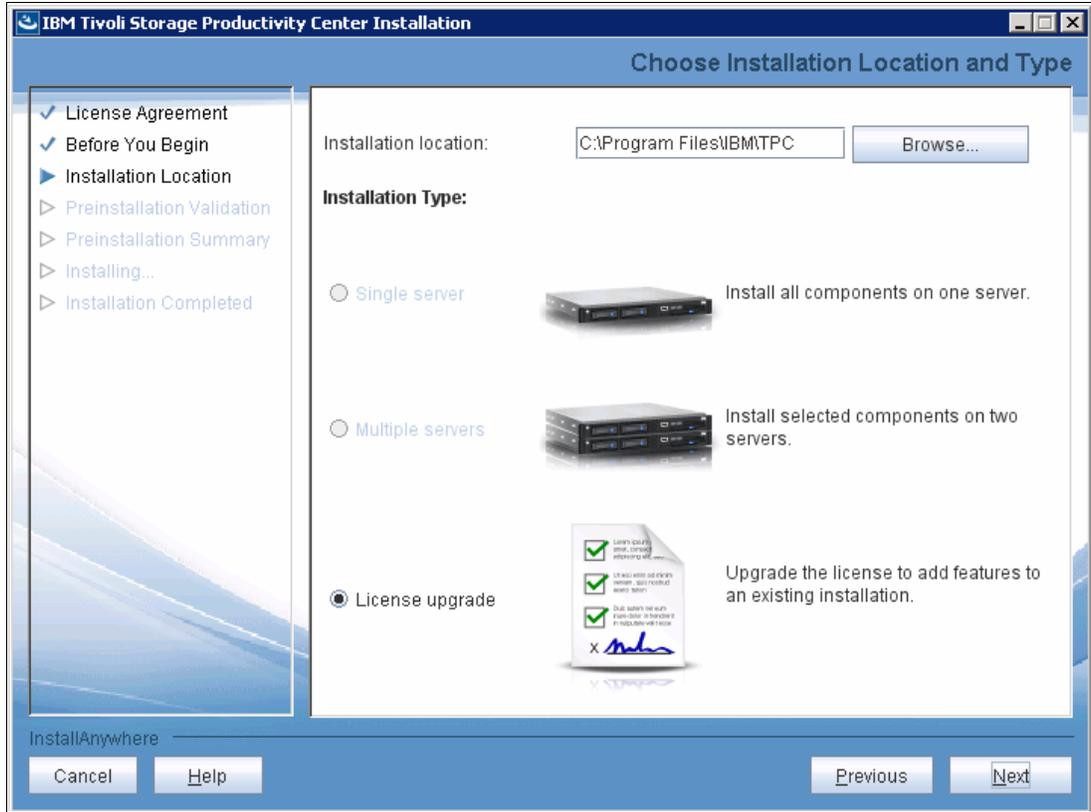


Figure 3-8 Installation type

5. Specify the location of the new license and click next (Figure 3-9).

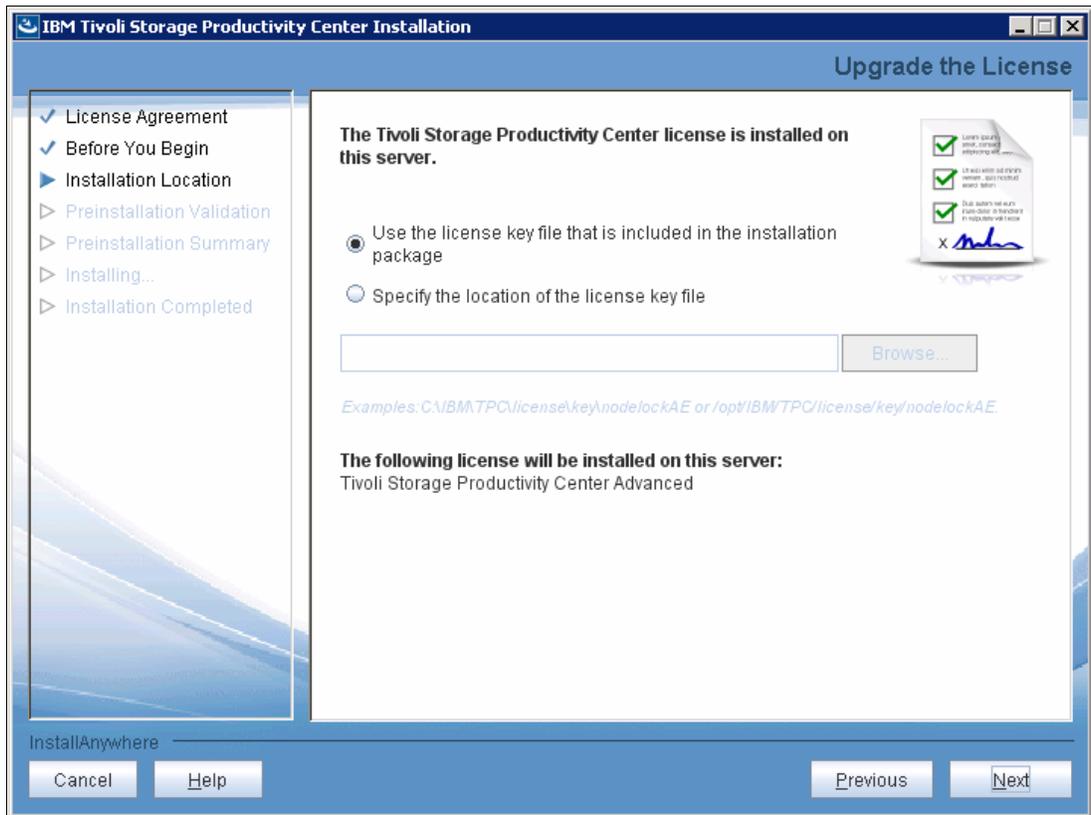


Figure 3-9 Specify new licence

6. On the Preinstallation summary panel, click **Install** (Figure 3-10).

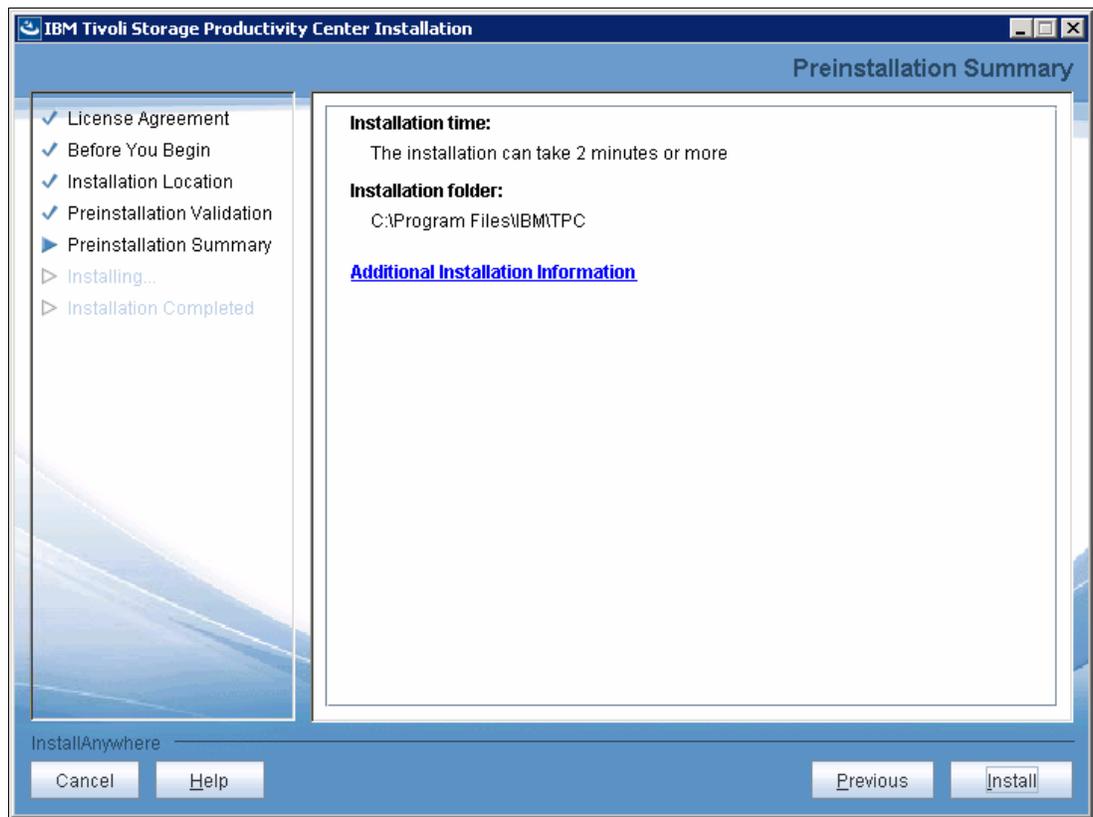


Figure 3-10 Licence upgrade summary

7. The installation starts. When it completes successfully, as shown in the Installation Completed page, click **Done** (Figure 3-11).

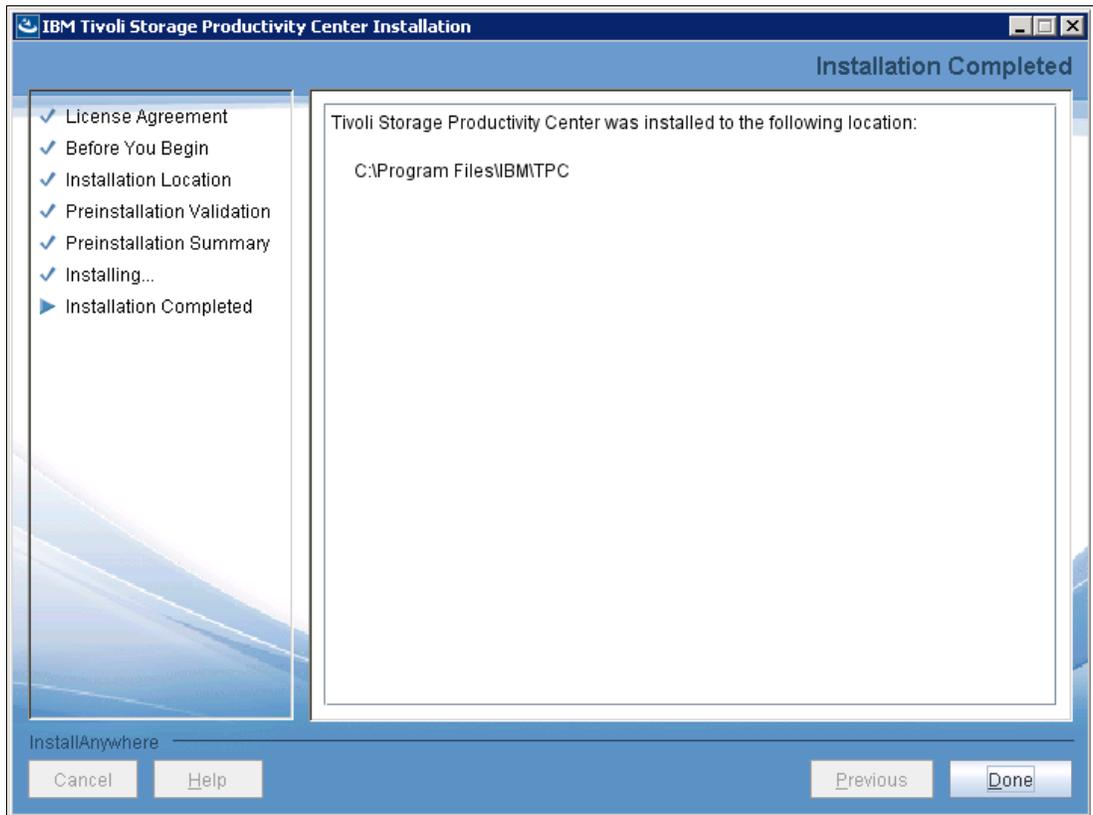


Figure 3-11 Licence upgrade

- Stop and restart the Tivoli Storage Productivity Center web-based GUI. New advanced analytics functions are available and you can use optimization and provisioning functions from the GUI (Figure 3-12 and Figure 3-13).

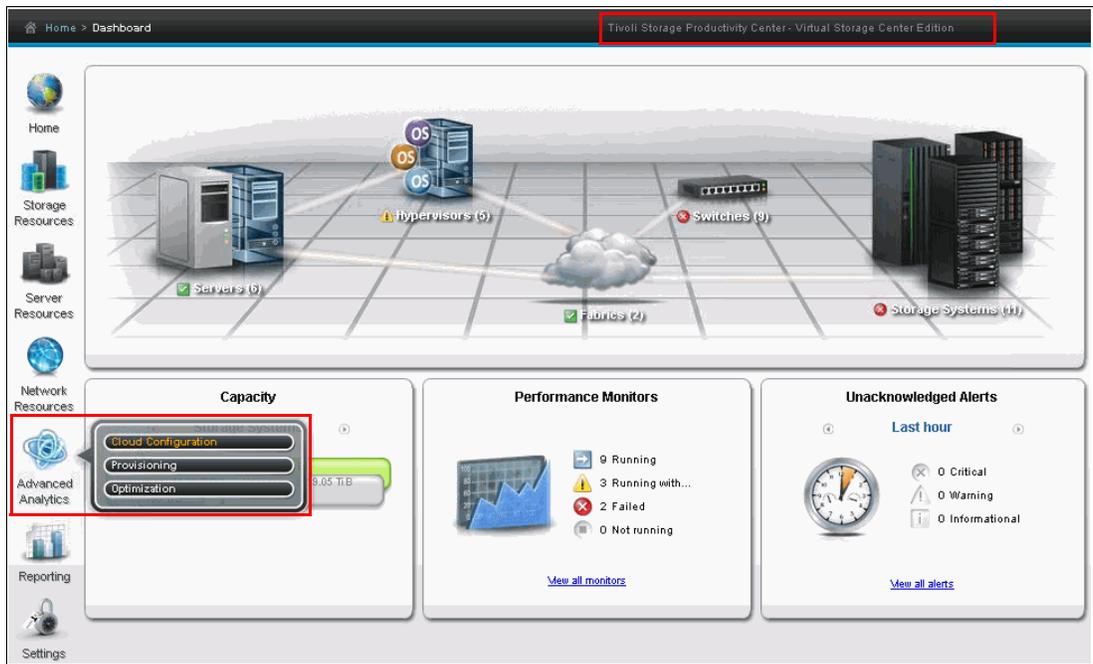


Figure 3-12 Tivoli Storage Productivity Center with advanced analytics functions

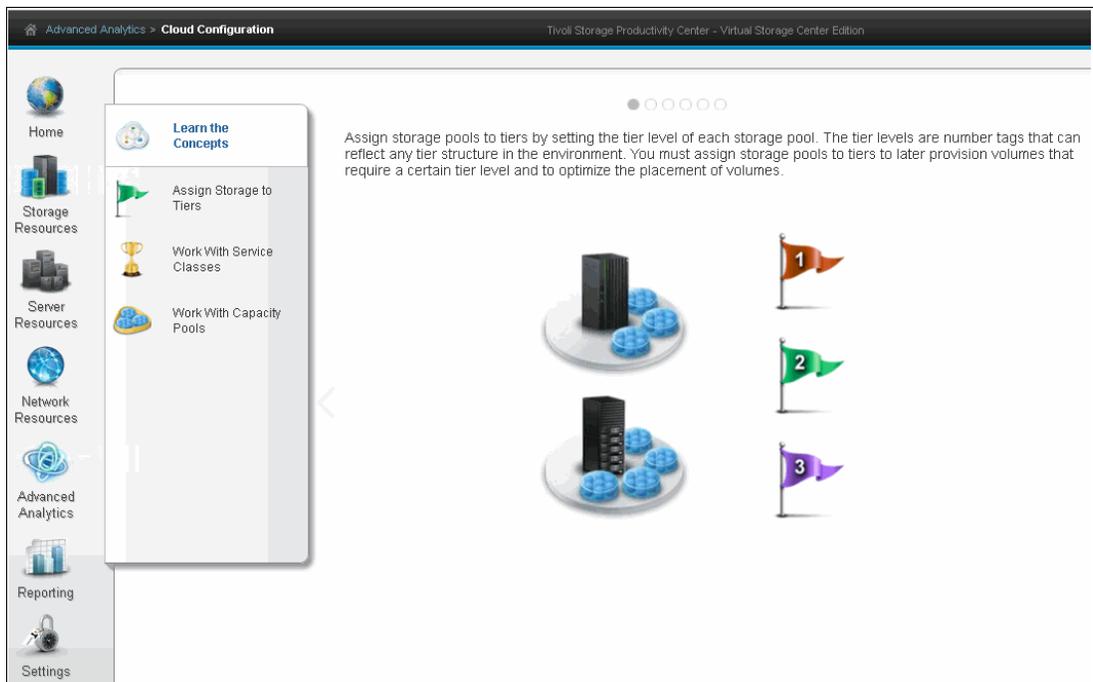


Figure 3-13 Cloud configuration option in Tivoli Storage Productivity Center

3.2.3 Use case: Replication management, installing Tivoli Storage Productivity Center in DR environments

If you plan to implement Tivoli Storage Productivity Center in your disaster recovery (DR) environment and use replication management (the Tivoli Storage Productivity Center for Replication component), consider installing Tivoli Storage Productivity Center on the primary and disaster recovery sites. By using the Tivoli Storage Productivity Center for Replication component of Tivoli Storage Productivity Center you can manage replication and automate complex replication tasks.

If you do not use the Tivoli Storage Productivity Center for Replication component, you might still consider installing, as “active” Tivoli Storage Productivity Center on the primary site and as “standby” Tivoli Storage Productivity Center server on the DR site. In such configurations the “active” Tivoli Storage Productivity Center server will manage the whole environment (primary site and DR site); the “standby” Tivoli Storage Productivity Center server will become active only in case of a primary site disaster. This requires restoring the Tivoli Storage Productivity Center database.

Note: *IBM Tivoli Storage Productivity Center: Beyond the Basics*, SG24-8236 explains backup and restore options of the Tivoli Storage Productivity Center database that reside on the Tivoli Storage Productivity Center server.

For DR solutions, high availability configuration of Tivoli Storage Productivity Center for Replication is highly suggested because it provides high availability of replication management. As a preferred practice we suggest that the active Tivoli Storage Productivity Center for Replication server is always the primary site; the standby server is required at the disaster site. If you have a three-site solution, the standby server is not required in the intermediate site; in a three-site solution, such as Metro Mirror and Global Mirror, the standby server is required in the third site. Tivoli Storage Productivity Center for Replication does not support two standby servers. In case of disasters on the primary site, the standby server will be in consistent disconnected status and it will be ready to take over. This action causes the standby server to be active and you can continue to manage replication.

3.3 Advanced storage analytics overview

As a storage management component of IBM SmartCloud Virtual Storage Center, Tivoli Storage Productivity Center is also designed to provide advanced storage analytics for storage optimization and provisioning capabilities. Those capabilities are used in cloud-based, software-defined, storage environments where the customer's workload requirements must be met in real time.

Tivoli Storage Productivity Center uses real performance metrics and advanced analytics to make recommendations to optimize storage pools and volumes by redistributing workloads across storage environment. By using real performance metrics, it enables optimization decisions to be made based on actual usage patterns, rather than on predictions.

To take advantage of the optimization and provisioning capabilities that are available in Tivoli Storage Productivity Center, some configuration is required. This configuration is called *cloud configuration* and it specifies storage tiers, service classes, and capacity pools that are used to transform your environment to an efficient, self-optimized, and cloud-agile environment.

The following sections introduce Tivoli Storage Productivity Center advanced storage analytics tasks. Also see the “Cloud configuration and provisioning” and “Storage optimization” topics in *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204.

3.3.1 Cloud configuration

With the Tivoli Storage Productivity Center cloud configuration function, you can organize your storage environment by categorizing the resources in tiers and defining service classes with specific qualities of service. This function is a requirement in optimizing your storage environment and in setting up a storage cloud implementation. It is also highly preferred in a traditional storage provisioning context.

To provision storage, you specify only the storage capacity and storage quality that is required. By using the service class, volumes are created with the required characteristics.

To optimize storage performance, Tivoli Storage Productivity Center analyzes tiering and, according to the recommendations that are generated, volumes are redistributed across each tier and can also be moved to higher or lower tiers.

Cloud configuration involves the following steps:

1. Assign the tier to storage pools.
2. Refine the customization by assigning tags to storage resource.
3. Define capacity pools.
4. Define service class.

Tiering

Storage tiering is a step toward defining service classes and provisioning volumes that require a certain tier level. It also allows you to optimize the placement of volumes by using Tivoli Storage Productivity Center optimization tasks, which redistribute volumes within the tier or move the volumes to higher or lower tiers.

Tivoli Storage Productivity Center uses 10 tiering levels of storage pools: tier 1 represents the best performing tier, and tier 10 the least performing tier. You can use as many levels as you want, based on the storage systems and disk technologies in your environment. In the storage pools tiering process, you might consider the technologies that are *not* present in your storage environment, but that might be added in the near future. In this way, you can leave space among tier levels for assignment later so that you do not need to reconfigure tiers and service classes when new technologies are added to your environment.

For example, you might categorize the following storage tiers:

- ▶ Tier 1. Leave this level available for future uses.
- ▶ Tier 2. Flash disk pools and solid-state drive (SSD) disk pools
- ▶ Tier 3. Leave this level available for future uses.
- ▶ Tier 4. Fibre Channel and SAS disk pools
- ▶ Tier 5. Leave this level available for future uses.
- ▶ Tier 6. Hybrid pool
- ▶ Tier 7. Leave this level available for future uses.
- ▶ Tier 8. NL-SAS disk pool
- ▶ Tier 9. Leave this level available for future uses.
- ▶ Tier 10. SATA disk pool

Figure 3-14 shows an example of storage tiering in Tivoli Storage Productivity Center where five tiers are defined.



Figure 3-14 Storage tiers

Service classes

A *service class* is a set of properties that describe capabilities and characteristics of storage resources. A service class typically describes a particular quality of service, and is used during provisioning to describe storage requirements. For example, a block-storage service class specifies properties such as a required RAID level, storage tier, volume mirroring, multipathing policy, and whether storage resources must be able to encrypt or thin provision volumes.

Service classes simplify provisioning requests by representing a level or type of storage quality. When you request storage, only the required capacity and service class must be specified. Before you can provision storage, you must create service classes that describe the capabilities and characteristics of the storage that you want to be able to provision. Service classes can later be modified or deleted as the needs of your installation change.

Tivoli Storage Productivity Center accounts for all attributes of the service class, specified in a provisioning request, and also current storage resource utilization (space, performance, and status) in order to identify the most appropriate resource for the new volume or share.

Service classes are a key point in mapping business requirements (capacity, accessibility, performance, and availability) in infrastructure capabilities (media type, disk technologies, RAID Levels, encryption, compression, and thin provisioning).

Two types of service classes are available:

- ▶ Block-storage service classes:

This type describes attributes and capabilities of block storage resources. When you provision volumes, you specify the requirements by using a block-storage service class. Based on the requirements of the service class, Tivoli Storage Productivity Center identifies a storage pool for the volume. Tivoli Storage Productivity Center provides three predefined block-storage service classes. Although the classes are predefined, you might want to change them or adjust the tiers, RAID levels, and so on:

- Gold: defined for mission-critical applications (highest-performing storage).
- Silver: defined for applications in production (high-performing storage).
- Bronze: defined for non-mission-critical applications (standard storage).

- ▶ File-storage service classes:

- NormalIsolation: (normal isolation file storage) The file system from which the NAS share is provisioned can contain other NAS shares. Shared storage is allowed.

- EnhancedIsolation: (enhanced isolation file storage) The file system from which the NAS share is provisioned cannot contain other NAS shares. Dedicated storage is required.

Figure 3-15 figure shows an example of defined service classes in Tivoli Storage Productivity Center.

Name	Type	Used Space (%)	Total Capacity (GiB)	Available Space (GiB)	Unavailable Space (GiB)	Capacity Pool	Description
Silver	Block	0%	442.00	442.00	0.00		High-performing storage for applications in pr
Gold	Block	0%	591.00	591.00	0.00		Highest-performing storage for mission-critica
Bronze	Block	0%	11,917.06	11,917.06	0.00		Standard storage for non-mission-critical appl
Normal Isolation	File	0.00	0.00	0.00	0.00		Normal isolated file storage.
EnhancedIsolation	File	0.00	0.00	0.00	0.00		Enhanced isolated file storage.

Figure 3-15 Predefined Services Classes in Tivoli Storage Productivity Center

Notes:

- ▶ For the gold configuration, the **Virtualization on/off** service class setting is important. If Virtualization is set to “on,” only IBM storage virtualizers are candidates for provisioning. If Virtualization is set to “off,” no IBM storage virtualizer is a candidate for provisioning.
- ▶ The Storwize systems have a **layer** setting that determines whether a Storwize system can virtualize external storage or replicate with another Storwize system. You can use the **chsystem** command with either the **-layer replication** or **-layer storage** option. Setting this option to **layer=storage** prevents the service classes from including pools as candidate pools.

To determine which storage systems (block and file) are supported for provisioning, see the following web page:

<http://www.ibm.com/support/docview.wss?uid=swg21386446>

Capacity pools

Capacity pools are logical groups of storage resources that include these items:

- ▶ Storage systems
- ▶ Storage pools
- ▶ File systems of file storage systems
- ▶ IBM SONAS Network Shared Disks (NSDs)

Capacity pools can group storage resources in any way that serves the needs of your environment or business. By configuring capacity pools, you can track the used and available space for block and file storage on any set of storage resources.

You can use capacity pools to define a set of storage resources from which provisioning requests must be satisfied. When you request storage by using the Provision Storage wizard or the vSphere Web Client extension, you can specify a capacity pool, and the provisioning request is restricted to the resources in this capacity pool.

You can also associate a service class with capacity pools. If a service class is associated with capacity pools, provisioning requests for the service class must be specified and be constrained to one of the associated capacity pools. Because you can also grant to non-administrative users permission to provision storage by using the service class, associating capacity pools with the service class restricts the users to a specific set of resources.

Optional: The use of capacity pools is optional.

Figure 3-16 shows an example of defined capacity pools in the Tivoli Storage Productivity Center web GUI.

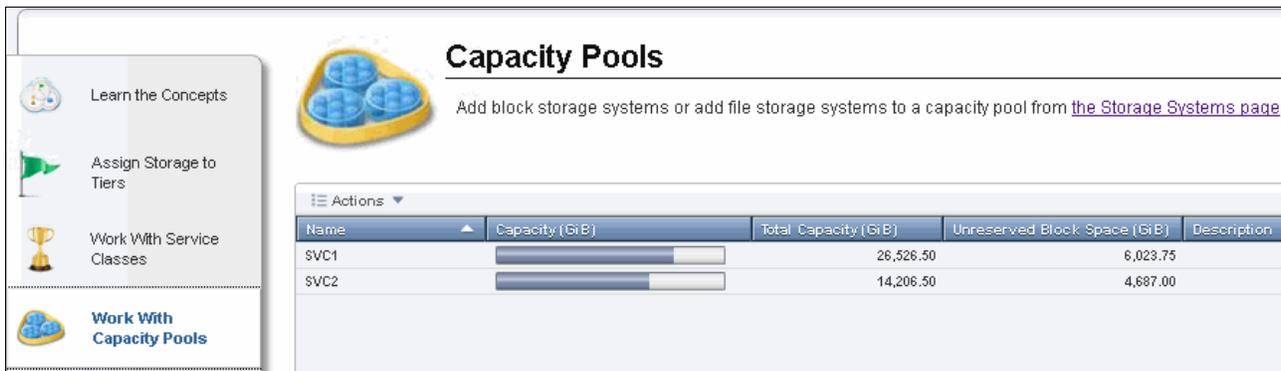


Figure 3-16 Capacity Pools

External clients integration with Tivoli Storage Productivity Center in Cloud configuration

Tivoli Storage Productivity Center Cloud configuration is based on the Storage Management API for Clouds (SMAC) API, which was introduced as a new API in Tivoli Storage Productivity Center V5.1. In Tivoli Storage Productivity Center V5.2 it was integrated in the web GUI.

The Storage Management API for Cloud (SMAC) API allows integration of external clients with Tivoli Storage Productivity Center. In this configuration the external clients can use Service Classes and Capacity Pools which are defined in the Tivoli Storage Productivity Center cloud configuration. Storage Management API for Cloud (SMAC) API is used by the following external clients:

- ▶ IBM Cloud Orchestrator
- ▶ IBM SmartCloud Storage Access
- ▶ Openstack Cinder driver
- ▶ Tivoli Storage Productivity Center vSphere plug-in

The external clients use provisioning capabilities with Storage Management API for Clouds (SMAC) API which includes Service Classes and optionally Capacity Pools to ease the provisioning of volumes.

The Storage Management API for Cloud (SMAC) REST API is used by the Tivoli Storage Productivity Center GUI and VMWare Tivoli Storage Productivity Center plugin. The VMWare Tivoli Storage Productivity Center plugin use Storage Management API for Clouds (SMAC) REST API for reporting capabilities.

Figure 3-17 shows how the external clients integrate with Tivoli Storage Productivity Center.

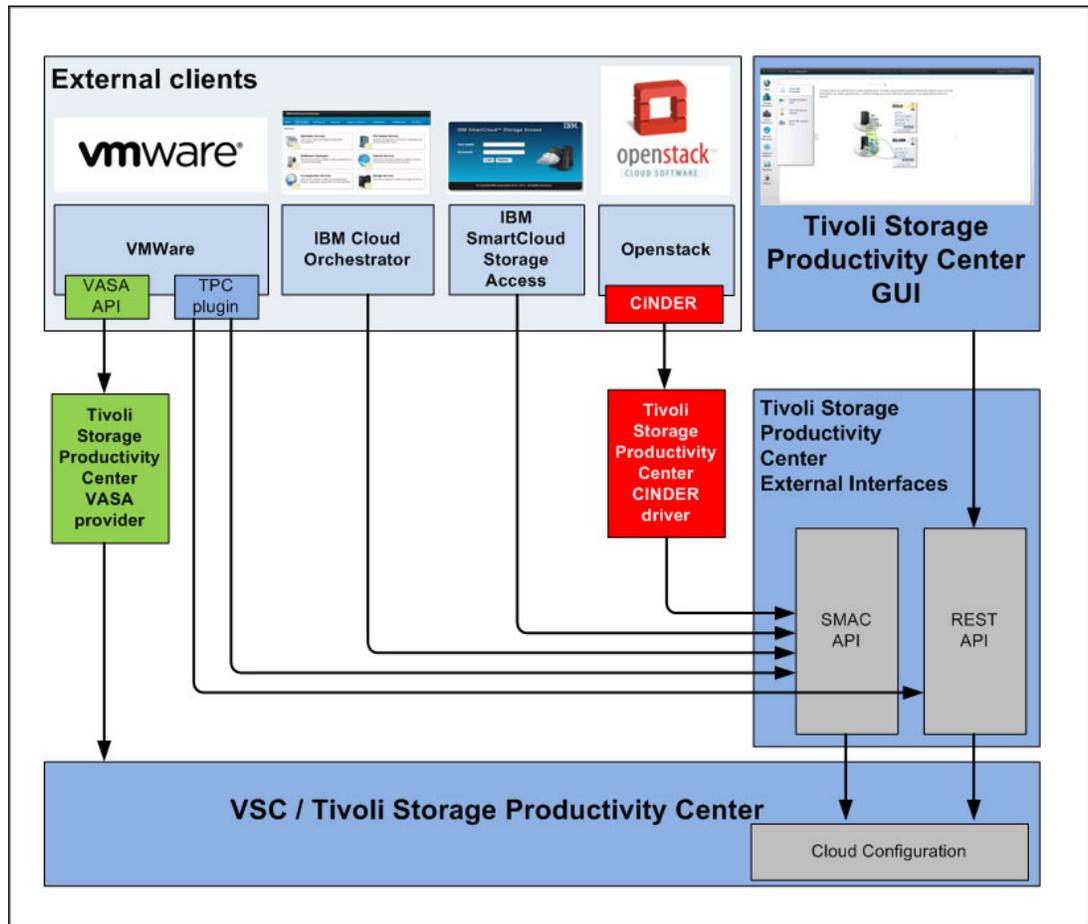


Figure 3-17 Tivoli Storage Productivity Center - Storage Management API for Clouds (SMAC)

3.3.2 Storage provisioning

With the Tivoli Storage Productivity Center Advanced Analytics function, you can provision storage resources to servers, hypervisors, or a cluster. You can provision storage resources such as storage volumes or NAS file shares to one or more servers, one or more hypervisors, or one cluster.

To provision the storage resources, you are required to specify only the storage capacity and storage quality that is represented by using the service class definition. Tivoli Storage Productivity Center identifies the storage resources that satisfy the requirements of the specified service class from a pool of available resources. By default, the pool of available resources includes all block storage or file storage resources that are known to Tivoli Storage Productivity Center. If you specify a capacity pool, new storage volumes and NAS file shares are provisioned only from storage resources in that capacity pool.

From the storage resources that can provide the required service class, Tivoli Storage Productivity Center identifies the best storage placement. The determination of the best storage placement is based on storage system free space. For provisioning storage volumes, performance data is also considered. Preference is first given to storage pools and systems that already contain volumes for the selected server, hypervisor, or cluster. Preference is then given to systems that have available performance data.

Figure 3-18 shows the provisioning wizard in Tivoli Storage Productivity Center GUI.

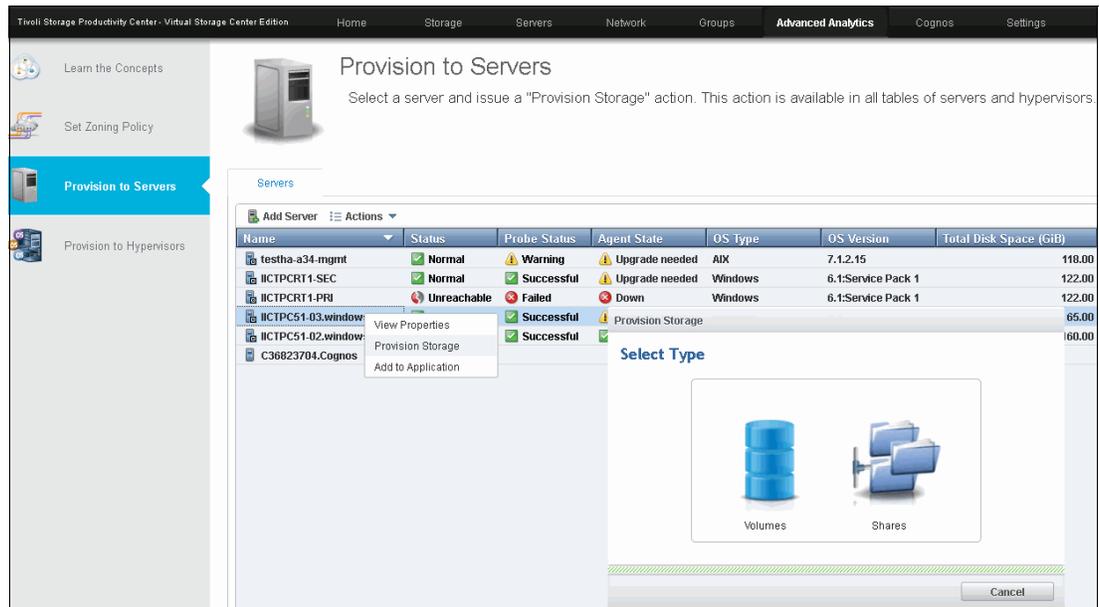


Figure 3-18 Tivoli Storage Productivity Center provisioning

Provisioning is described in more detail in Chapter 6, “Provisioning” on page 141.

3.3.3 Optimization

By using storage optimization function in Tivoli Storage Productivity Center you can optimize resources in your storage environment. The optimization function is used to help improve performance of your storage environment and to better utilize storage resources. The optimization function in Tivoli Storage Productivity Center has three main tasks:

- ▶ Balancing the workload of volumes across storage pools
- ▶ Re-tiering volumes
- ▶ Transforming volumes

Figure 3-19 on page 83 shows the optimization function in Tivoli Storage Productivity Center web GUI.

Note: Tivoli Storage Productivity Center uses the VDisk copy function to implement optimization recommendations. This means that the optimization tasks are supported with only IBM SAN Volume Controller, IBM Storwize V7000, and Storwize IBM V7000 Unified.

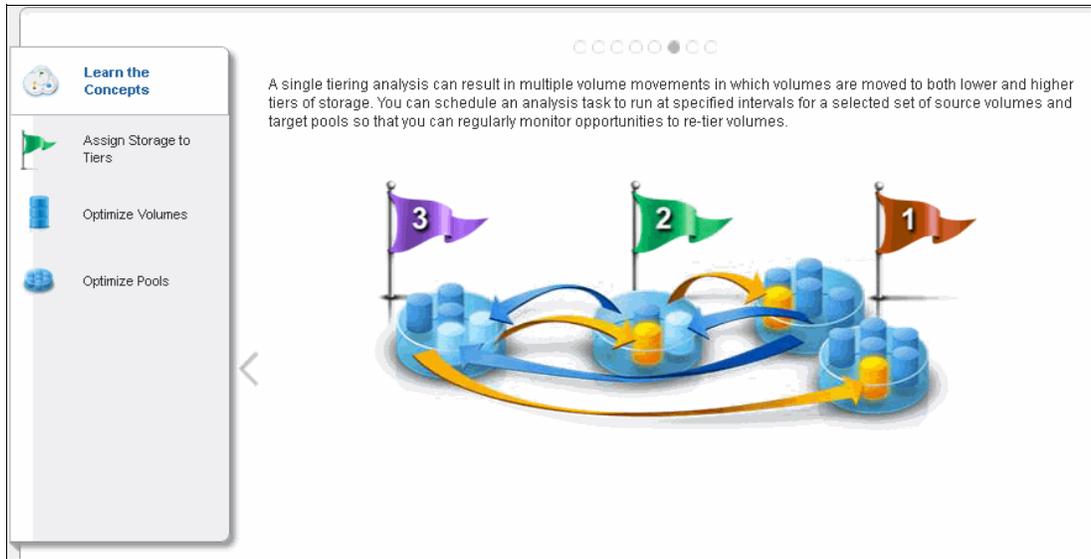


Figure 3-19 Optimization function

Balance pools

Balancing the workload of volumes across storage pools is done with balance pools function where the workload of volumes is balanced across pools on the same tier. Balance pools is used to analyze the pool performance and according to recommendations done on pool activity, volumes are moved from pools with high-activity values to pools with low-activity values in the same tier. Balance pools help you to achieve a more balanced workload across the pools within same tier.

Analyze tiering

The analyze tiering function in Tivoli Storage Productivity Center is for optimizing the placement of volumes on storage tiers. The purpose of analyzing tiering is to tier volumes based on the criteria that you set in tiering policies. For example, you can tier volumes based on the volume workload or on file usage, or both. Depending on the conditions that are set in the tiering policy, recommendations are generated that you can implement to ensure that the volumes are placed on the tiers that best match the workload requirements.

The analyze tiering function can help improve storage performance by moving volumes with heavy workloads to the tiers that meet the workload requirements of the volumes. It also can help you to reduce storage costs by moving volumes with low workloads from higher and more expensive tiers to lower and less expensive tiers.

Volume transformation

The volume transformation function in Tivoli Storage Productivity Center is used to convert volumes in storage pools to fully allocated volumes, compressed volumes, or thin-provisioned volumes. It can be also used to move volumes to other pools on the same storage system or to pools that are enabled for Easy Tier on the same storage system.

The following volume transformation options can be used:

- ▶ Migrate pool

Migrate pool option can move the selected volume on the recommended pool among those that you selected from the available pools.

- ▶ Compression

The compression option is used to convert your fully allocated volume to compressed, or to transform the compressed volume to a fully allocated volume.

- ▶ Thin provisioning

Thin provisioning enables the storage to present the required capacity to the host while allocating only the actual used capacity in terms of space on the physical storage media. By using the thin provisioning option, you can convert fully allocated volumes to thin-provisioned volumes or thin-provisioned volumes to fully allocated volumes.

- ▶ Easy Tier

Easy Tier is a performance function that automatically migrates or moves extents off a volume to, or from, one MDisk storage tier to, or from, another MDisk storage tier. Easy Tier monitors the host I/O activity and latency on the extents of all volumes with the Easy Tier function enabled in a multitier storage pool over a 24-hour period (heatmap creation). Next, it creates an extent migration plan based on this activity and then dynamically moves high activity or hot extents to a higher disk tier within the storage pool. It also moves extents whose activity has dropped or cooled from the high-tier MDisks back to a lower-tiered MDisk.

3.4 SAN and storage management

Tivoli Storage Productivity Center is designed to provide SAN and storage infrastructure management capabilities such as automated system discovery, provisioning, configuration, performance monitoring, and replication for storage systems. By using data collection capabilities within managed environment Tivoli Storage Productivity Center provides assets and status information, availability monitoring, usage and trending information and also server monitoring.

Tivoli Storage Productivity Center provides, in a simple way, device management for multiple storage arrays and storage area network (SAN) fabric components from a single integrated console. Both IBM and non IBM storage systems (EMC, NetApp, Hitachi, Oracle Solaris and HP) are supported through the Storage Networking Industry Association (SNIA) Storage Management Initiative Specification.

Figure 3-20 on page 85 and Figure 3-21 on page 85 show an example of SAN and storage management in Tivoli Storage Productivity Center web GUI.

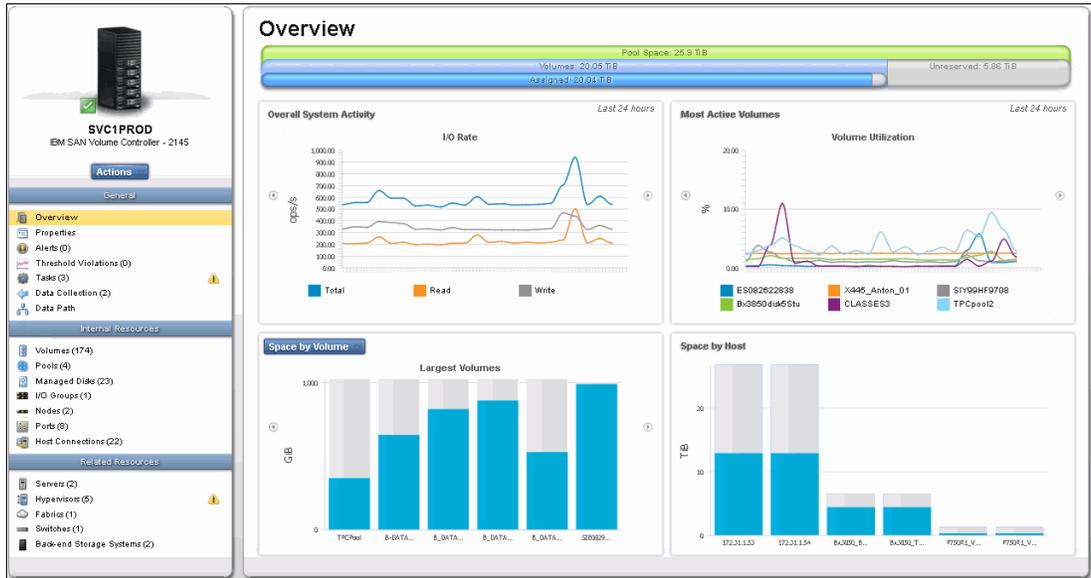


Figure 3-20 Storage management

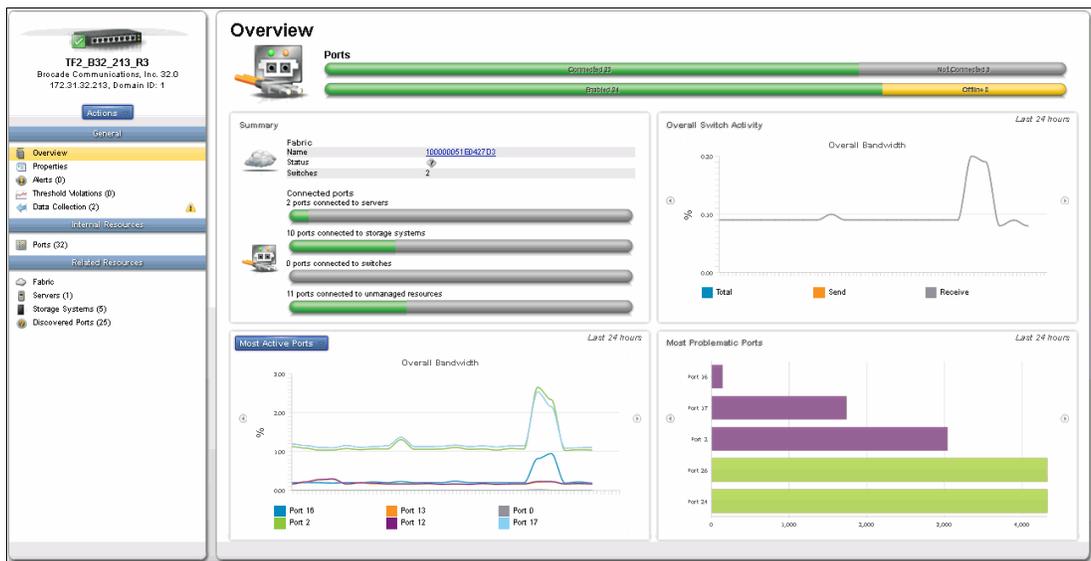


Figure 3-21 SAN management

3.5 Performance management

Tivoli Storage Productivity Center integrates built-in, context-sensitive performance management that is easily accessible from a single integrated console. Performance management is server-centric and storage performance problems can be more easily visualized from the user perspective. Performance graphs can be produced from several perspectives and they can be aligned to help you better understand performance problems.

Tivoli Storage Productivity Center helps monitor and manage performance and measure service levels by storing received performance statistics into database tables for future use. Policy-based automation enables event action based on different business policies. You can set Tivoli Storage Productivity Center performance thresholds for devices, based on selected performance metrics, generating alerts when those thresholds are exceeded. These capabilities can help you simplify the complex management of multiple SAN attached storage devices.

Tivoli Storage Productivity Center performance management has these capabilities:

- ▶ Proactive performance management from a single, integrated console for monitoring storage and SAN devices
- ▶ Monitoring of various metrics, such as I/O rates, throughput, cache utilization, back-end storage utilization and so on
- ▶ Measuring and tracking of service levels by storing historical performance statistics for analysis and report generation
- ▶ Generation of timely alerts that enable event action by setting performance thresholds based on different business policies

Figure 3-22 shows an example of storage system performance.



Figure 3-22 Storage system performance

3.6 Advanced monitoring and alerting

Tivoli Storage Productivity Center provides advanced monitoring and alerting for various conditions and violations of performance thresholds that you defined in your storage environment. Alerts are triggered by the thresholds or conditions that are detected during data collection and event processing.

The conditions that trigger alert notifications depend on the type of resource that you are monitoring. Some triggering conditions, like performance thresholds, require you to enter values for triggering alerts. In general, the following types of conditions can trigger alerts:

- ▶ A performance threshold was violated
- ▶ A data collection job did not complete
- ▶ A change occurred in the storage infrastructure
- ▶ A change occurred in storage replication

When an event occurs and triggers an alert, the alert is written to a log. You can also select one or more other ways to be notified of the event. These alert notifications include SNMP traps, IBM Tivoli Enterprise Console® events, login notifications, entries in Windows event log or UNIX syslog, and email.

Tivoli Storage Productivity Center shows you all defined alerts in the web GUI (Figure 3-23).

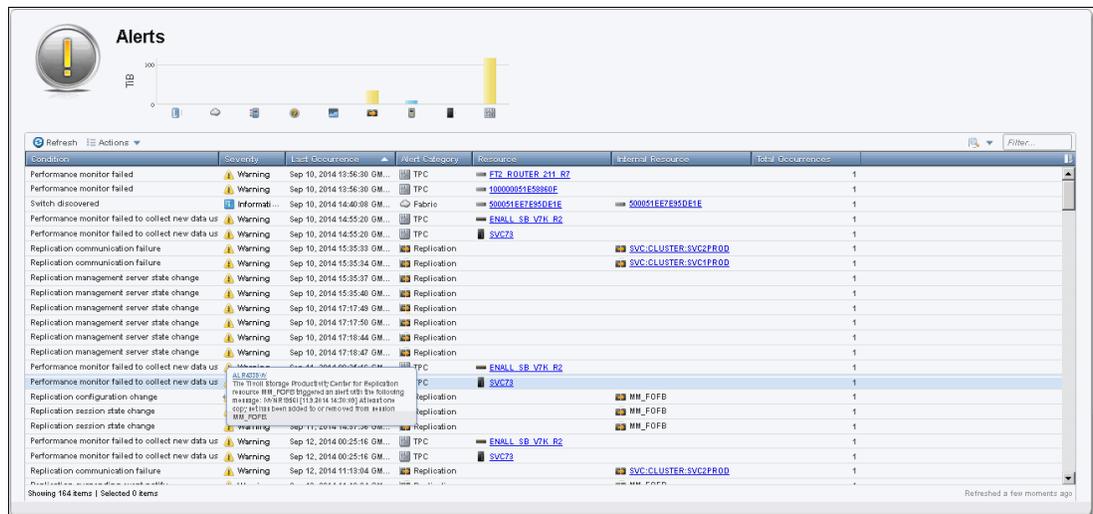


Figure 3-23 Alerts



Storage virtualization

This chapter provides information about the three options available for the storage virtualization component of the IBM SmartCloud Virtual Storage Center:

- ▶ IBM System Storage SAN Volume Controller
- ▶ IBM Storwize V5000
- ▶ IBM Storwize V7000

A comparison between those three options is made so that the people involved in an IBM SmartCloud Virtual Storage Center project can decide which one best fits their business needs, based on criteria such as:

- ▶ Performance
- ▶ Scalability
- ▶ Particular capabilities

4.1 External storage virtualization and software-defined storage

IT environments are evolving to a model where higher levels of efficiency, availability, and flexibility are mandatory characteristics of the infrastructure. New workloads and business needs make infrastructure virtualization a faster way to achieve those goals compared to using islands of resources.

Server virtualization has been adopted for a long time to help companies make better use of their assets. Capabilities like virtual machines being moved nondisruptively between physical servers, single point of control and management, resource pooling, agility when deploying new applications, and so on, make server virtualization the foundation for new service delivery models, such as cloud computing or software defined environments.

However, server virtualization is only part of the story. A need also exists to virtualize storage, so that the entire infrastructure can achieve the business goals. Additionally, storage virtualization is the bridge between the storage hardware (or data plane) and the other services management modules (or control plane) of the software-defined storage (SDS) framework (for more details about SDS, see 1.2.2, “Software-defined storage overview” on page 17).

In the following topics, the characteristics of storage virtualization using IBM SAN Volume Controller, Storwize V5000, and Storwize V7000 are discussed, with a focus on their integration with the other IBM SmartCloud Virtual Storage Center components.

4.1.1 Product overview and integration with IBM SmartCloud Virtual Storage Center

As a core part of the IBM SmartCloud Virtual Storage Center, the *virtualization component* plays several important roles:

- ▶ Provides flexibility for the storage infrastructure, allowing multi-vendors and pools that are in both faster more expensive storage and slower less expensive storage to be managed as one global resource.
- ▶ Enables a common set of advanced functions to be applied to the storage infrastructure, even if the individual hardware does not support advanced functions, such as Thin Provisioning, Easy Tier, Real-time Compression, among others.
- ▶ Integrates with the *management component* so the entire storage environment has a single point of control for monitoring, provisioning, and automation
- ▶ Provides a single platform for the *application-aware data protection component* to establish point-in-time copies that go beyond the scope of individual disk subsystems.
- ▶ Enables the *advanced analytics component* optimization recommendations to be executed, moving volumes between different pools and tiers nondisruptively to optimize the workload, consisting of heterogeneous vendors and technologies

The following products, with these external storage virtualization capabilities, are available with IBM SmartCloud Virtual Storage Center:

- ▶ IBM SAN Volume Controller
- ▶ IBM Storwize V5000
- ▶ IBM Storwize V7000

The products have a common Storwize software platform so, independently of the size of the environment, the user experience is mostly the same. For more details about the software within the Storwize family of products, see 4.3, “Storwize software stack” on page 93.

4.2 Benefits of storage virtualization

Virtualization is a foundational technology for both cloud and software-defined environments because of the larger number of benefits it brings to IT infrastructure. The following topics discuss the many ways storage virtualization helps organizations obtain the best benefits from their investment.

4.2.1 Operational efficiency

With the virtualization of the physical resources, the utilization of storage capacity grows from an average of 50% up to 90%¹. This can be achieved by enabling online data migration for load balancing and easily moving volumes to the most cost-effective tier. Storage virtualization also enables the provisioning of capacity to application servers from any of the storage pools, independently of where the physical capacity resides in the global repository.

Other technologies are also introduced by storage virtualization, which apply to all the back-end devices, even if they do not natively support those functions:

- ▶ Thin provisioning, for better physical capacity utilization
- ▶ Real-time Compression, to store more in the same space
- ▶ Automated tiering (Easy Tier), to optimize the investment in flash technology
- ▶ Single point of management using an award-winning, user-friendly interface
- ▶ Flexibility to add any supported back-end storage that better matches price/performance requirements

IBM SmartCloud Virtual Storage Center leverages those benefits and complements them with analytics capabilities, which help make better use of all the storage tiers, both homogeneous and heterogeneous (when Easy Tier is enabled). Alternatively, storage virtualization enables the IBM SmartCloud Virtual Storage Center analytics to execute the optimization recommendations transparently moving data between tiers or transforming volumes.

4.2.2 Improved return of investment

Storage virtualization with IBM SAN Volume Controller and the Storwize family has a comprehensive support matrix for back-end devices, allowing customers not only to build new environments with heterogeneous systems, but also to virtualize what they already have installed in their data centers. When reusing existing devices, unused space in the file systems can also be reclaimed.

¹ According to IBM storage infrastructure optimization assessments, 2011-2012:
http://www-03.ibm.com/employment/execjobs/files/GMU_External_Presentation.pdf

Support matrix information:

- ▶ The support matrixes for each version of the IBM SAN Volume Controller software are at the support portal web page:

<http://www.ibm.com/support/docview.wss?uid=ssg1S1003658>

- ▶ For the Storwize V7000, the support matrixes are at the following web page:

<http://www.ibm.com/support/docview.wss?uid=ssg1S1003741>

Software licensing can be reduced by using storage virtualization, since it concentrates all the functions in the same layer, and individual features in the storage devices do not need to be licensed anymore. These features include remote mirroring, point-in-time copy, thin provisioning, and other licenses charged on a one-time basis or on a monthly basis.

Multipathing drivers that are charged by some vendors can also be reduced or eliminated. IBM external storage virtualization solutions use drivers that are embedded in the operating systems almost all the time, and IBM provides a no-charge complement for some drivers.

4.2.3 Enhanced data availability

When virtualizing the storage environment, advanced copy services are centralized in the virtualization layer, making it possible to protect volumes in a heterogeneous infrastructure, with multiple vendors and technologies. Snapshots can be moved from one storage device to another, and remote replication can be done by using different vendors in each data center. Data can be protected more easily and its recovery is faster.

IBM SAN Volume Controller can also be implemented in a stretched cluster architecture, which isolates the hosts from individual disk subsystem or SAN failures. This solution distributes the hardware components between two data centers and delivers continued access to a logical volume which becomes available to hosts on both sites simultaneously.

Stretched cluster solutions: For more information, see these Redbooks publications:

- ▶ *IBM System Storage SAN Volume Controller and Storwize V7000 Replication Family Services*, SG24-7574
- ▶ *Implementing the IBM System Storage SAN Volume Controller V7.4*, SG24-7933
- ▶ *IBM SAN and SVC Stretched Cluster and VMware Solution Implementation*, SG24-8072
- ▶ *IBM SAN Volume Controller Stretched Cluster with PowerVM and PowerHA*, SG24-8142
- ▶ *IBM SAN Volume Controller Enhanced Stretched Cluster with VMware*, SG24-8211

With IBM SAN Volume Controller and Storwize family solutions, volumes can be migrated transparently from one storage pool to another, even if their data resides in different disk subsystems. This way, applications do not suffer down time when data migrations are done, for example, to isolate a device for maintenance, to replace an old subsystem by a new one, to aggregate flash technology to the infrastructure, or simply relocating data.

4.2.4 Transparent data mobility

Besides the great contribution to data availability as described in 4.2.3, “Enhanced data availability” on page 92, *transparent volume migration* also provides a way to avoid overtime of the storage management staff. As it occurs with server hypervisors which can move virtual machines between physical servers nondisruptively, volume migration can also be done within the production shift, or at least be initiated just before leaving, because it runs with no need of human intervention.

Another way to migrate data with no impact to availability is by using *volume mirroring*, which adds a second copy to a volume, synchronizes the volumes, and then the original copy can be removed when it is no longer needed. This function also enables the *volume transformation* function of the IBM SmartCloud Virtual Storage Center.

4.3 Storwize software stack

SAN Volume Controller and the Storwize family of products combine software and hardware into comprehensive, modular appliances that use symmetric virtualization in a cluster architecture. The Storwize software, which is a common platform to SAN Volume Controller and Storwize family members, performs the following functions for the host:

- ▶ Creates a single pool of storage, including capacity from external subsystems.
- ▶ Provides logical unit virtualization.
- ▶ Manages logical volumes with multipathing capabilities.
- ▶ Mirrors logical volumes.

Note: External virtualization is only supported by SAN Volume Controller, Storwize V7000 and Storwize V5000.

SAN Volume Controller and Storwize systems also provide the following functions:

- ▶ Large scalable cache management
- ▶ Transparent data migration
- ▶ Copy services, including point-in-time copy, synchronous and asynchronous remote copy, and volume mirroring
- ▶ Space management with Easy Tier, thin-provisioned logical volumes and real-time compression

All these functions are implemented in a common software stack, as shown in Figure 4-1 on page 94. This architecture applies to Storwize software version 7.3 and later.

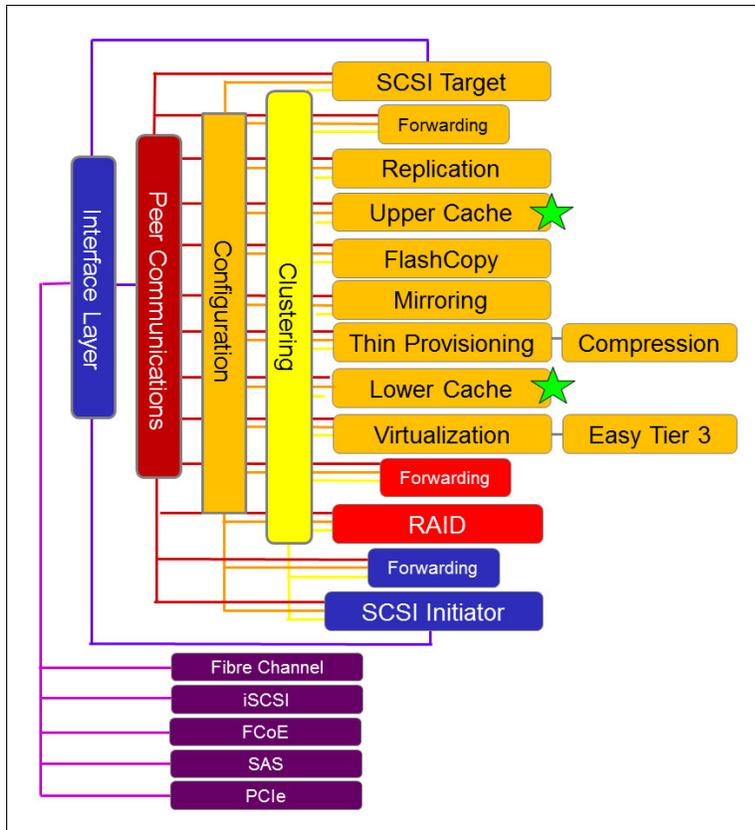


Figure 4-1 Storwize V7.3 software stack

The main difference compared to previous versions of the software, as highlighted in the diagram, is the cache re-architecture, where the *upper cache* and the *lower cache* now allow for these benefits:

- ▶ More independent implementation of new functions affecting the front or the back-end
- ▶ Higher scalability of the system in the future
- ▶ Improved performance of previous functions such as FlashCopy, Thin Provisioning, Real-time Compression, and Volume mirroring

4.4 SAN Volume Controller component overview

The SAN Volume Controller product provides block-level aggregation and volume management for attached disk storage. In simpler terms, the SAN Volume Controller manages several back-end storage controllers or locally attached disks, and maps the physical storage within those controllers or disk arrays into logical disk images, or volumes, that can be seen by application servers and workstations in the SAN.

The SAN is zoned so that the application servers cannot see the back-end physical storage, which prevents any possible conflict between the SAN Volume Controller and the application servers both trying to manage the back-end storage. In this section, we briefly explain basic architecture components of SAN Volume Controller.

Nodes

Each SAN Volume Controller hardware unit is called a *node* as it pertains to a cluster, or *system*. The node provides the necessary resources to the virtualization of a set of *volumes*, such as cache, processors, and I/O ports. It can optionally provide compression accelerator cards to help Real-time Compression processing. There is also an option to connect expansion drawers to the nodes to accommodate flash drives.

SAN Volume Controller nodes are deployed in pairs, or *I/O groups*, and multiple pairs make up a clustered system, also referred to as simply *system*. A system can consist of between one and four SAN Volume Controller node pairs.

One of the nodes within the system is known as the *configuration node*. The configuration node manages the configuration activities for the system. If this node fails, the system chooses a new node to become the configuration node. The configuration information is stored in the *quorum disks* to be safeguarded and accessible by all nodes in the system.

Because the nodes are installed in pairs, each node provides a failover function to its partner node in the event of a node failure. This failover also enables SAN Volume Controller for nondisruptive node replacement in case of severe hardware failure, or even for hardware upgrade to new node models replacing the old ones.

SAN Volume Controller allows temporary coexistence of different node models in the same pair in those situations, but the normal production environment must have two nodes of the same model within an I/O group. Different I/O groups in the same system can have distinct models of nodes.

I/O groups

Each pair of SAN Volume Controller nodes is also referred to as an *I/O group*. A SAN Volume Controller clustered *system* can have from one to four node pairs. A specific *volume* is always presented to a host server by a single I/O group of the system for *caching* purposes with all the required redundancy and protection. Other I/O groups of the system can be assigned to the same volume for *access* purposes to support nondisruptive volume migration between I/O groups.

When a host server performs I/O to one of its volumes, all the I/Os for a specific volume are directed to one specific I/O group in the system, or the *caching I/O group*. Also, under normal conditions, the I/Os for that specific volume are always processed by the same node within that I/O group. This node is referred to as the *preferred node* for this specific volume.

Both nodes of an I/O group act as the preferred node for their own specific subset of the total number of volumes that the I/O group presents to the host servers. A maximum of 2,048 volumes per caching I/O group is allowed. However, both nodes also act as failover nodes for their respective partner node within the I/O group. Therefore, a node takes over the I/O workload from its partner node, if required.

Thus, in an environment based on SAN Volume Controller environment, the I/O handling for a volume can switch between the two nodes of the I/O group. For this reason, servers that are connected through Fibre Channel *must* have paths through the SAN fabrics to both nodes, and use *multipath drivers* to be able to handle these failover situations.

If required, host servers can access volumes mapped from more than one I/O group within the SAN Volume Controller system; therefore, they can access volumes from separate I/O groups simultaneously. You can move volumes between I/O groups to redistribute the load between them; however, only selected Operating Systems support this nondisruptive move of volumes between I/O groups.

More information: For more information about the maximum supported objects by I/O group or system, and also about what operating systems support nondisruptive volume moves between I/O groups, see the SAN Volume Controller Support Portal web page:

<http://www.ibm.com/support/docview.wss?uid=ssg1S1003658>

There is a list of supported environments and also a list of the configuration limits for each version of the SAN Volume Controller software. Use the most appropriate version for the environment being considered.

System

The system or clustered system consists of one through four I/O groups. Certain configuration limitations are then set for the entire system or for individual I/O groups. For example, the maximum number of volumes supported for each system is 8,192 but there is a maximum of 2,048 volumes for each I/O group. For whichever maximum limitation is reached first for a specific system configuration, the lowest limitation must be followed.

All configuration, monitoring, and service tasks are performed at the system level, and configuration settings are replicated to all nodes in the system and saved to the *quorum disks* too. To facilitate these tasks, a unique management IP address is set for the system.

A process is provided to back up the system configuration data from the cluster so that it can be restored in the event of a disaster. This method *does not* back up application data; only SAN Volume Controller system configuration information is backed up. For the purposes of remote data mirroring, two or more systems must form a partnership prior to creating relationships between mirrored volumes.

MDisks

The IBM SAN Volume Controller system and its I/O groups view the storage that is presented to the SAN by the back-end controllers as several disks or LUNs, known as *managed disks (MDisks)*. Because the SAN Volume Controller does not attempt to provide recovery from physical disk failures within the back-end controllers, an MDisk is usually provisioned from a RAID array. The only extra protection SAN Volume Controller can have against physical disk subsystem failures is using *Volume Mirroring* (for more information about the Volumes component, see “Volumes” on page 97).

The application servers, however, do not see the MDisks. Instead, they see several logical disks, known as *virtual disks* or *volumes*, which are presented by the SAN Volume Controller I/O groups through the SAN (Fibre Channel or Fibre Channel over Ethernet) or LAN (iSCSI) to the servers. The MDisks of same characteristics are then grouped together to form *storage pools* where they are divided into several *extents*, which can be in the range of 16 - 8182 MB in size, as defined by the SAN Volume Controller administrator.

A *volume* is a host-accessible unit from storage that has been provisioned out of one storage pool, or if it is a mirrored volume, out of two different storage pools. A volume is composed by the extents it takes from the MDisks in the assigned storage pool or pools. The maximum size of an MDisk is 1 PB and an SAN Volume Controller system supports up to 4096 MDisks (including those from internal RAID arrays).

Quorum disk

A *quorum disk* is a managed disk (MDisk) that contains a reserved area of just above 256 MB for use exclusively by the system to store its configuration and cluster-related data, and also volume mirroring status information. The remaining area of the MDisks that are selected to

act as quorum disk candidates are still available to provide extents to accommodate volumes with user data.

The system uses quorum disks for tie-breaking when exactly half the nodes in the system remain active after a failure, or when a SAN failure occurs, preventing one node from communicating with the other in the same I/O group. This situation is referred to as “split brain.”

There are always three candidate quorum disks in a system. However, only one quorum disk is active at any time. To avoid the possibility of losing all the quorum disk candidates with a single failure, quorum disk candidates must be assigned on multiple storage systems, if possible.

For more information about the quorum disk configuration with SAN Volume Controller, see the following web page in the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/STPVGU_7.3.0/com.ibm.storage.svc.console.730.doc/svc_scsi-quorumdiskvr_1bchni.html

Storage pool

A *storage pool* is a collection of up to 128 *MDisks* that provides the pool of storage from which *volumes* are provisioned. A single system can manage up to 128 storage pools. The size of these pools can be changed (expanded or shrunk) nondisruptively by adding or removing *MDisks*, without taking the storage pool or the volumes offline. At any time, an *MDisk* can be a member in only one storage pool.

Each *MDisk* in the storage pool is divided into several *extents*. The size of the extent is selected by the administrator at the creation time of the storage pool and cannot be changed later. The size of the extent is in the range of 16 - 8192 MB.

A preferred practice is to use the same extent size for all storage pools in a system. This approach is a prerequisite for supporting volume migration between two storage pools. If the source and target storage pool extent sizes are not the same, volume mirroring can be used to migrate volumes between them.

Volumes

Volumes are logical disks that are presented to the host or application servers by the SAN Volume Controller. The hosts cannot see the *MDisks*; they can see only the logical volumes that are created from combining extents from a storage pool.

The three types of volumes are striped, sequential, and image. These types are determined by the way in which the extents are allocated from the storage pool, as explained here:

- ▶ A volume created in striped mode has extents allocated from each *MDisk* in the storage pool in a round-robin fashion.
- ▶ With a sequential mode volume, extents are allocated sequentially from an *MDisk*.
- ▶ Image mode is a one-to-one mapped extent mode volume.

Using striped mode is the best method to use for most cases because they use extents coming from all the *MDisks* presented by a system to the pool, achieving best overall performance for random workloads to various volumes residing in the same pool. However, sequential extent allocation mode can slightly increase the sequential performance for certain workloads with sequential access, by nature. Image mode volumes are normally used to import preexisting volumes into the virtualized environment, or to export back to native access from the storage.

4.5 Storwize family component overview

The IBM Storwize family of products, which has entry, mid-range, and enterprise members, is shown in Figure 4-2. Of those members, other than SAN Volume Controller, which is described in the previous sections, only V5000 and V7000 can participate in the IBM SmartCloud Virtual Storage Center (VSC) solution. A specific VSC offering is available to be used with Storwize V5000 and V7000; it is the IBM SmartCloud Virtual Storage Center for Storwize Family, which aims to have all the VSC functions, but at a lower cost for smaller environments.

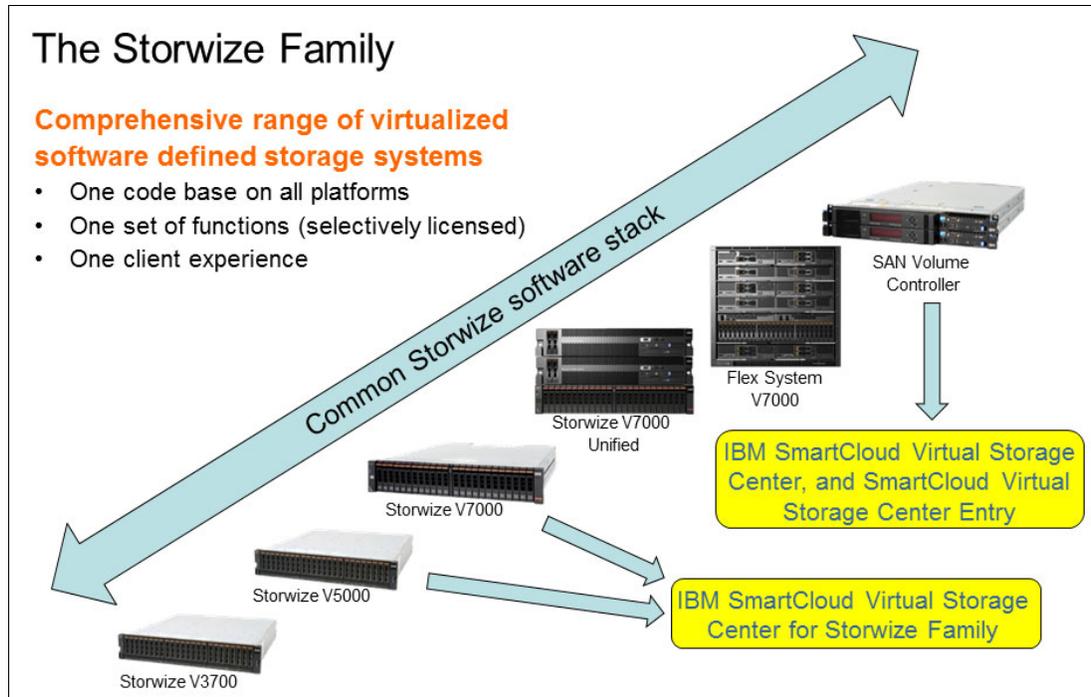


Figure 4-2 IBM Storwize products family and how they relate to VSC offerings

Both Storwize V5000 and V7000 also provide block-level aggregation and volume management for external attached disk storage systems additionally to their internal capacity. In this section we briefly explain basic architecture components of Storwize V5000 and V7000 and what is different from SAN Volume Controller. For the characteristics and functions not mentioned here, they are the same as with SAN Volume Controller.

Note: IBM Storwize V7000 Unified and Storwize V7000 for Flex System are out of the scope of this Redbooks publication.

Nodes

Each Storwize control enclosure *canister* is called a *node* as it pertains to a cluster or *system*. A control enclosure has two canisters that communicate with each other through the back plane. Nodes in one control enclosure communicate to nodes in another enclosure in the same system through the SAN. This way, the capacity in the expansion enclosures that are physically connected to one control enclosure through SAS cables becomes available to all nodes in that system.

External capacity virtualized by a Storwize V5000 or V7000 must be zoned and mapped to all the canisters in the system. This provides the necessary resources to the virtualization of a

set of *volumes*, such as cache, processors, and I/O ports. Storwize V7000 Gen2 canisters include one installed compression accelerator card to help Real-time Compression processing. A second compression accelerator card is optional.

The same way as SAN Volume Controller nodes are deployed in pairs, or *I/O groups*, with Storwize V5000 and V7000, a control enclosure also makes up an I/O group. Multiple control enclosures may form a Storwize clustered system, or just a *system*.

I/O groups

Each pair of Storwize V5000 or V7000 canisters within a control enclosure is also referred to as an *I/O group*. An I/O group cannot be composed of one node in a Storwize control enclosure and one node in another control enclosure. Storwize V7000 clusters also allow the coexistence of different control enclosure generations in the same system.

System

The system or clustered system consists of up to two I/O groups if the system is a Storwize V5000 or up to four I/O groups if the system is a Storwize V7000.

MDisks

A Storwize V5000 or V7000 system and their I/O groups view both the internal storage capacity and the capacity that is provided to the SAN by the back-end controllers that they virtualize. Independent of the source, the capacity is presented to the Storwize system as several disks or LUNs, known as *managed disks (MDisks)*.

Internal hard disk drives are combined into RAID arrays; each RAID array forms one MDisk. MDisks of the same characteristics, internal or external, are then grouped together to form *storage pools* where they are divided into several *extents*.

Quorum disk

A *quorum disk* in a Storwize V5000 or V7000 system is a *managed disk (MDisk)* with the same function as in SAN Volume Controller. The difference is that, with Storwize, there is a choice to use an internal or external MDisk as a quorum disk.

When using internal quorum disks, the availability of a cluster composed by more than one I/O group can be affected by a remote circumstance of a failure in the control enclosure that “owns” that MDisk. This failure will make the active quorum disk inaccessible by the other I/O groups to act as the tie-break. However, all the three quorum disks will still safely hold the cluster information to resume activity when the system comes up again.

A way to avoid this situation, although unlikely to occur as a result of the lack of a single point of failure in the Storwize family, is to select one MDisk that is provided by an external virtualized system as the active quorum disk to support tie-break situations.

For more information about the quorum disk configuration with Storwize V7000 V7.3, see the following web page in the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ST3FR7_7.3.0/com.ibm.storwize.v7000.730.doc/svc_scsi_quorumdiskovr_1bchni.html

Storage pool

A *storage pool* in Storwize V5000 and V7000 is also a collection of *MDisks*. Because internal and external MDisks might be available, be careful when combining both in the same storage pool, for example, when the external MDisks are provided from flash technology to compose an Easy Tier pool together with internal MDisks. In this case, the external system must be always available, not to affect the entire pool availability. This suggested practice is also valid for SAN Volume Controller.

Volumes

Volumes are logical disks that are presented to the host or application servers by the Storwize V5000 or V7000. They are created from combining *extents* from a *storage pool*. All the characteristics of the volumes in SAN Volume Controller also apply to Storwize, including their use with advanced copy services, mirroring, thin provisioning, Real-time Compression in the case of V7000, and so on.

4.6 When to choose SAN Volume Controller or Storwize family

When developing an IBM SmartCloud Virtual Storage Center project, there are three alternatives for the virtualization component of the solution as seen in the previous sections. Here, we describe the criteria to consider for selecting the appropriate scenario. This is not a 100% comprehensive list, but is a starting point of discussion between the client and the technical people responsible for the design and sizing of the solution.

Table 4-1 on page 101 compares Storwize V5000, Storwize V7000, and SAN Volume Controller features when they are part of the VSC offering.

Note: The features and characteristics in Table 4-1 are available when each product *is part of the respective VSC offering*. This might differ from the standard licensing of the individual products. For more information about the most current technical specifications of each product when acquired alone, see the following web pages:

- ▶ For IBM SAN Volume Controller:
<http://www.ibm.com/systems/storage/software/virtualization/svc>
- ▶ For IBM Storwize V7000:
<http://www.ibm.com/storage/storwizev7000>
- ▶ For IBM Storwize V5000:
<http://www.ibm.com/storage/storwizev5000>

Table 4-1 Comparison of Storwize V5000, Storwize V7000, and SAN Volume Controller with VSC

Feature	Storwize V5000	Storwize V7000	SAN Volume Controller
Management software	IBM Storwize Family Software for Storwize V5000	IBM Storwize Family Software for Storwize V7000	IBM Storwize Family Software for SAN Volume Controller
Internal capacity	Up to 480 drives per control enclosure (up to 19 expansions); 960 per clustered system (two-way clustering)	Up to 504 drives per control enclosure (up to 20 expansions); 1,056 per clustered system (four-way clustering)	Up to 48 flash drives per dual data engines (up to 2 expansions); 192 per clustered system (four-way clustering)
Port types	1 Gbps iSCSI, 6 Gbps SAS, 8 Gbps FC, 10 Gbps iSCSI/FCoE	1 Gbps iSCSI, 8 Gbps FC, 16 Gbps FC, 10 Gbps iSCSI/FCoE	1 Gbps iSCSI, 8 Gbps FC, 16 Gbps FC, 10 Gbps iSCSI/FCoE
Cache	16 GB per dual controller; up to 32 GB per clustered system (two-way clustered)	64 GB or 128 GB per dual controller; up to 512GB per clustered system (four-way)	64 GB or 128 GB per dual data engines; up to 512GB per clustered system (four-way)
SMP processors	One Intel Xeon E3-1265Lv2 2.5 GHz 4-core processor per control canister	One Intel Xeon E5-2628Lv2 1.9 GHz 8-core processor per control canister	One or two Intel Xeon E5-2650v2 2.6 GHz 8-core processors per data engine
Clustering	Yes (up to 2 control enclosures: 4 nodes)	Yes (up to 4 control enclosures: 8 nodes)	Yes (up to 4 data engine pairs: 8 nodes)
Compression	No	Yes, Real-time Compression optional	Yes, Real-time Compression optional
Unified support	No	NAS connectivity with Storwize V7000 Unified; IBM Active Cloud Engine® integrated	No
Stretched cluster support	No	No	Yes

Note: For more information about the software functions included in each IBM SmartCloud Virtual Storage Center offering, see 2.6, “IBM Virtual Storage Center offerings” on page 51.

When you chose a storage virtualization option, consider these aspects:

► Performance

Depending on the I/O workload to be processed, consider the equipment that has the necessary resources, such as cache memory, processors, ports, and the appropriate number of controllers or nodes to accommodate that workload. The use of a modeling tool based on the current or expected workload is highly suggested. This will indicate the minimum system configuration necessary to provide the desired average I/O response time, and with the hardware resources at acceptable levels of usage for both current and future needs.

► Scalability

The initial capacity is an important aspect in any storage project, but also important is to look at the growth needs for the next years. All three options have their own characteristics for internal scalability, but worth mentioning is that all of them have external virtualization capabilities, which expands the possibilities of capacity growth. The use of externally

virtualized controllers might affect the overall performance of the system, so they should be part of the entire sizing study.

► Particular capabilities

If a particular capability is needed in the project, Table 4-1 on page 101 can help you find the correct option. For example, if you are considering Real-time Compression, only Storwize V7000 and the SAN Volume Controller support it. If you require NAS connectivity, only Storwize V7000 supports Unified File Modules today. And if you are considering a high available architecture through a stretched cluster, you can have this only with SAN Volume Controller.

Other aspects can be considered also, such as licensing costs, space and power consumption, host platform and operating system compatibility, and so on. All of these aspects must also be considered for storage environments.



Application-aware data protection

In this chapter, we introduce the IBM Tivoli Storage FlashCopy Manager product. FlashCopy Manager is included as part of the license for Virtual Storage Center (VSC) and provides application-aware data protection through advance snapshot capabilities of storage subsystems. We provide a high-level overview of the supported FlashCopy Manager applications, including what application data they can protect.

We also provide a practical use case, which shows how the three products that make up Virtual Storage Center (SAN Volume Controller, Tivoli Storage Productivity Center, and FlashCopy Manager for VMware) work together to virtualize, control, and protect your storage environment.

Notes:

- ▶ This chapter assumes that you have FlashCopy Manager for VMware installed and configured, which is required for the use case described in 5.3, “Use case: FlashCopy Manager for VMware custom application support” on page 108. The other assumption is that you have experience with SAN Volume Controller and Tivoli Storage Productivity Center.
- ▶ FlashCopy Manager also integrates with Tivoli Storage Manager but requires additional licenses. Contact your IBM sales representative or IBM Business Partner for assistance or questions about Tivoli Storage Manager licensing.

5.1 FlashCopy Manager overview

IBM Tivoli Storage FlashCopy Manager uses advanced snapshot capabilities of disk subsystems to create application, database, and VM-aware point-in-time snapshots. These snapshots can be retained on disk only, or stored by using IBM Tivoli Storage Manager to take advantage of the full range of advanced data protection and data reduction capabilities. As the explosion of data continues to increase, and the backup windows decrease, an application-aware snapshot operation consumes much less time than conventional tape backup and can be offloaded to a backup server, as shown in Figure 5-1.

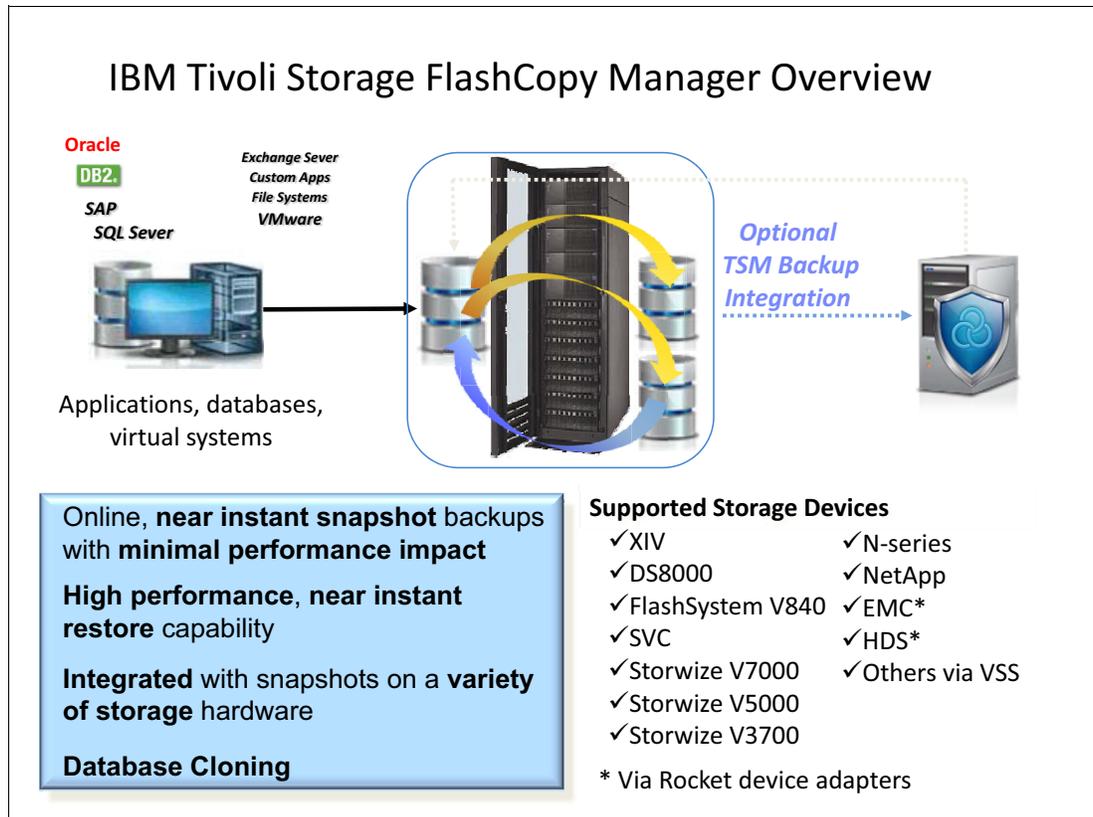


Figure 5-1 Tivoli FlashCopy Manager overview

5.2 Data protection and recovery capabilities

FlashCopy Manager can perform and manage frequent, near-instant, nondisruptive, application-aware snapshot backups and restores by using the underlying snapshot capabilities of disk subsystems from IBM and other vendor. Several capabilities are as follows:

- ▶ Generates application-aware online snapshots in seconds with virtually no backup related impact on the application server.
- ▶ Can quickly restore from snapshots.
- ▶ Manages multiple snapshots on disk.
- ▶ Can run stand-alone, or optionally off loaded to IBM Tivoli Storage Manager.
- ▶ Does not require a proxy server, with the exception of VMware.

- ▶ Offers Volume Shadow Copy Service (VSS) Instance restore for Microsoft Exchange and SQL Server.
- ▶ Customer application and file system support through use of pre- and post-snapshot scripts.
- ▶ Offers individual mailbox restore for Microsoft Exchange.
- ▶ Database cloning support.
- ▶ Hardware snapshot backups of VMware VMFS data stores.
- ▶ Supports block-level incremental forever backups with VMware Changed Block Tracking (CBT).

Note: This applies only when integrating with Tivoli Storage Manager. Exploitation of CBT is a function of Data Protection for VMware, not of FlashCopy Manager.

- ▶ Restores individual virtual machines from a hardware snapshot of a VMFS data store; no OS-specific agents are needed in guest.
- ▶ Mount of a backup to a guest for individual drive or files access.
- ▶ Restore of individual virtual disk.
- ▶ Snapshot with remote mirror support.

For a full list of FlashCopy Manager capabilities see the following web page:

<http://www.ibm.com/support/docview.wss?uid=swg21427692>

5.2.1 FlashCopy Manager: Supported platforms

Some of the supported platforms include Microsoft Exchange, Microsoft SQL Server, and Windows File Systems using the Microsoft VSS and hardware snapshot providers, DB2, SAP, Oracle, VMware, and UNIX File Systems.

Depending on the platform, FlashCopy Manager protects various applications, components, and constructs. FlashCopy Manager for Windows protects Microsoft SQL Server and Microsoft Exchange. FlashCopy Manager for UNIX protects DB2, Oracle, and SAP. FlashCopy Manager for VMware protects data stores and the virtual machines inside. Other applications and components are supported by using custom scripting.

For a complete and current list of supported platforms and versions see this web page:

<http://www.ibm.com/support/docview.wss?uid=swg21427692>

5.2.2 Components

FlashCopy Manager components can be divided into three distinct categories:

- ▶ FlashCopy Manager for Windows
- ▶ FlashCopy Manager for VMware
- ▶ FlashCopy Manager for UNIX and Linux

An overview of the FlashCopy Manager agents in each of these categories is discussed in the following sections.

5.2.3 FlashCopy Manager Windows overview

FlashCopy Manager for Windows provides the tools and information needed to create and manage volume-level snapshots of Microsoft SQL server data, Microsoft Exchange data, file systems and customer applications. These snapshots are created while the application remains online. FlashCopy Manager uses the Microsoft Volume Shadow Copy Services, VSS, to create online point-in-time copies of these applications and file systems and is able to restore those snapshots to a specific destination. FlashCopy Manager integrates with IBM hardware and any other hardware that provides a Microsoft VSS provider. Optionally FlashCopy Manager can be configured for Tivoli Storage Manager support to take advantage of the full range of advanced data protection and data reduction capabilities.

Protection for Microsoft Exchange

The FlashCopy Manager provides the following protection for Microsoft Exchange:

- ▶ Individual mailbox and mail item restore for Microsoft Exchange servers from a snapshot backup, including messages, calendars, contacts and other mail objects
- ▶ Support for Microsoft Exchange Database Availability Group
- ▶ Mailbox level restore on a remote system
- ▶ Restore mailboxes directly from the Exchange database files
- ▶ Restoring mailbox messages using the Mailbox Restore Browser
- ▶ Integration with Tivoli Storage Manager (requires additional licensing for IBM Tivoli Storage Manager for Mail)

Protection for Microsoft SQL Server

The FlashCopy Manager provides the following protection for Microsoft SQL Server:

- ▶ Full and application-aware VSS Microsoft SQL databases backups.
- ▶ Support for Microsoft SQL server cluster environments.
- ▶ Locally stored snapshots for instance restore.
- ▶ Integration with Tivoli Storage Manager (requires additional licensing for IBM Tivoli Storage Manager for Databases).

Protection for Windows file systems

The FlashCopy Manager provides the following protection for Windows file systems:

- ▶ Microsoft VSS snapshots for Windows NTFS and ReFS.
- ▶ Locally stored snapshots for instance restore.
- ▶ Integration with Tivoli Storage Manager (requires additional licensing).
- ▶ Pre-snapshot and post-snapshot scripts can be configured to quiesce any application to enable application aware backups.

5.2.4 FlashCopy Manager for VMware

FlashCopy Manager for VMware provides nondisruptive off-host backup, restore, and disaster recovery solutions for VMware environments. This snapshot approach facilitates faster backup operations at the virtual machine and data store level. You can restore from FlashCopy snapshot at the data store, virtual machine, volume, file system and file level.

Protection for data stores and virtual machines

FlashCopy Manager provides the following protection for VMware:

- ▶ Snapshot coverage for VMFS and NFS data stores (NFS data stores must be either IBM N-Series or NetApp).
- ▶ File level restore granularity from a data-store level snapshot.
- ▶ Ability to exclude virtual machines from data-store level backups.
- ▶ VMware Storage vMotion aware.
- ▶ Support for Virtual machine with virtual disks on multiple data stores
- ▶ VMware template support.
- ▶ Virtual machine backup mode includes VMware snapshot (includes memory), snapshot exclude memory, suspend virtual machine, and ASIS.
- ▶ Instant restore of multiple data stores.
- ▶ Coexistence with VMware vCenter Site Recovery Manager.
- ▶ Hardware replication between sites through Metro and Global Mirror and remote mirror snapshot.
- ▶ Integration with Tivoli Storage Manager (requires additional licensing IBM Tivoli Storage Manager for Virtual Environments).

5.2.5 FlashCopy Manager for UNIX and Linux

FlashCopy Manager for UNIX and Linux provides online backup and restore of data that is stored in SAP on IBM DB2 and Oracle databases by using the advanced snapshot technologies of storage subsystems. Also, in combination with IBM DB2 pureScale®, FlashCopy Manager can back up and restore data on IBM General Parallel File System (GPFS, also referred to as *elastic* storage) by using file system snapshots.

Protection for UNIX and Linux

FlashCopy Manager provides the following protection for UNIX and Linux platforms:

- ▶ DB2 and Oracle with or without SAP
- ▶ GPFS in combination with DB2 pureScale
- ▶ Database cloning for DB2 and Oracle
- ▶ File system and custom application support
- ▶ Remote mirror snapshot support.
- ▶ Integration with Tivoli Storage Manager (Requires additional licensing for IBM Tivoli Storage Manager for Databases)

5.2.6 IBM Tivoli Storage Manager integration

FlashCopy Manager can be integrated with Tivoli Storage Manager by using other Tivoli Storage Manager products. Depending on the application, Tivoli Storage FlashCopy Manager can transfer snapshots by using Tivoli Storage Manager for Mail, Tivoli Storage Manager for Databases, Tivoli Storage Manager Backup-Archive client, or Tivoli Storage Manager for Virtual Environments; additional licensing is required. These snapshots can be sent to Tivoli Storage Manager so you can take advantage of the full range of advanced data protection and data reduction capabilities.

5.3 Use case: FlashCopy Manager for VMware custom application support

This use case demonstrates how you can use FlashCopy Manager to provide application-aware data protection for a DB2 database that is running on a VMware virtual machine.

This use case shows you the process of creating a point-in-time or crash-consistent copy of a virtual machine that is running a DB2 database. For this case, we use the Tivoli Storage Productivity Center's database. To accomplish this, we use FlashCopy Manager for VMware integration with VMware by using pre-freeze and post-thaw scripts that we created.

Note: The Tivoli FlashCopy Manager DB2 scripts *pre-freeze* and *post-thaw* can be referenced in Appendix A, "Tivoli Storage FlashCopy Manager and DB2 scripts" on page 227.

Prerequisites

The following prerequisites are for this use case:

- ▶ FlashCopy Manager for VMware must be installed and configured for the storage system and the vCenter server where the virtual machine is running.
- ▶ VMware tools must be installed in the virtual machine that is running the application you want to protect.
- ▶ You must write custom pre-freeze and post-thaw scripts for the specific application you are backing up.

Scripts: An example of pre-freeze and post-thaw scripts is in Appendix A, "Tivoli Storage FlashCopy Manager and DB2 scripts" on page 227.

- ▶ For Windows 2008 virtual machines that were created using vCenter version before 4.1, you must enable the disk UUID attribute. More information is at the following web page:
http://pubs.vmware.com/vsphere-50/index.jsp?topic=%2Fcom.vmware.datarecovery.admin.doc_20%2FGUID-25A3EBF2-3158-4CB8-A088-133B8EB68120.html

Environment overview

For this example, we configured a small test environment of these components (Figure 5-2 on page 109):

- ▶ A Windows Server 2008 R2 with VMware vCenter 5.5
- ▶ Two virtual machines running ESXi 5.5
- ▶ A Red Hat Enterprise Linux 6.5 virtual machine with FlashCopy Manager for VMware installed and configured
- ▶ A Tivoli Storage Productivity Center server, version 5.2.3 virtual machine running on Windows 2008 R2
- ▶ A IBM SAN Volume Controller version 7.1.0.3 for the back-end volumes for the VMware data store. These volumes are connected to the ESX servers using iSCSI protocol.

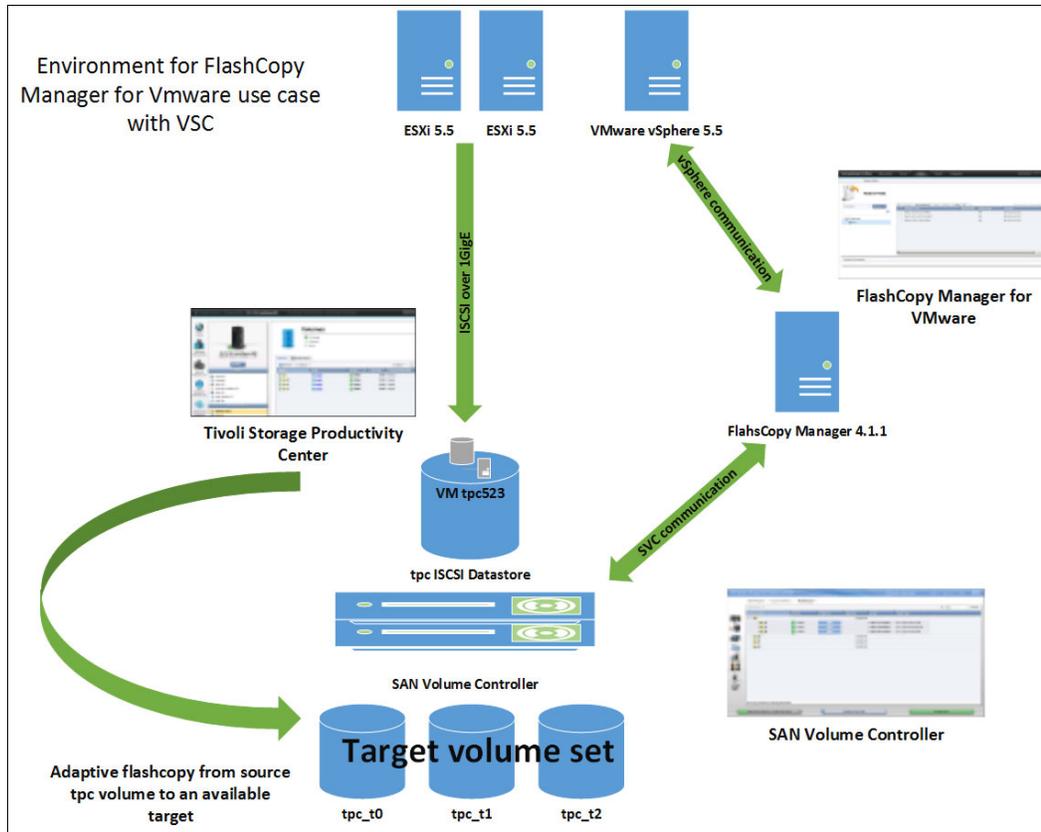


Figure 5-2 Small test environment for FlashCopy Manager for VMware with VSC

Steps for configuring custom application support

Complete the following steps for this use case:

1. Identify which data store the virtual machine that contains the application you want to backup is running on.
2. Identify which volume that data store represents on your storage subsystem or storage virtualizer.
3. Create the set of target volumes you plan to use as copies
4. Edit the profile file on the FlashCopy Manager for VMware server, set up or edit the Device_Class, and set up the Target_Set and either Volumes_File definition or Target_Name convention.
5. Create the application pre-freeze and post-thaw scripts and place them in the appropriate directory according to the Table 5-1 on page 110. An example of the scripts is in Appendix A, "Tivoli Storage FlashCopy Manager and DB2 scripts" on page 227.

Table 5-1 Directory location for freeze and thaw scripts.

Version of ESX	Custom script directory
ESX/ESXi 3.5 Update 1 or earlier	C:\Windows\pre-freeze-script.bat C:\Windows\post-thaw-script.bat
ESX/ESXi 3.5 Update 2 or later	C:\Program Files\VMware\VMware Tools\backupScripts.d\
ESX/ESXi 4.x or later	C:\Windows\backupScripts.d\
ESXi 5.0	C:\Windows\ C:\Program Files\VMware\VMware Tools\backupScripts.d\
ESXi 5.1 and ESXi 5.5	C:\Windows\pre-freeze-script.bat C:\Windows\post-thaw-script.bat

Table 5-1 is from the following VMware Knowledge Base web page, which has more information about pre-freeze and post-thaw script location:

http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1006671

Example steps for this use case

First, we identify the data store on which our target virtual machine is running. To do this, we log in to the vCenter web, click the virtual machine, click the **Summary** tab (Figure 5-3), and look at the Storage field in the Related Objects pane.

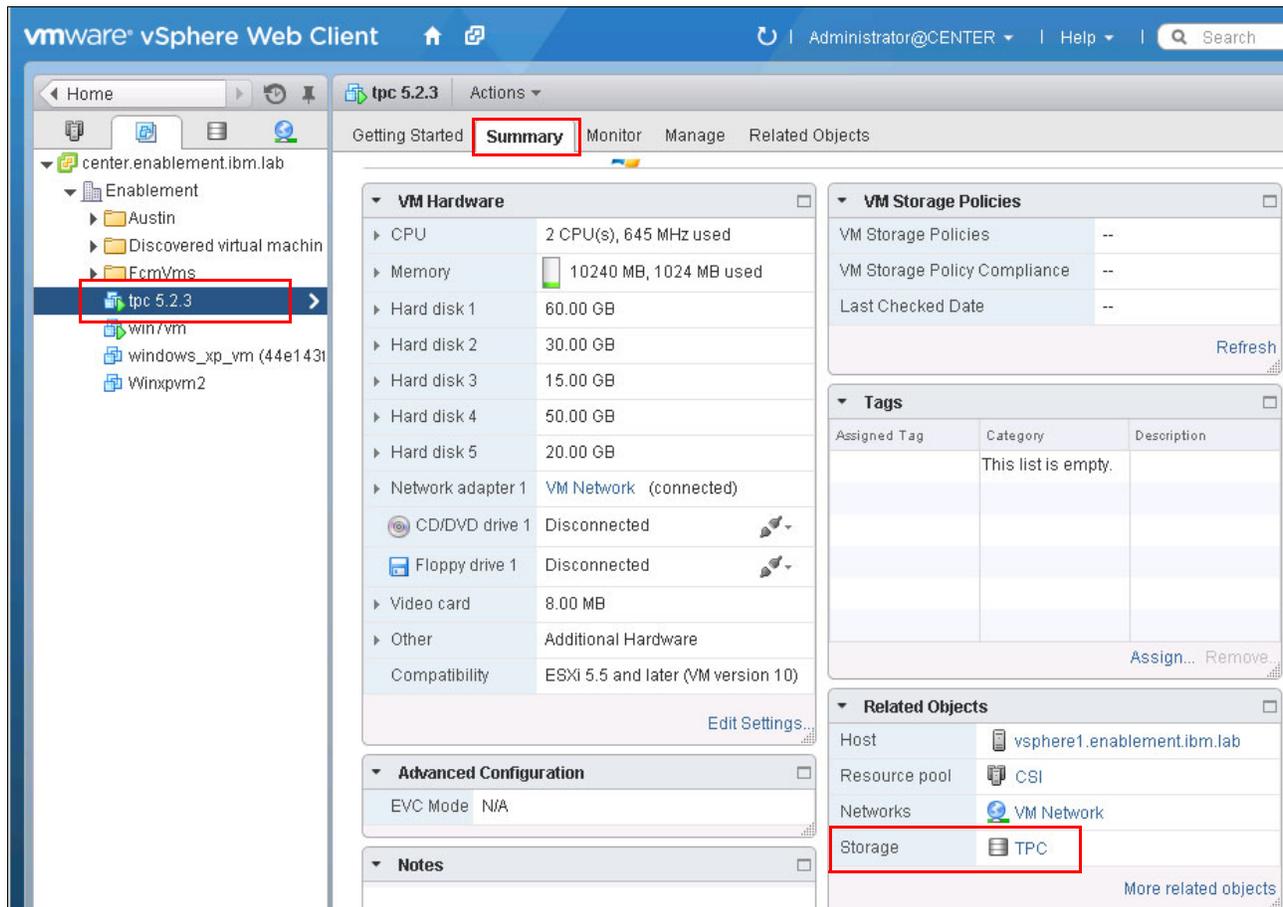


Figure 5-3 Identifying the data store the virtual machine is running on.

The next task is to find the mapping between the data store and the volume on the storage virtualizer. In this example, TPC (Figure 5-5 on page 112) is the name of the data store, and tpc (Figure 5-4) is the name of the volume.

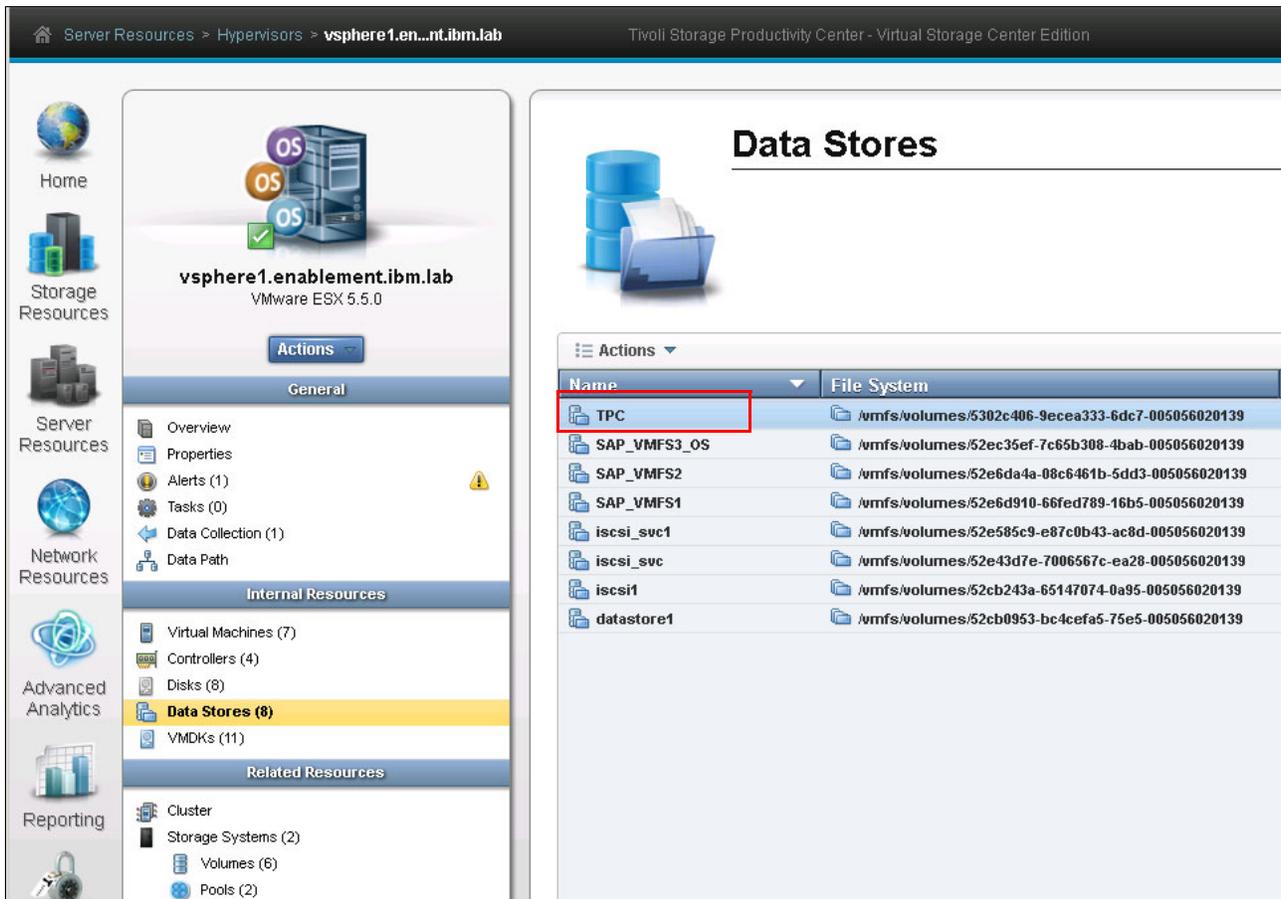


Figure 5-4 Tivoli Storage Productivity Center shows “TPC” data stores and the VMware esxi server mapping.

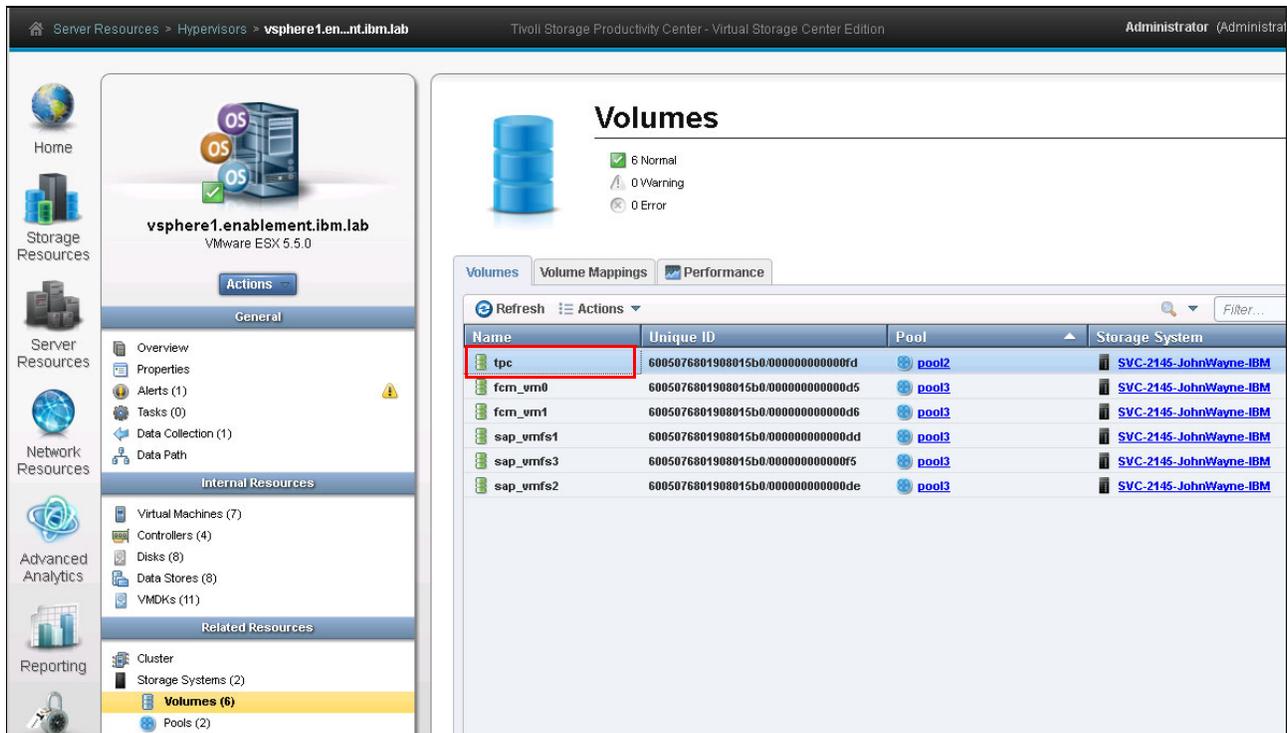


Figure 5-5 Using Tivoli Storage Productivity Center, you see the “tpc” volume and the VMware esxi server mapping.

Now that we understand the volume-to-data-store mapping, we can create the target volume set on the SAN Volume Controller. The target volumes must be at least the same size as the source volume, in this example the size of the tpc volume is 120 GB. Using this naming convention helps to more easily identify source-to-target-volumes mapping. The target volume naming convention used here is tpc_t0, tpc_t1, and tpc_t2 (Figure 5-6).

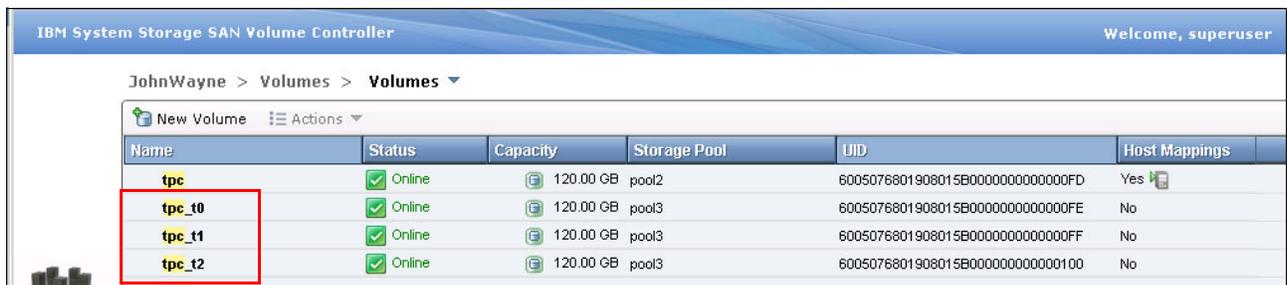


Figure 5-6 Target volume naming

After the volumes are defined, we use them as the target volumes on the SAN Volume Controller. We must edit the configuration file on the FlashCopy Manager server, validate the VMWARE section, and define the DEVICE_CLASS section to be used for this FlashCopy set.

In the VMWARE section, the following parameters must be validated:

- ▶ VCENTER_SERVER
- ▶ AUXILARY_ESX_HOST
- ▶ VCENTER_SERVER_USER
- ▶ HOST_NAME_MAPPING.

In the `DEVICE_CLASS` section, the following items must be defined:

- ▶ A `DEVICE_CLASS` for the storage subsystem you use. In this example, we are using a SAN Volume Controller, we need to define the following parameters, `DEVICE_CLASS`.
- ▶ `COPYSERVICES_HARDWARE_TYPE`
- ▶ `COPYSERVICES_PRIMARY_SERVERNAME`
- ▶ `COPYSERVICES_USERNAME`
- ▶ `COPYSERVICES_REMOTE`
- ▶ `TARGET_SETS`
- ▶ `TARGET_NAMING`, or `VOLUME_FILE`, in our example we are using `TARGET_NAMING`.

The default location for the profile file is `/home/tdpvmware/tdpvmware/config`.

Several ways exist to set these parameters. You can use a file edit tool like `vi` and edit the file directly. If you choose this method you must restart the `acs` servers manually. You can also use the `setup.sh` file, which is in the `/opt/tivoli/tsm/tdpvmware/fcm` directory. This method restarts the `acs` servers for you. The easiest method, new in version Tivoli FlashCopy Manager version 4.1.1, is to use the configuration wizard in the web interface. Choose the method that you feel most comfortable using. The text in the boxes must be verified or, for the `DEVICE_CLASS`, be created. See Figure 5-7.

```
>>> VMWARE
VCENTER_SERVER center.enablement.ibm.lab
AUXILIARY_ESX_HOST vsphere2.enablement.ibm.lab
# VCENTER_SERVER_VM_NAME
VCENTER_SERVER_USER Administrator
# FCM_VM_NAME
# VM_BACKUP_MODE SNAPSHOT_EXCL_MEM
# NUMBER_CONCURRENT_VM_TASKS 1
# MAX_VERSIONS ADAPTIVE
HOST_NAME_MAPPING vsphere1.enablement.ibm.lab:vsphere1
HOST_NAME_MAPPING vsphere2.enablement.ibm.lab:vsphere2
# TIMEOUT_PARTITION 3600
# TIMEOUT_PREPARE 3600
# TIMEOUT_FLASH 300
# TIMEOUT_VERIFY 3600
# TIMEOUT_CLOSE 3600
# TIMEOUT_FLASHRESTORE 3600
# TIMEOUT_COMPLETERESTORE 3600
<<<

>>> DEVICE_CLASS SVC
COPYSERVICES_HARDWARE_TYPE SVC
COPYSERVICES_PRIMARY_SERVERNAME 192.168.63.10
COPYSERVICES_USERNAME superuser
# SVC_COPY_RATE 50
# SVC_CLEAN_RATE 50
# SVC_GRAIN_SIZE 256
COPYSERVICES_REMOTE NO
# COPYSERVICES_COMMPROTOCOL HTTPS
# COPYSERVICES_CERTIFICATEFILE NO_CERTIFICATE
# COPYSERVICES_SERVERPORT 5989
# FLASHCOPY_TYPE COPY
# COPYSERVICES_TIMEOUT 6
# RECON_INTERVAL 12
TARGET_SETS 0 1 2
TARGET_NAMING %SOURCE_t%TARGETSET
<<<
```

Figure 5-7 Example of the profile configuration file on the FlashCopy Manager server

For more information about the configuration file, see the following web page:

http://www.ibm.com/support/knowledgecenter/SS36V9_4.1.1/com.ibm.itm.fcm.vm.doc/r_fm_profileparameters_ovr.html?lang=en

The last step to do before we can run a backup is to create our customer application scripts. These scripts are in the virtual machine where our customer application is running. In our case, we create a point-in-time or crash-consistent copy of the DB2 database that is used for Tivoli Storage Productivity Center. The name of the virtual machine is tpc523.

In our example, we use the process described in the VMware Knowledge Base:

http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1006671

For a detailed review of the scripts in this use case, see Appendix A, “Tivoli Storage FlashCopy Manager and DB2 scripts” on page 227.

After our scripts are defined and placed in the correct directories, as shown in Table 5-1 on page 110, we can create a copy of the data store where the virtual machine is located on the virtual machine running DB2. To accomplish this, we log in to the FlashCopy Manager for VMware web UI. We define a backup task for the specific virtual machine that we want to back up, then review the logs to verify that our pre-freeze and post-thaw scripts run.

First, log in to IBM Tivoli Storage FlashCopy Manager for VMware web interface, as shown in Figure 5-8.



Figure 5-8 FlashCopy Manager for VMware login page

Next, define a backup task. Do this from the Getting Started window (Figure 5-9).

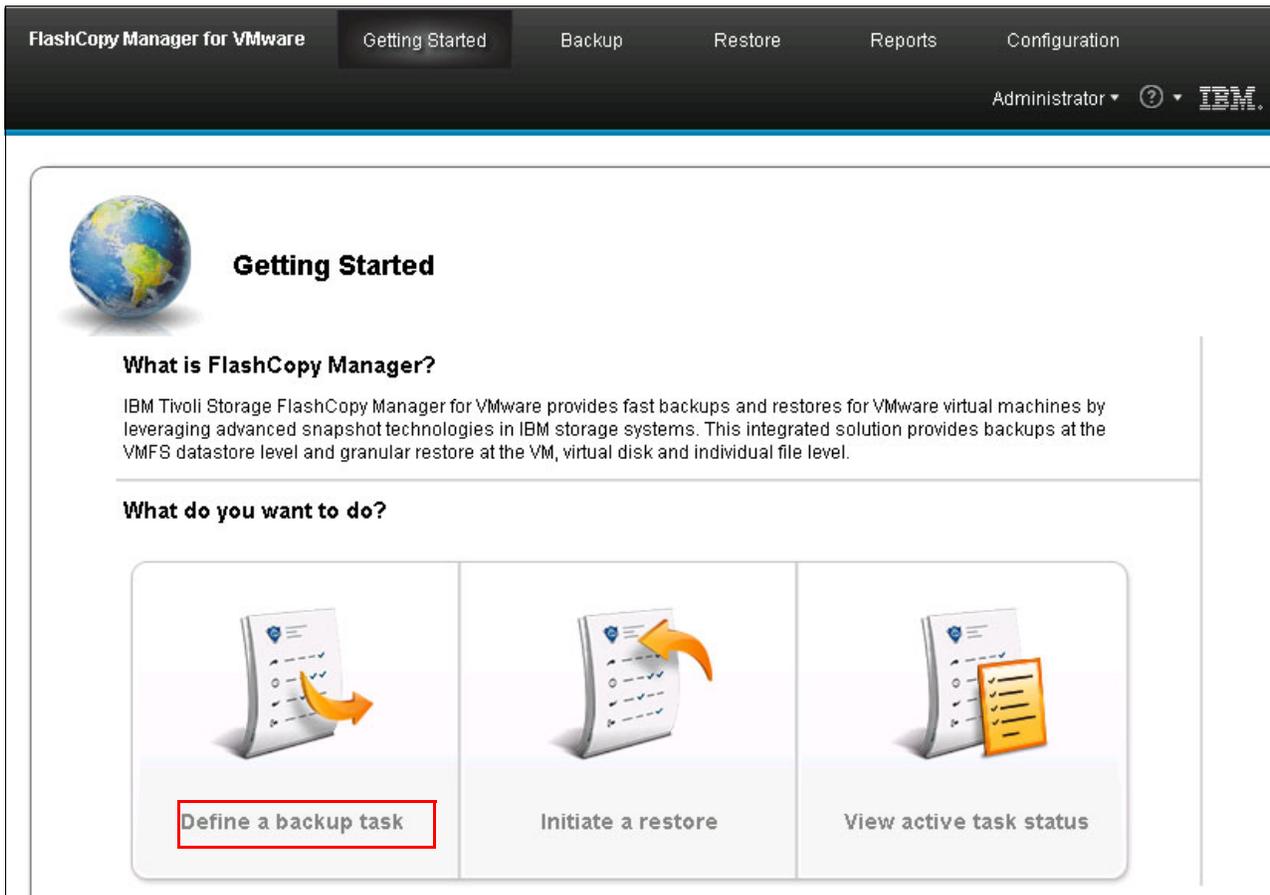


Figure 5-9 FlashCopy Manager for VMware Getting Started

Click the **Define a backup task**.

The Create Schedule wizard starts (Figure 5-10) Click **Next**.

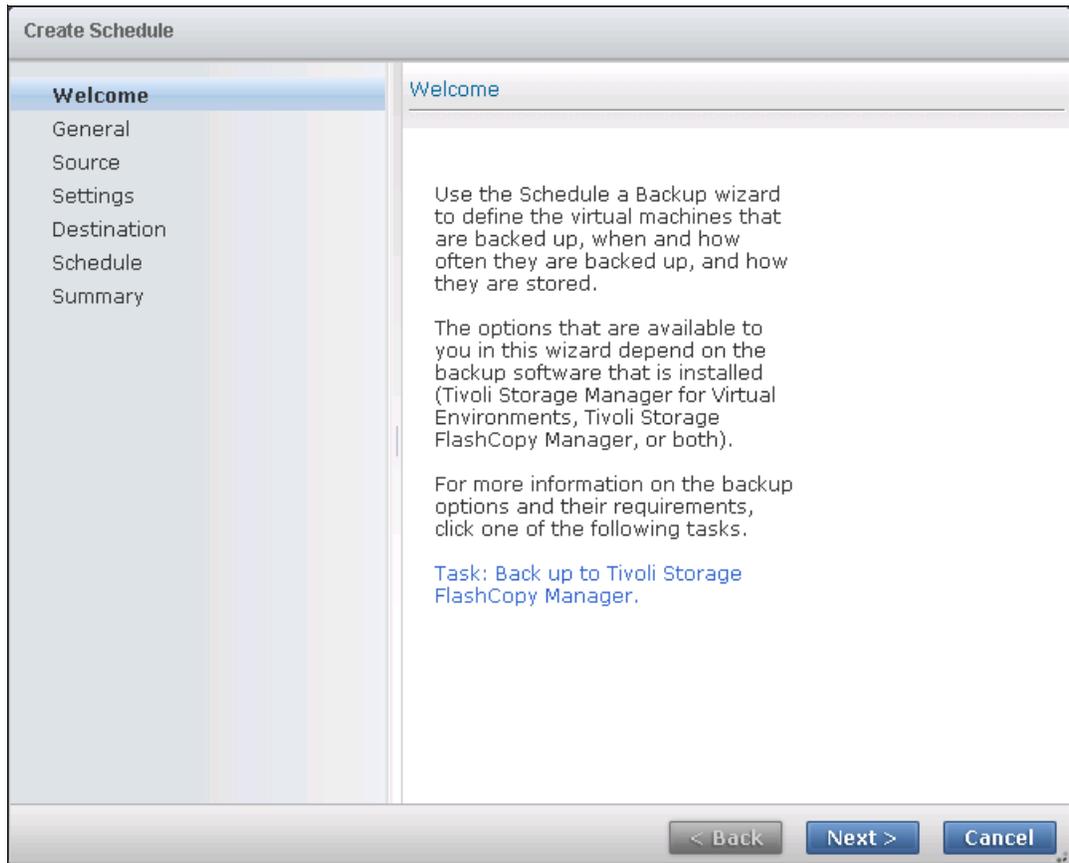


Figure 5-10 The Welcome page in the Create Schedule wizard

The General page opens (Figure 5-11). Provide a name and optional description to the backup schedule. In this case, the name is DB2. Click **Next**.

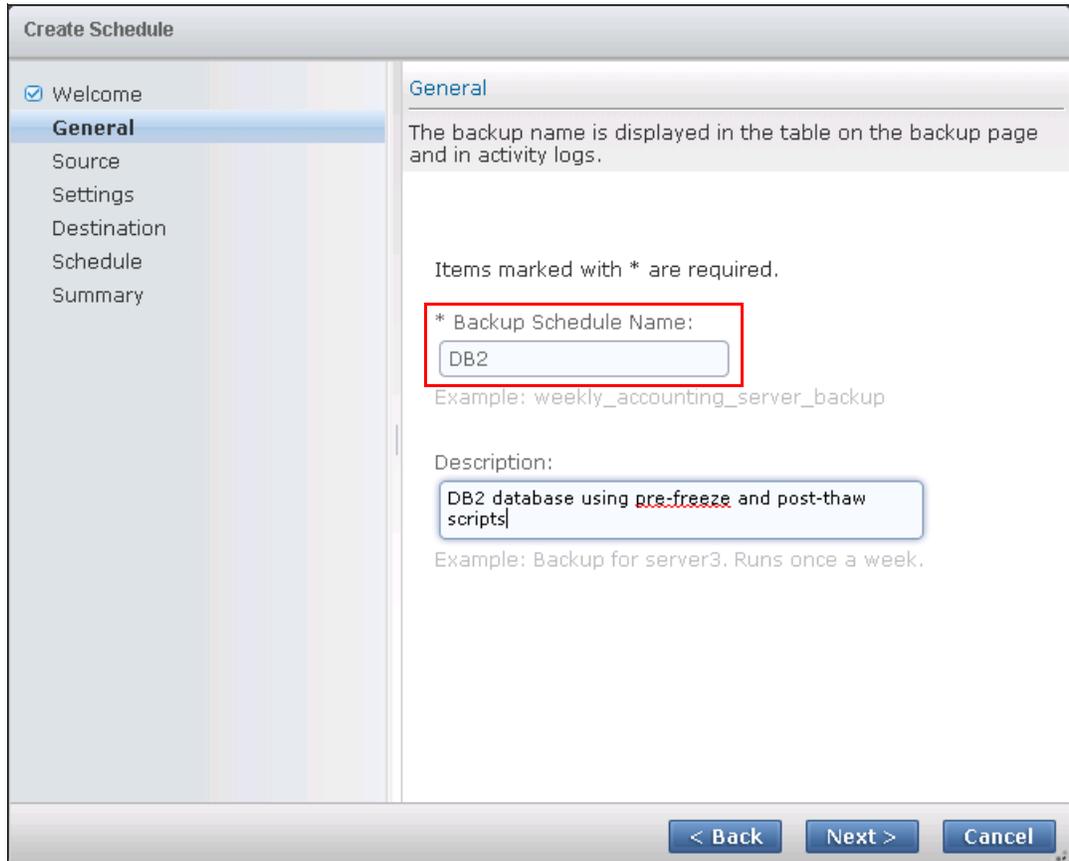


Figure 5-11 The General page in the Create Schedule wizard

The Source panel opens (Figure 5-12). Select the data store and the virtual machines to back up. In this case, we select the **TPC** data store and the **tpc523** virtual machine.

In most cases, many virtual machines will be on a data store. Although you can choose which ones you want to back up, they are all available on the target volume. The virtual machines that are not selected for backup are not available in the Restore panel but the files that make up those virtual machine are on the target volume. The reason for this is that FlashCopy Manager provides protection at the volume level.

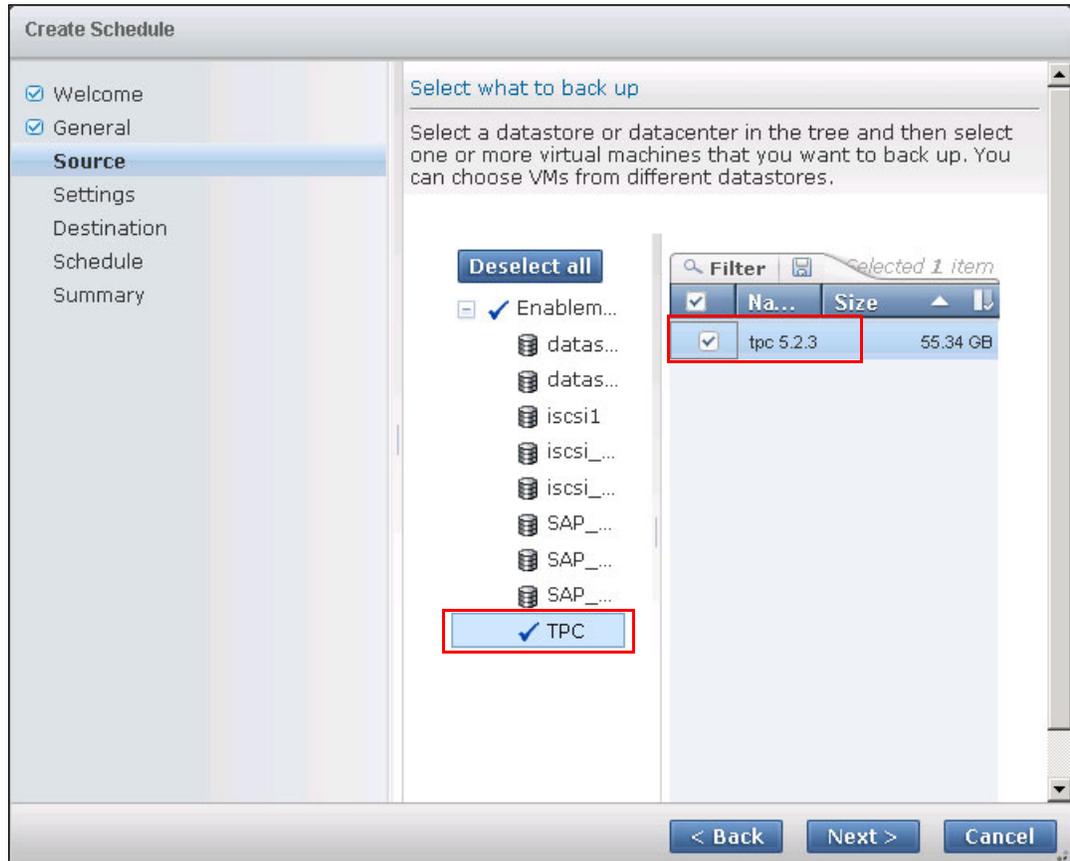


Figure 5-12 The Source panel is where you select what is going to be backed up

After selecting a source data store and virtual machine, determine the method that you want VMware to use to create the virtual machine snapshot. Click **Next**.

The backup settings are listed (Figure 5-13). This is a VMware snapshot and is created before the hardware snapshot. In this example, we choose to create the VMware snapshot without memory.

Tip: For more information about these settings, click the **Learn more about these backup settings** link in the Backup setting panel.

Click **Next**.

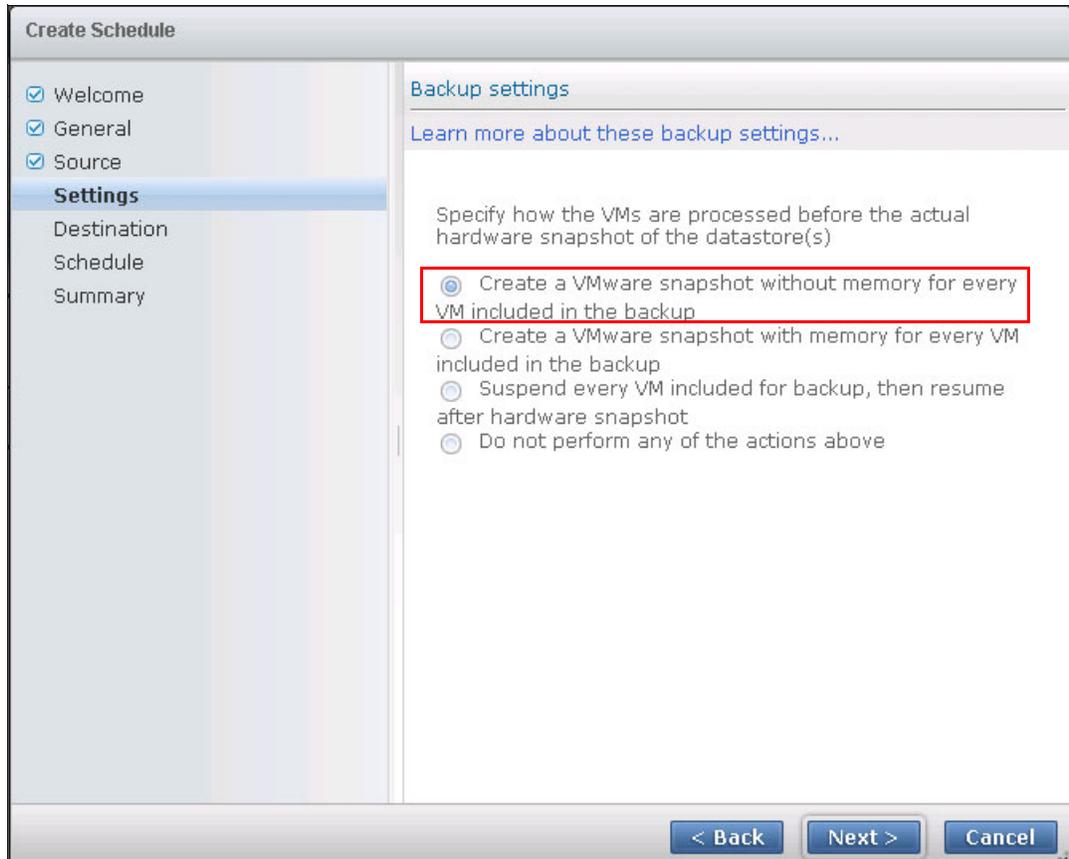


Figure 5-13 VMware snapshot options.

The Destination settings panel opens (Figure 5-14). In our example, we select **SVC** (to use SAN Volume Controller) for our destination device class.

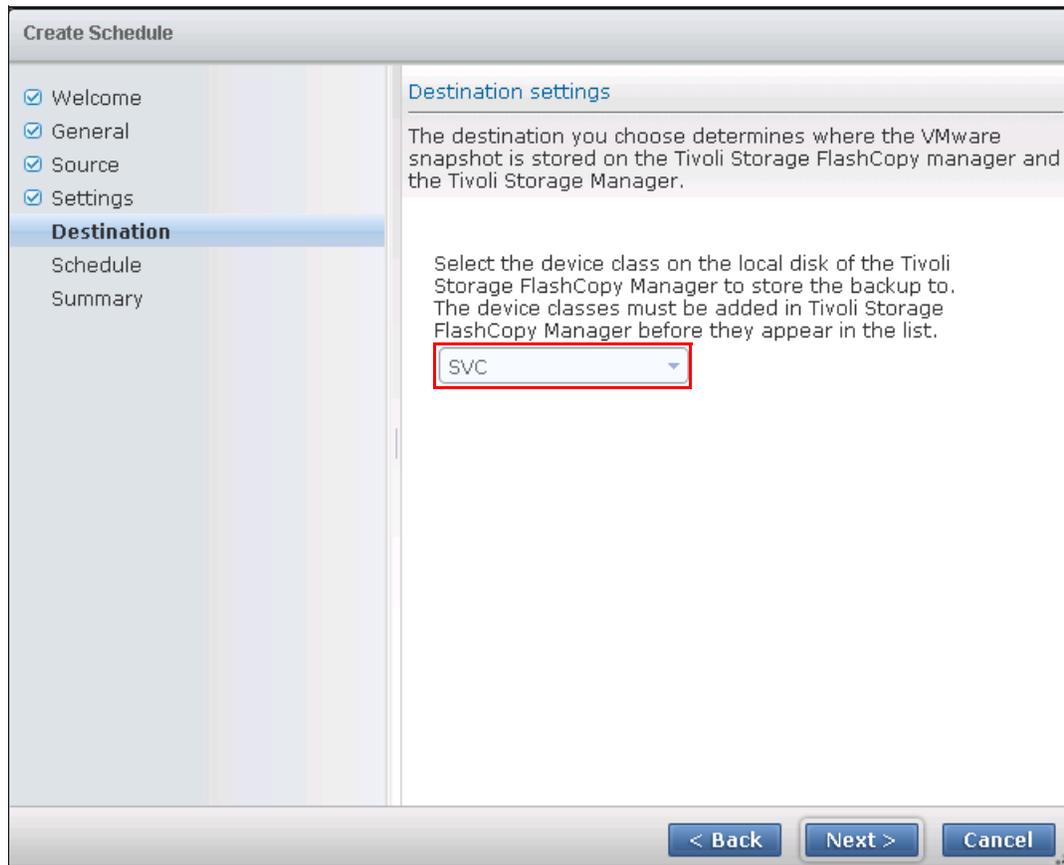


Figure 5-14 Selecting the device class you setup for your target volumes

The backup settings are now defined. Click **Next**.

The Schedule settings panel opens (Figure 5-15). Here you have the option to schedule this task for a specific time, or you can execute the task immediately. Click **Next**.

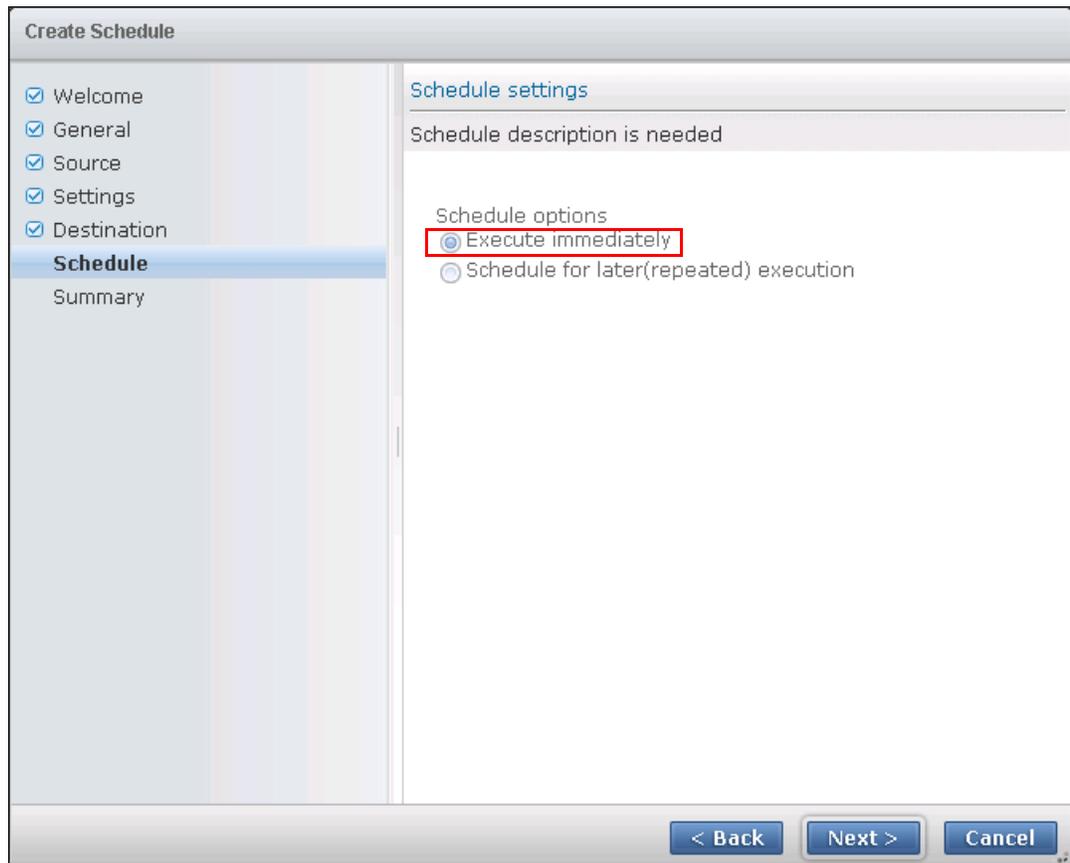


Figure 5-15 Define a schedule or execute the task immediately

A summary opens (Figure 5-16). This page lists the selections we made in the previous panels so we can review or choices. You are now ready to execute the task, click **Finish**.

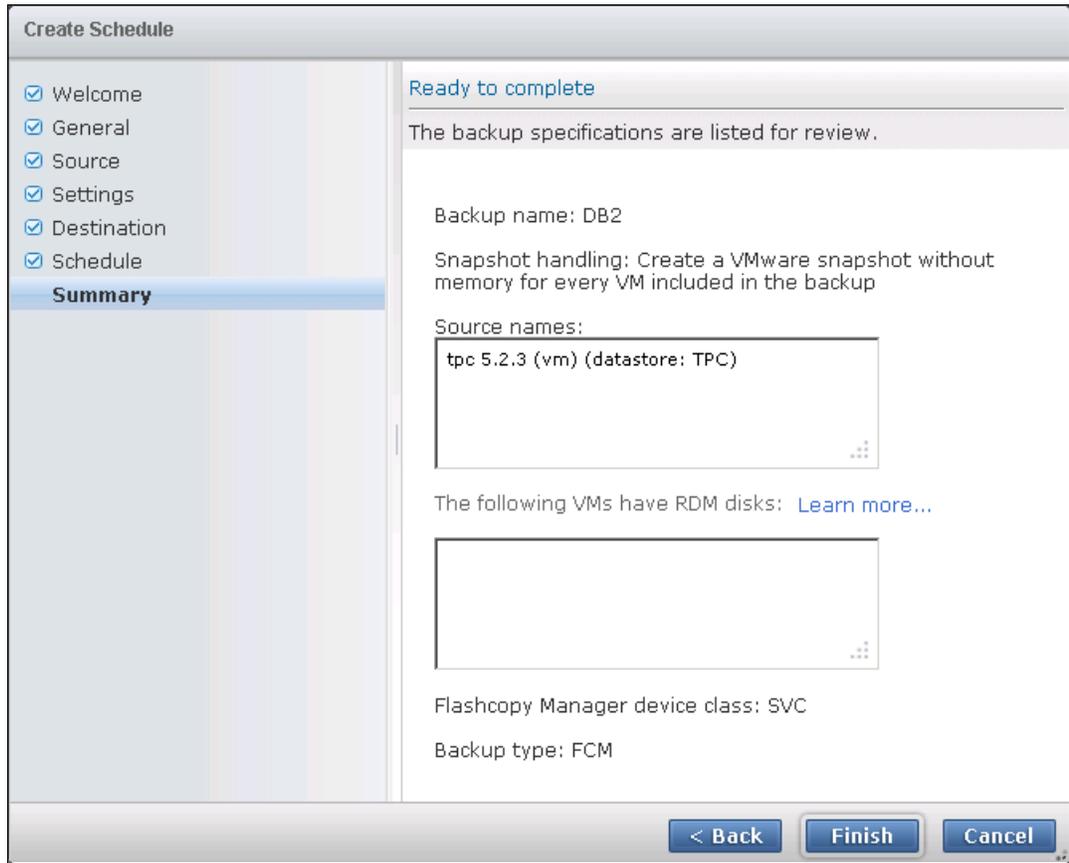


Figure 5-16 Summary page

After the task is executed, you can view the progress in the FlashCopy Manager UI. Click the **Reports** tab under **Recent Tasks** (Figure 5-17).

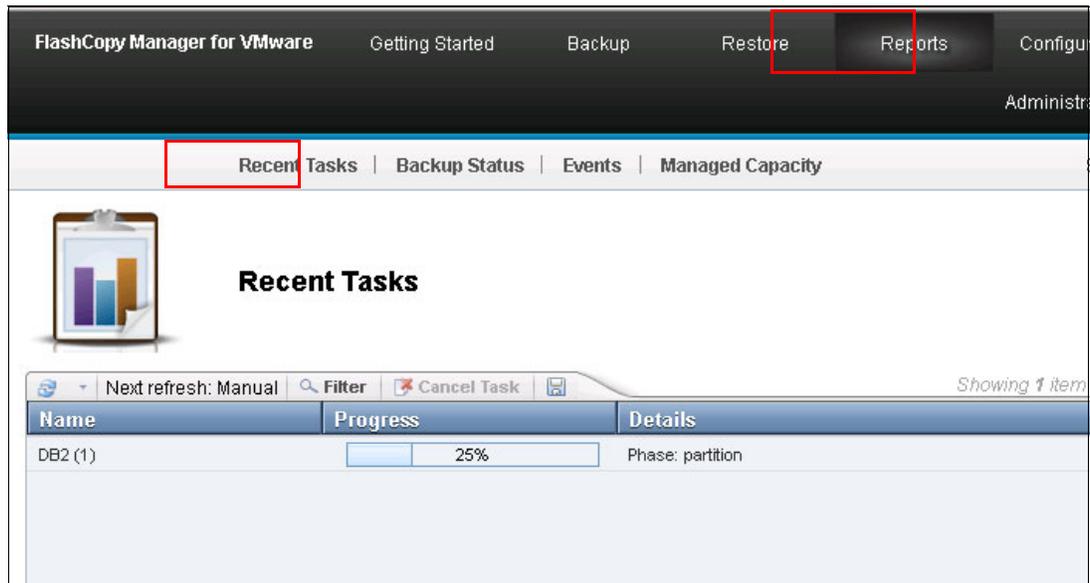


Figure 5-17 Recent Tasks report for FlashCopy Manager

We check the log status of our freeze and thaw scripts; we see that both scripts executed with a return code of 0, as shown in Figure 5-18 and Figure 5-19.

Scripts: Remember, the scripts are in Appendix A, “Tivoli Storage FlashCopy Manager and DB2 scripts” on page 227.

```
freeze_2014030722470233.log - Notepad
File Edit Format View Help
Fri 03/07/2014 22:47:02.33 Running c:\windows\freeze.cmd ...
Fri 03/07/2014 22:47:02.33 Script level 20080806
Fri 03/07/2014 22:47:02.33 call db2cmd -w -c -i ""c:\windows\db2_executesQL.cmd"" SUSPEND ""G:\logs\freeze_2014030722470233.log""
Fri 03/07/2014 22:47:02.50 Running c:\windows\db2_executesQL.cmd...
dbuser      : db2admin
dbpass      : *****
dbinst      : DB2
dbname      : TPCDB
operation   : SUSPEND
log         : "G:\logs\freeze_2014030722470233.log"
Fri 03/07/2014 22:47:02.52 set DB2INSTANCE=DB2
Fri 03/07/2014 22:47:02.53 Connecting to TPCDB database...
CONNECT TO TPCDB USER db2admin USING

Database Connection Information
Database server      = DB2/NT64 10.1.3
SQL authorization ID = DB2ADMIN
Local database alias = TPCDB

00000
Fri 03/07/2014 22:47:03.88 Successfully connected to TPCDB database.
Fri 03/07/2014 22:47:03.88 Temporarily suspend writing to database...
SET WRITE SUSPEND FOR DATABASE
DB20000I The SET WRITE command completed successfully.

00000
Fri 03/07/2014 22:47:03.99 Terminate the CLP's back-end process...
TERMINATE
DB20000I The TERMINATE command completed successfully.

Fri 03/07/2014 22:47:04.03 type "G:\logs\db2.err"
0
Fri 03/07/2014 22:47:04.05 attrib +H "G:\logs\db2.err"
Fri 03/07/2014 22:47:04.09 executesQL.cmd exited with RC=0
Fri 03/07/2014 22:47:04.09 Exit c:\windows\freeze.cmd
Fri 03/07/2014 22:47:04.09 RC=0
```

Figure 5-18 Log for the freeze script

```
thaw_2014030722470824.log - Notepad
File Edit Format View Help
Fri 03/07/2014 22:47:08.26 Running c:\windows\thaw.cmd ...
Fri 03/07/2014 22:47:08.28 Script level 20080806
Fri 03/07/2014 22:47:08.29 call db2cmd -w -c -i ""c:\windows\db2_executesQL.cmd"" RESUME ""G:\logs\thaw_2014030722470824.log""
Fri 03/07/2014 22:47:08.68 Running c:\windows\db2_executesQL.cmd...
dbuser      : db2admin
dbpass      : *****
dbinst      : DB2
dbname      : TPCDB
operation   : RESUME
log         : "G:\logs\thaw_2014030722470824.log"
Fri 03/07/2014 22:47:08.70 set DB2INSTANCE=DB2
Fri 03/07/2014 22:47:08.71 del /F /Q /A:H "G:\logs\db2.err"
Fri 03/07/2014 22:47:08.73 type "G:\logs\db2.err"
-99
Fri 03/07/2014 22:47:08.73 attrib +H "G:\logs\db2.err"
Fri 03/07/2014 22:47:08.74 Connecting to TPCDB database...
CONNECT TO TPCDB USER db2admin USING

Database Connection Information
Database server      = DB2/NT64 10.1.3
SQL authorization ID = DB2ADMIN
Local database alias = TPCDB

00000
Fri 03/07/2014 22:47:09.91 Successfully connected to TPCDB database.
Fri 03/07/2014 22:47:09.91 Resume writing to database...
SET WRITE RESUME FOR DATABASE
DB20000I The SET WRITE command completed successfully.

00000
Fri 03/07/2014 22:47:09.99 Terminate the CLP's back-end process...
TERMINATE
DB20000I The TERMINATE command completed successfully.

Fri 03/07/2014 22:47:10.04 del /F /Q /A:H "G:\logs\db2.err"
Fri 03/07/2014 22:47:10.05 type "G:\logs\db2.err"
0
Fri 03/07/2014 22:47:10.05 attrib +H "G:\logs\db2.err"
Fri 03/07/2014 22:47:10.07 executesQL.cmd exited with RC=0
Fri 03/07/2014 22:47:10.07 Exit c:\windows\thaw.cmd
Fri 03/07/2014 22:47:10.07 RC=0
```

Figure 5-19 Log for thaw script

Look at the vSphere Web Client (Figure 5-20) to see the task that VMware was asked to execute by FlashCopy Manager for VMware. Here you see that VMware creates a snapshot of the virtual machine prior to the hardware snapshot.

VMware tools executes our freeze script just before this happens. After the snapshot is created, the hardware snapshot is created and our thaw script is executed. The VMware snapshot is then removed.

Task Name	Target	Status	Start Time	Completion Time	Initiator
Remove snapshot	tpc 5.2.3	Completed	3/7/2014 11:45 PM	3/7/2014 11:45 PM	Administrat
Create virtual machine snapshot	tpc 5.2.3	Completed	3/7/2014 11:45 PM	3/7/2014 11:45 PM	Administrat
FCM backup virtual machines	TPC	Completed	3/7/2014 11:45 PM	3/7/2014 11:45 PM	Administrat
Unregister virtual machine	vhull2 temp1 (6882...	Completed	3/7/2014 12:54 AM	3/7/2014 12:54 AM	Administrat
Unregister virtual machine	vhull temp1 (2bf3b...	Completed	3/7/2014 12:53 AM	3/7/2014 12:53 AM	Administrat
Unregister virtual machine	vhull3	Completed	3/7/2014 12:53 AM	3/7/2014 12:53 AM	Administrat

Figure 5-20 FlashCopy Manager tasks as seen in the vSphere web client.

By returning to the Recent Tasks page (from the FlashCopy Manager UI, click the **Reports** tab and then click **Recent Tasks**), we see that the job completed successfully (Figure 5-21).

Name	Progress	Details	Start Time
DB2 (1)	Success		March 7, 2014 11:46:25 PM EST

Figure 5-21 Successful backup.

To summarize, we accomplished the following tasks:

- ▶ We identified the data store where the virtual machine containing the application that we wanted to back up was located.
- ▶ We identified the data store to SAN Volume Controller volume mapping.
- ▶ We created a set of target volumes that we used as our targets.
- ▶ We configured the FlashCopy Manager for VMware server, validated the VMWARE section, set up our Device_Class and Target_Set in the configuration file.
- ▶ We created the application pre-freeze and post-thaw scripts and placed them in the appropriate directories.
- ▶ We defined a backup schedule, executed it successfully, and validated our freeze and thaw script logs.

Next, we show the source-volume-to-target relationship in Tivoli Storage Productivity Center. To do that, we log into our Tivoli Storage Productivity Center web GUI, select **Storage Resources** → **Storage Systems** and then select the specific subsystem we are looking for.

In this example, we specify SVC-2145-JohnWayne-IBM (Figure 5-22). From here we select **Volumes** under the Internal Resources list. To simplify our search, we apply a filter to display only the volumes we are looking for. In this example, we filter on the name tpc.

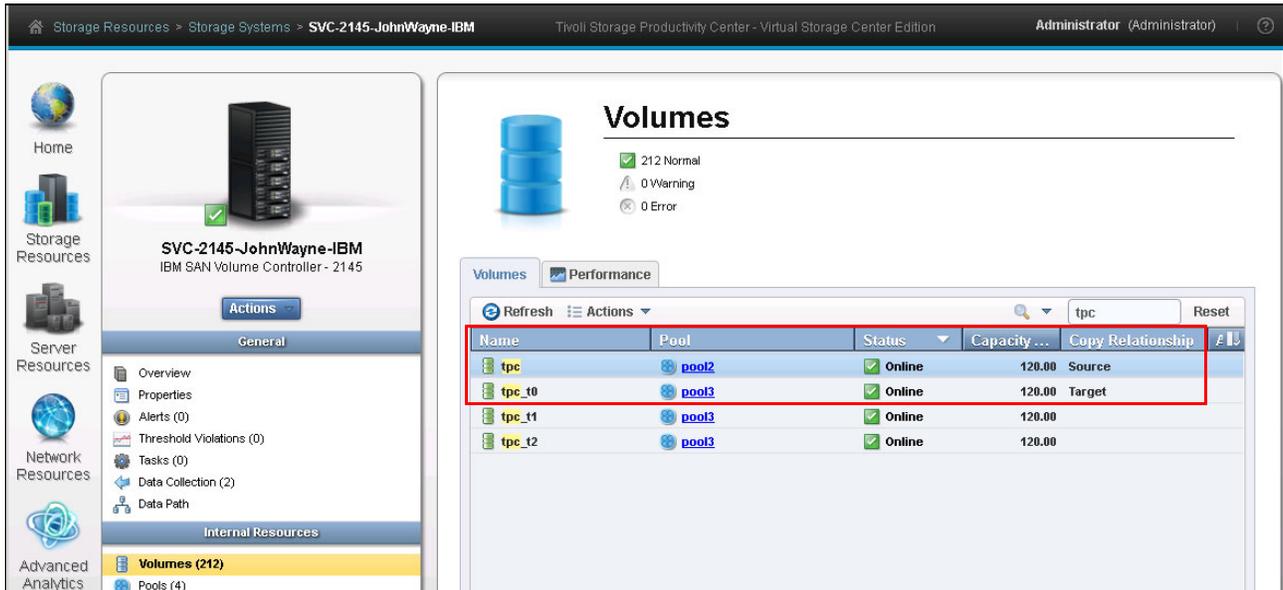


Figure 5-22 Report shows which volumes are source and which are target

We can dig deeper into this scenario to see the entire FlashCopy relationship. To do this we look at the properties of the source volume; the source volume is named tpc. Right-click the **tpc** volume and select **Properties**.

The Properties panel opens (Figure 5-23). Click the **Relationships** tab. Here we can see that the source volume, tpc has three target relationships: tpc_t0, tpc_t2, and tpc_t2. These are the target sets we defined in the configuration file for FlashCopy Manager in previous steps.

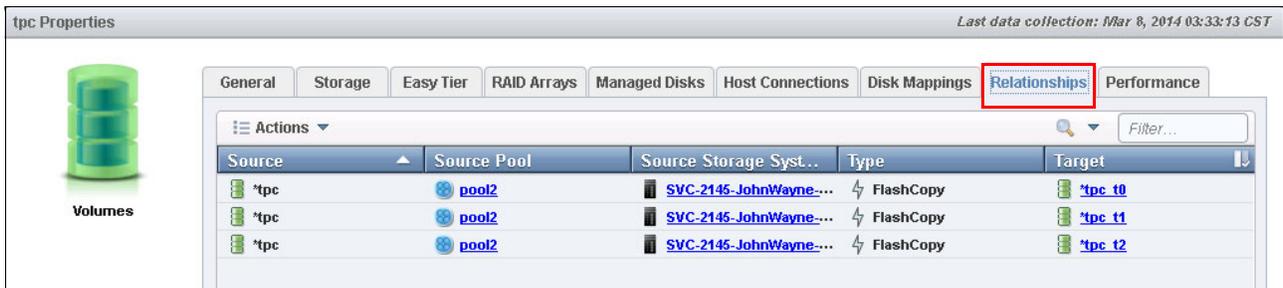


Figure 5-23 Full source to target volume mapping in Tivoli Storage Productivity Center

Restore options

Next are the restore options with FlashCopy Manager for VMware. Now that we have a restore-point for our data store and our virtual machine, there are a several methods we can use for restoring. We can restore a single virtual machine, the entire data store, or attach any of the virtual machine’s disks from the backup to the running virtual machine.

With the attach feature, we can do a single file-level restore from a full virtual machine-level backup. To accomplish this, we use the FlashCopy Manager for VMware web GUI. As shown in Figure 5-24, we first select the **Restore** and navigate to the virtual machine that we just backed up (tpc523). Next, we see that we have a restore point and the date and time of that restore point. From here, we can choose to restore the entire virtual machine or we can attach one or all of disks to a running virtual machine.

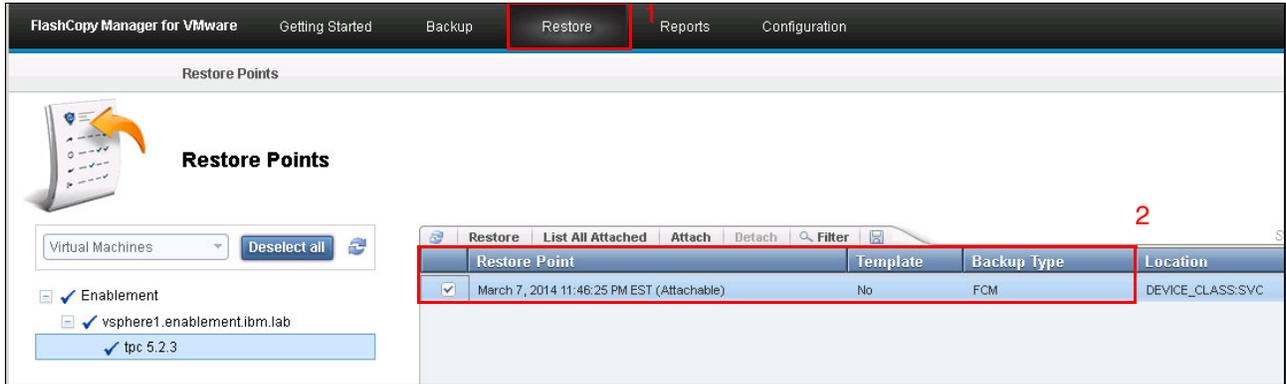


Figure 5-24 FlashCopy Manager for VMware attachable restore

You can choose your restore point and either restore or attach one or all of the virtual disks from the backup to a running virtual machine. We choose to attach to a virtual machine, as shown in Figure 5-25.

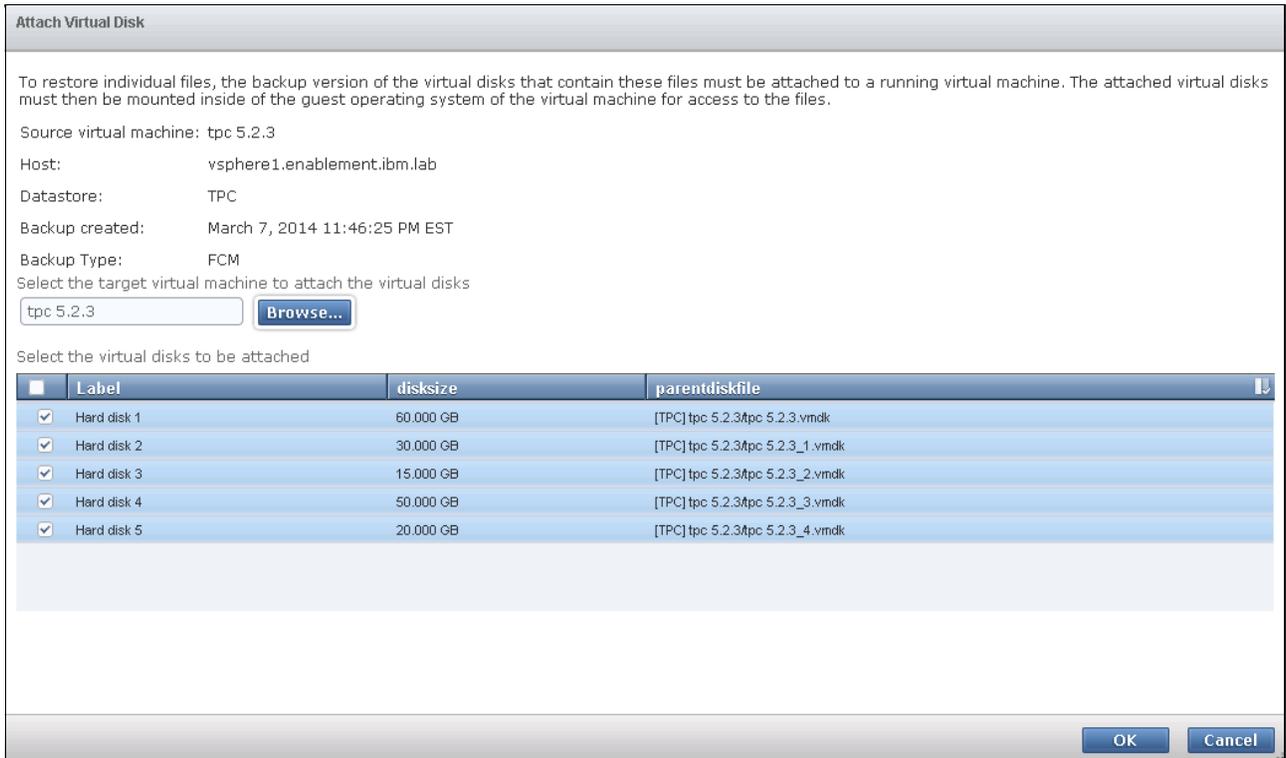


Figure 5-25 Attaching virtual disks to a running virtual machine

The attach operation was successful, as shown in Figure 5-26.



Figure 5-26 Recent Tasks shows the attach operation was successful

We can also view the attach operation from the vSphere Web Client. This example shows that FlashCopy Manager attaches the volume in vSphere, using the original data store name, and appends the backup ID to it, TPC_A0HSIETQ0M, as shown in Figure 5-27.

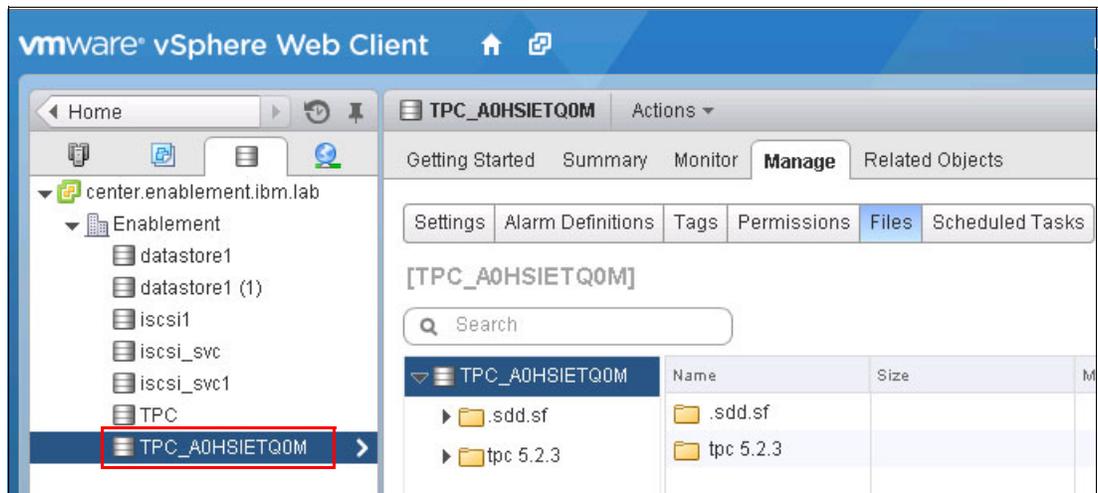


Figure 5-27 The entire data store is attached and the backup ID is appended to the data store original name

We can also view this from a vSphere virtual machine perspective (Figure 5-28).

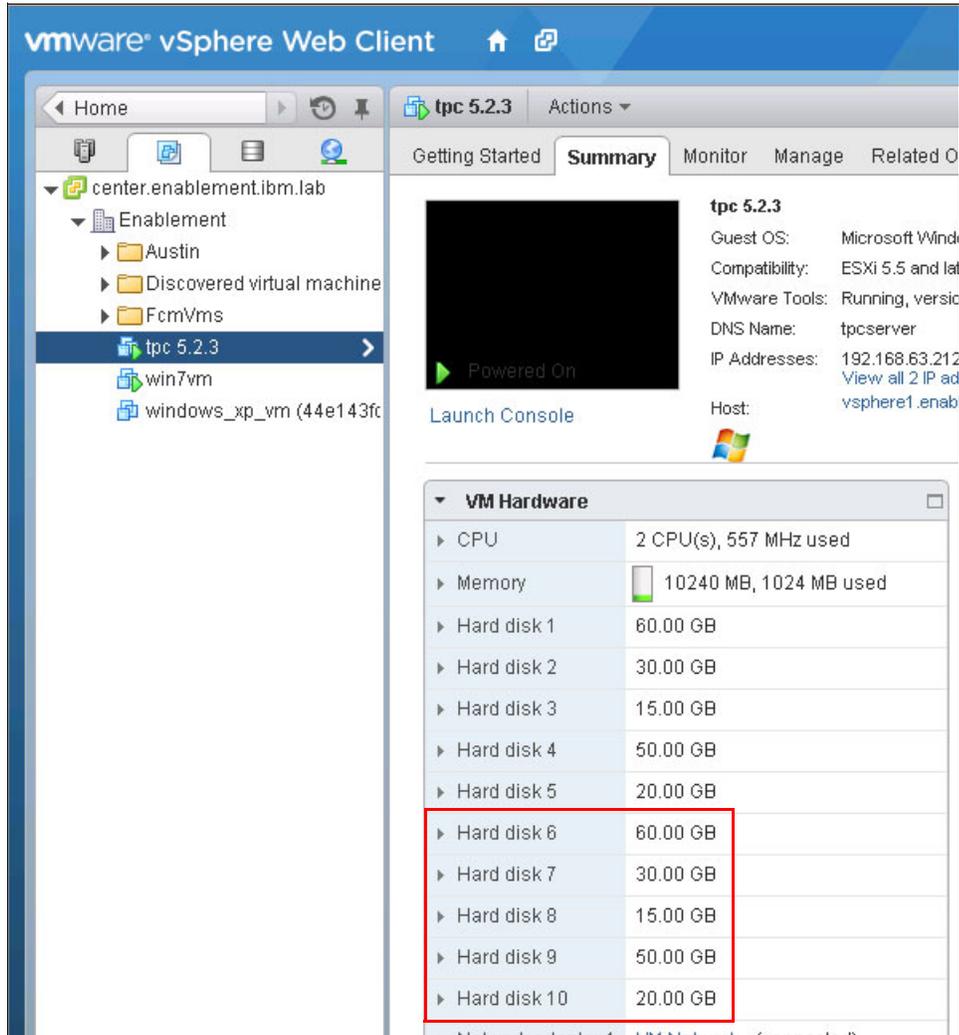


Figure 5-28 The virtual machine now has the additional disk attached

When we log in to the virtual machine, those disks are listed as additional drives (Figure 5-29). With this functionality, we can do a single file restore by browsing to any of the attached volumes and copying any files to be restored.

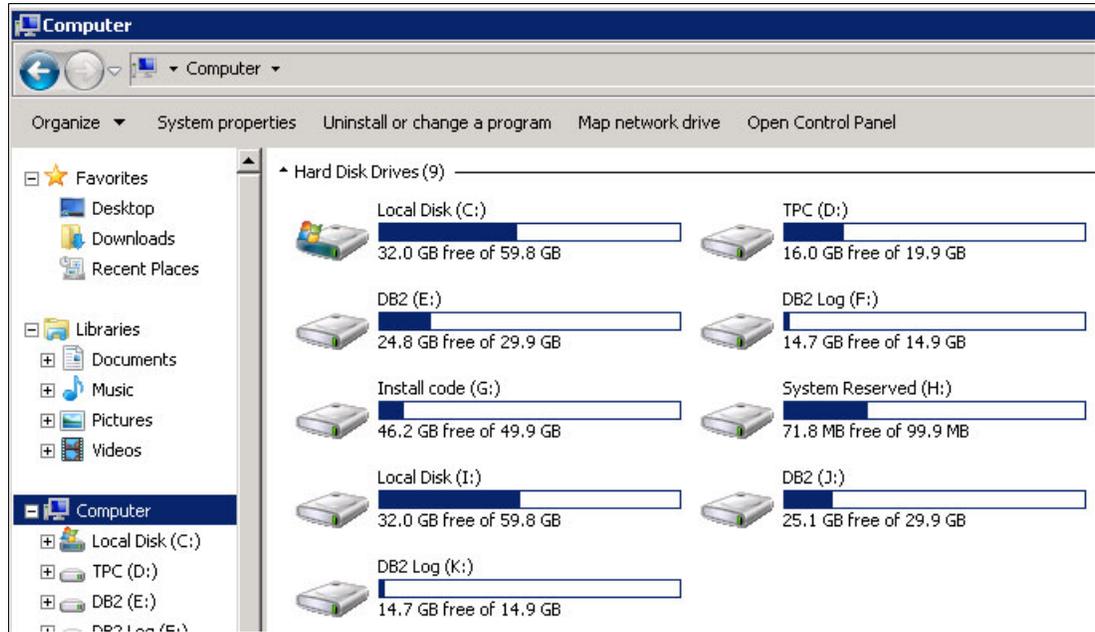


Figure 5-29 The view from inside the virtual machine

When we no longer need those volumes to be attached, we detach them from the virtual machine by using the FlashCopy Manager UI. To accomplish this, click the **Restore** tab (Figure 5-30), click the virtual machine's restore point that shows **Attached**, and then click **Detach**. The **Detach** panel opens. Click **Detach**.

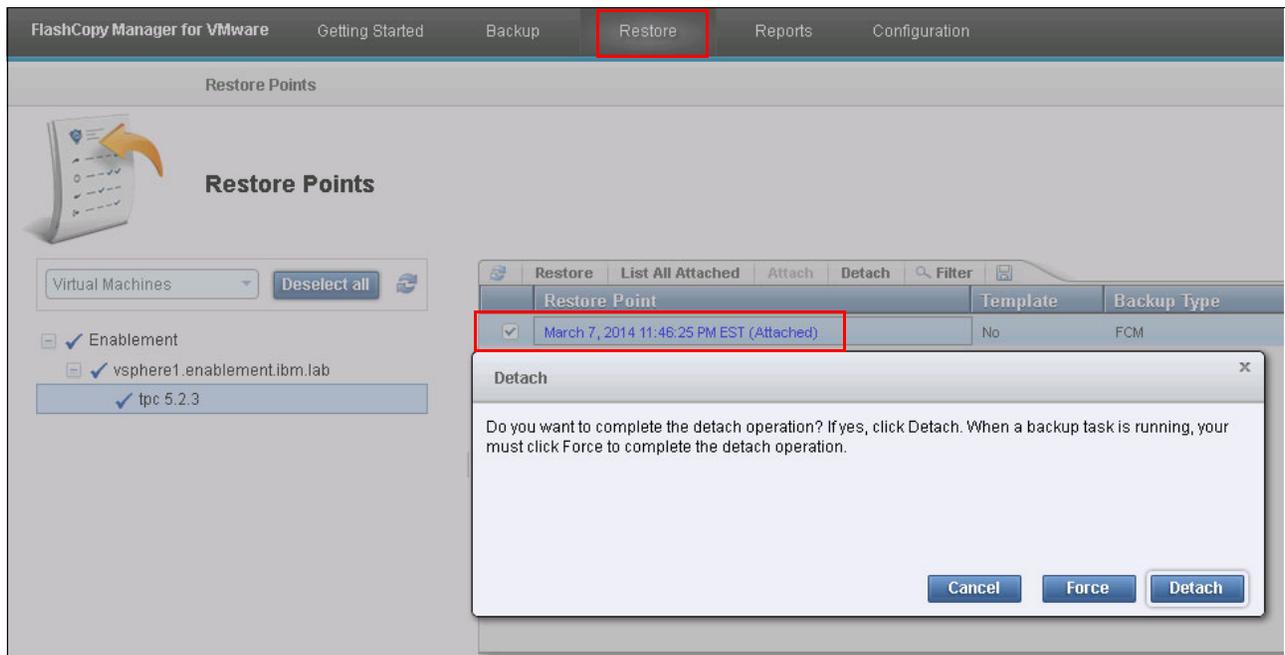


Figure 5-30 Detach backup volumes from the virtual machine

The volume is removed from vSphere Web Client. See Figure 5-31.

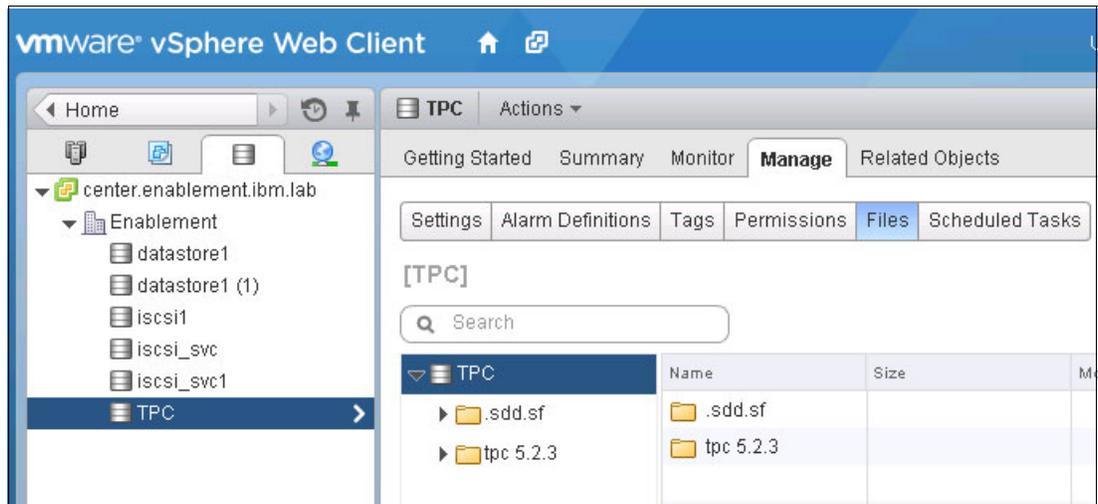


Figure 5-31 vSphere web client view

Notice that the TPC_A0HSIETQ0M volume is no longer available.

Also notice that those volumes were removed from the virtual machine (Figure 5-32).

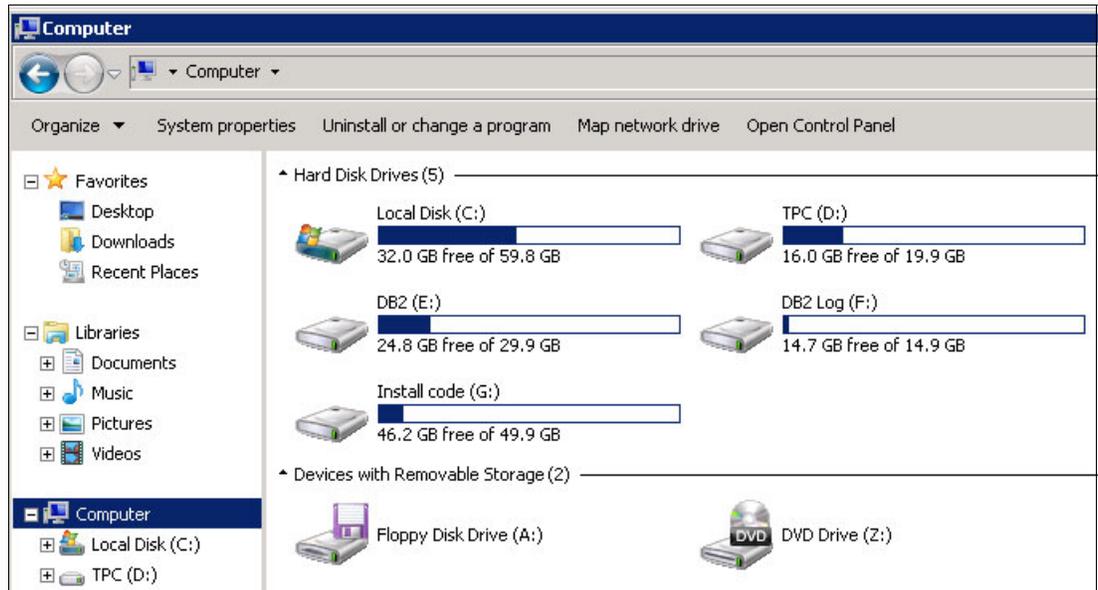


Figure 5-32 All attached backup volumes are removed without the need to reboot the virtual machine

Instant restore

As demonstrated, we can perform a file system or file level restore based of a virtual machine or data store level backup. We now do a full virtual machine restore by using the *instant restore* function in FlashCopy Manager. In the following steps, we do a data store instant restore. We delete the virtual machine from the data store, use FlashCopy Manager for VMware to restore the entire data store, and then log in to the virtual machine and verify that Tivoli Storage Productivity Center is working and ready for use.

First we delete the virtual machine located on that data store (Figure 5-33).

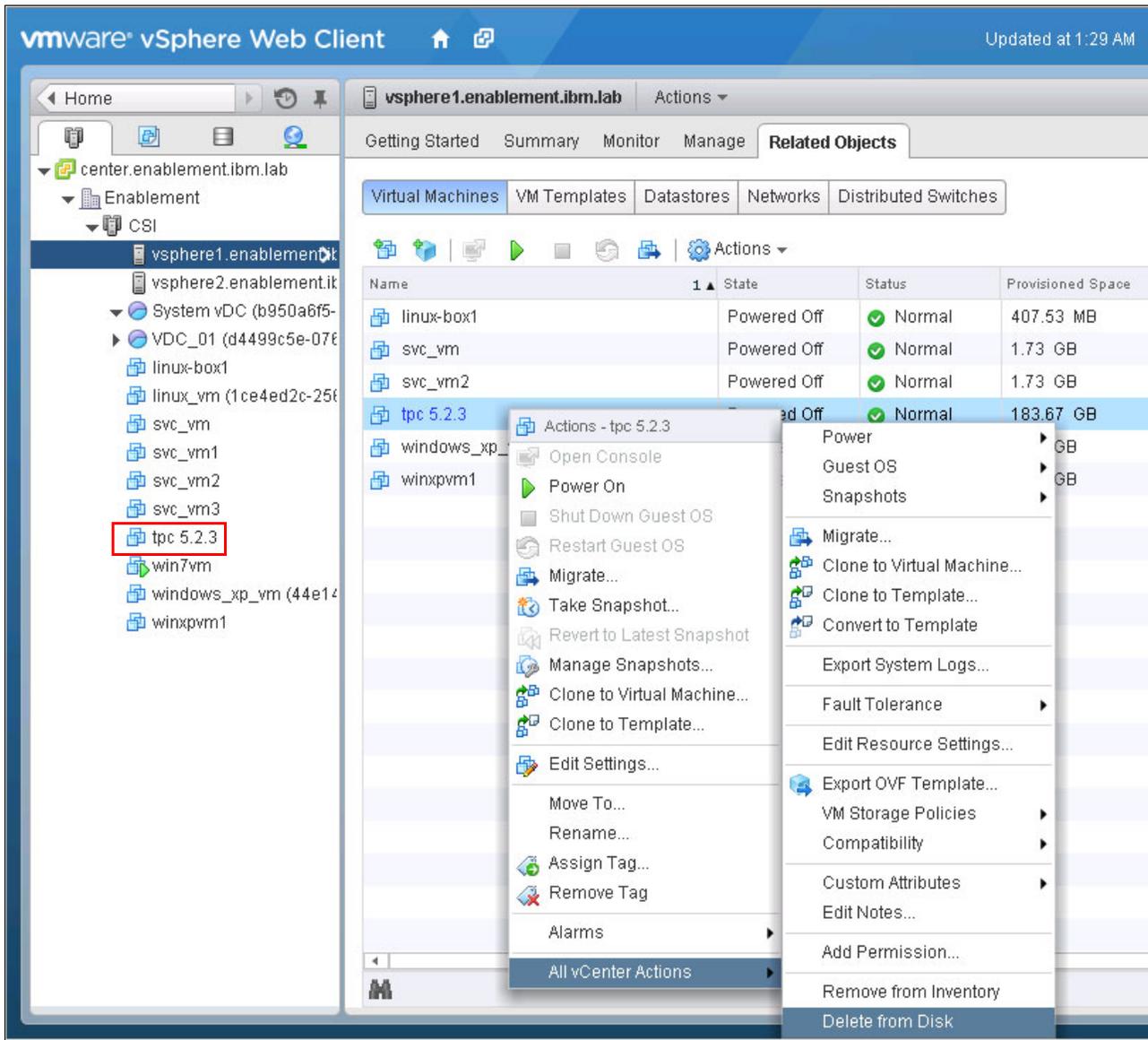


Figure 5-33 Deleting virtual machine from the data store

Notice that the virtual machine named tpc523 is no longer listed (Figure 5-34).

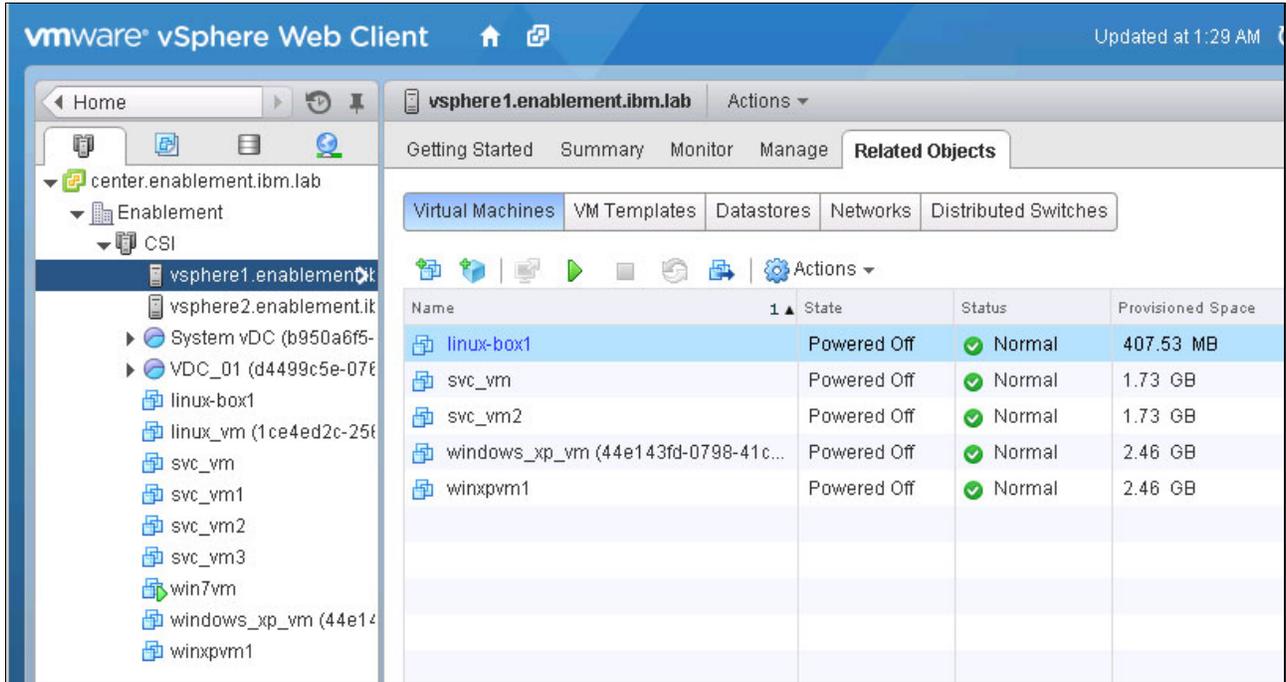


Figure 5-34 The virtual machine named tpc523 has been deleted.

From the FlashCopy Manager for VMware GUI (Figure 5-35), we click the **Restore** tab (1), select **Datastores** as our restore level (2), and select the most recent restore point (3).

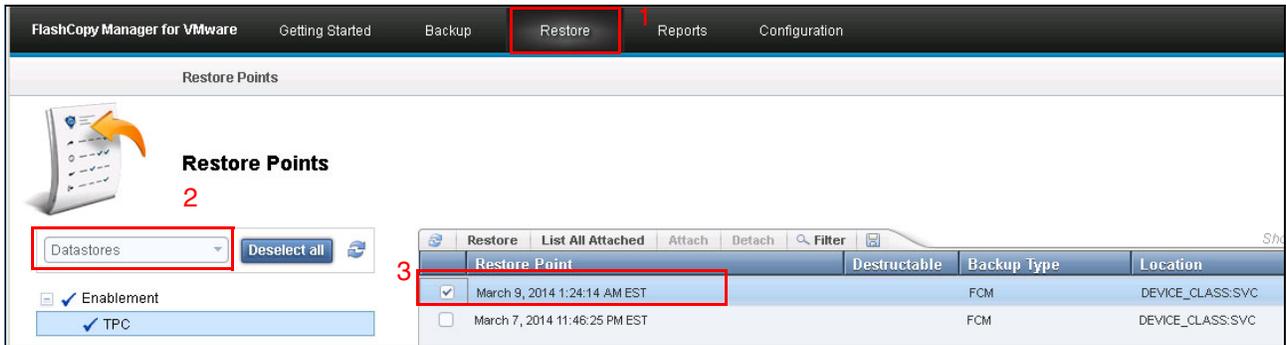


Figure 5-35 Latest data store restore point

The Restore wizard **Welcome** page opens (Figure 5-36). Click **Next**.

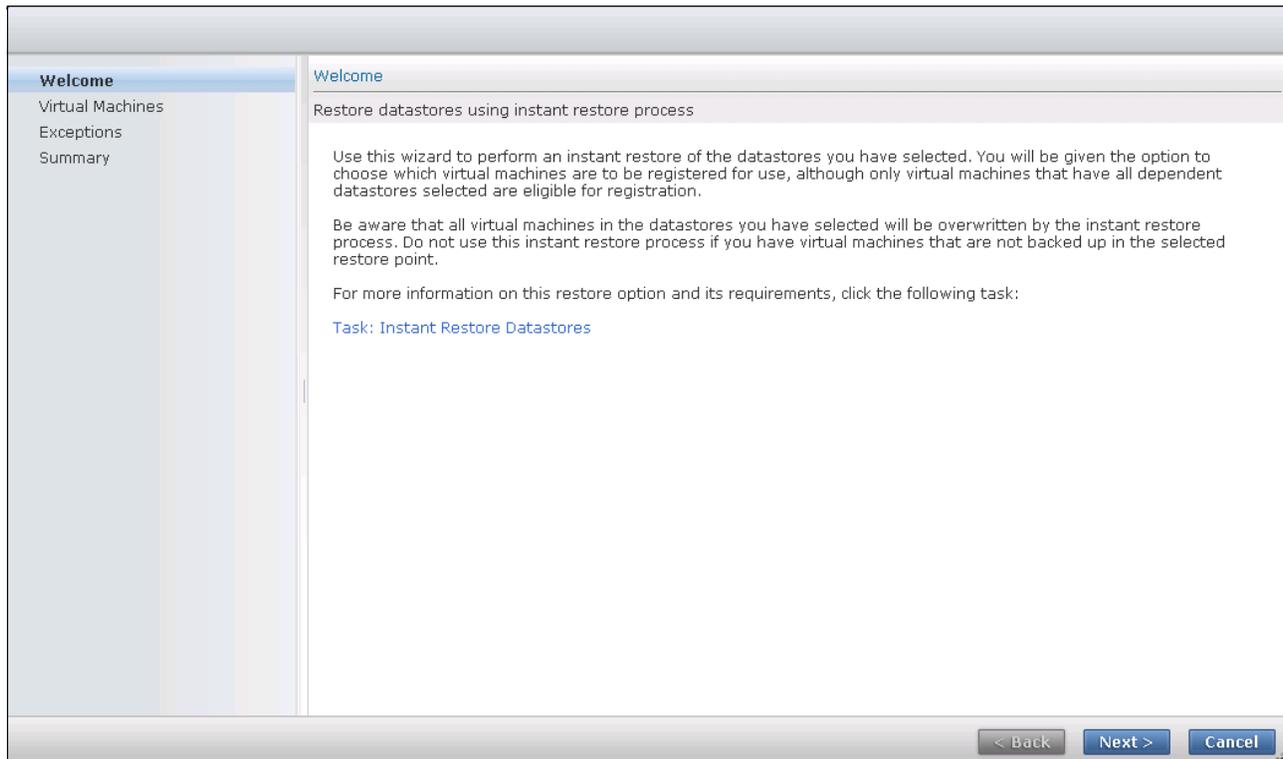


Figure 5-36 Restore wizard welcome page

We select the virtual machine that we want to register in VMware vSphere. In our example, we select virtual machine tpc523 (Figure 5-37). Click **Next**.

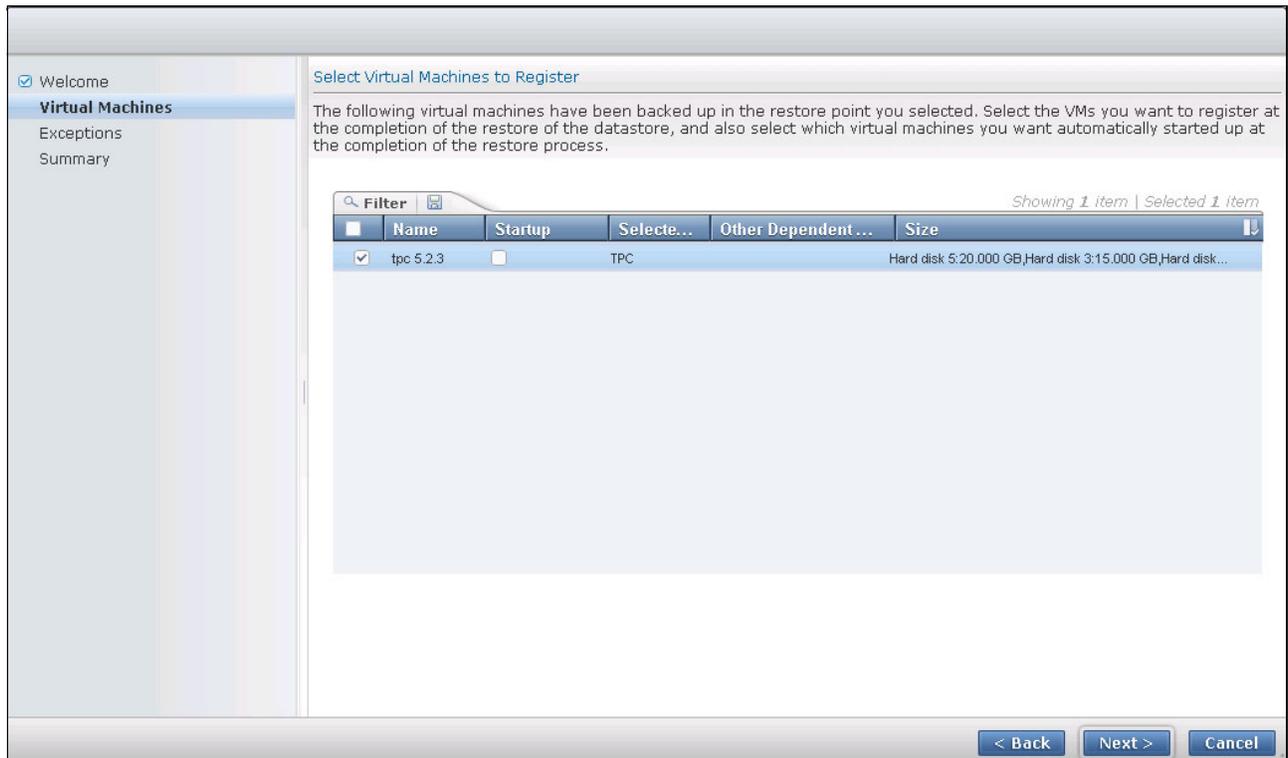


Figure 5-37 Virtual machine registration

The Registration Exceptions page opens (Figure 5-38). This page is displayed for several reasons:

- ▶ If any virtual machines are on the data store that you are about to restore and that are not in your restore point.
- ▶ It lists any virtual machines that have disk files on other data stores that have not been selected.
- ▶ It lists any virtual machines that the user did not select for restore.

Click **Next**.

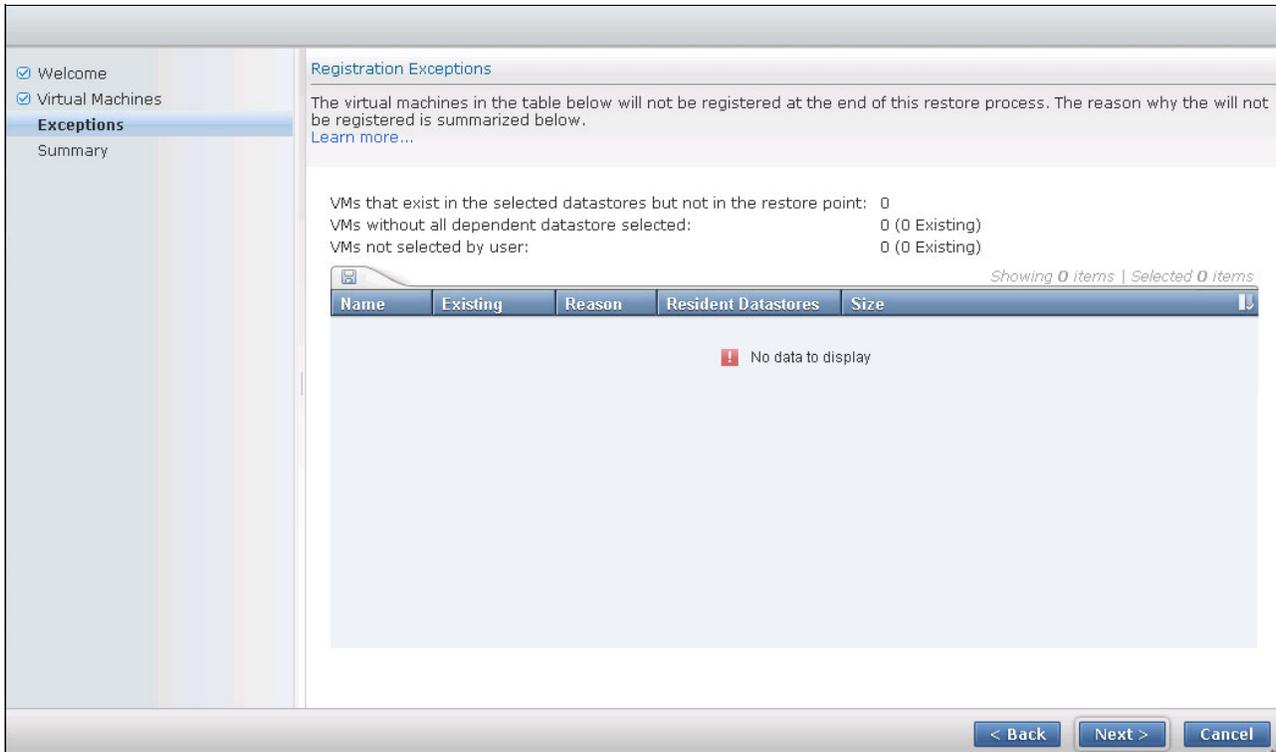


Figure 5-38 Registration exceptions for VMware vSphere

The Summary page (Figure 5-39) lists several acknowledgement check boxes. These are warning you that this is a full data store restore, and that virtual machines that are not in the restore point will be deleted. Click **Finish**.

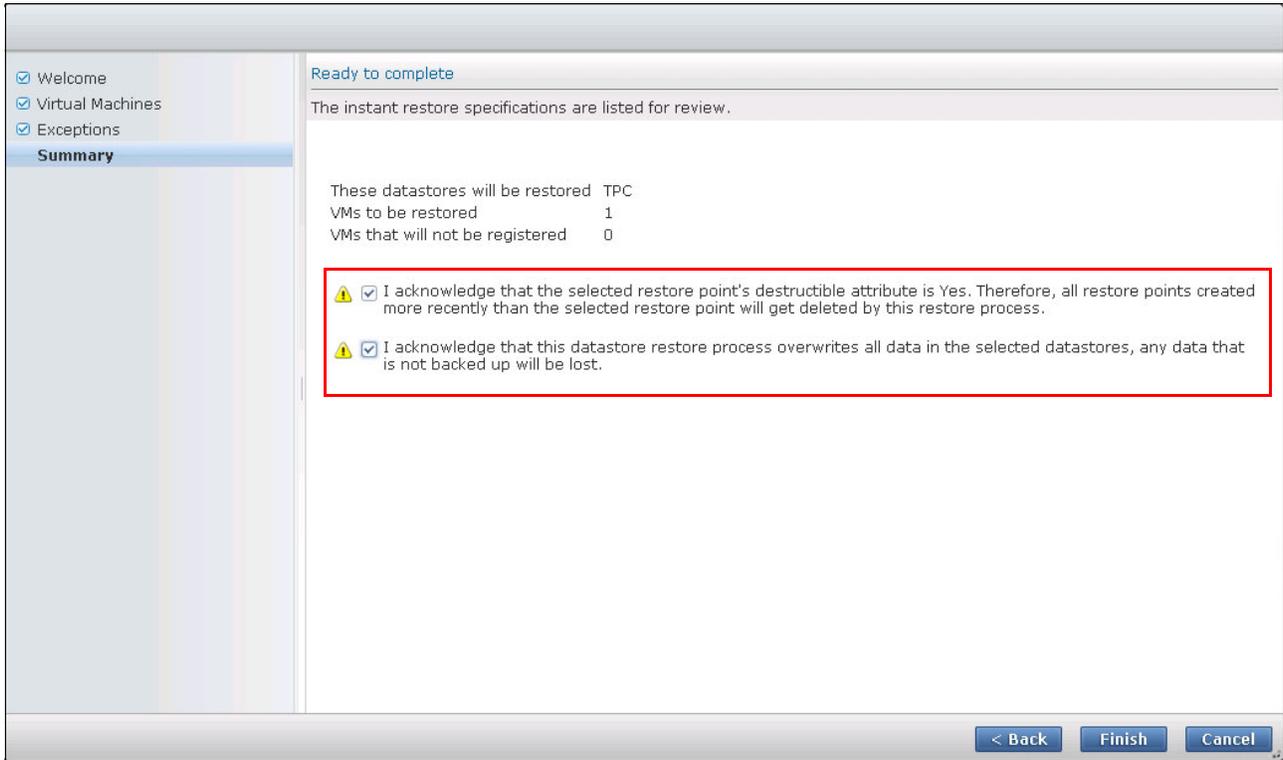


Figure 5-39 Summary page

The data store restore is now started. You can view the status by selecting **Summary** on the Recent Tasks page. Our instance restore was successful, as shown in Figure 5-40.

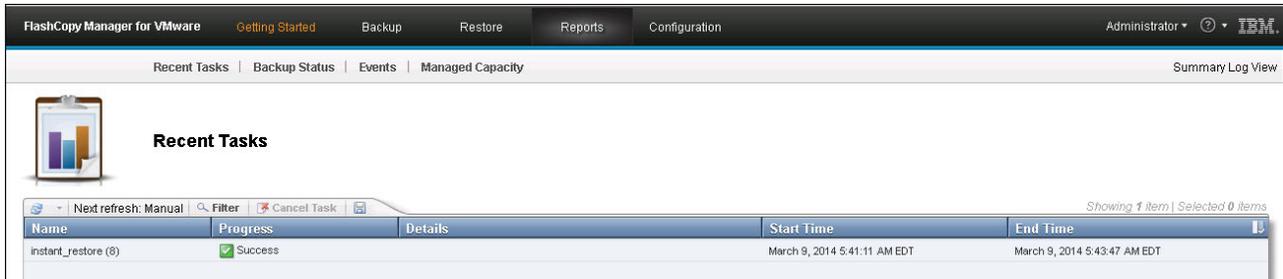


Figure 5-40 As you can see from the start and end time, this process took about 2 minutes

The VMware vSphere Web Client shows the virtual machine (tpc523) was restored and is starting (Figure 5-41).

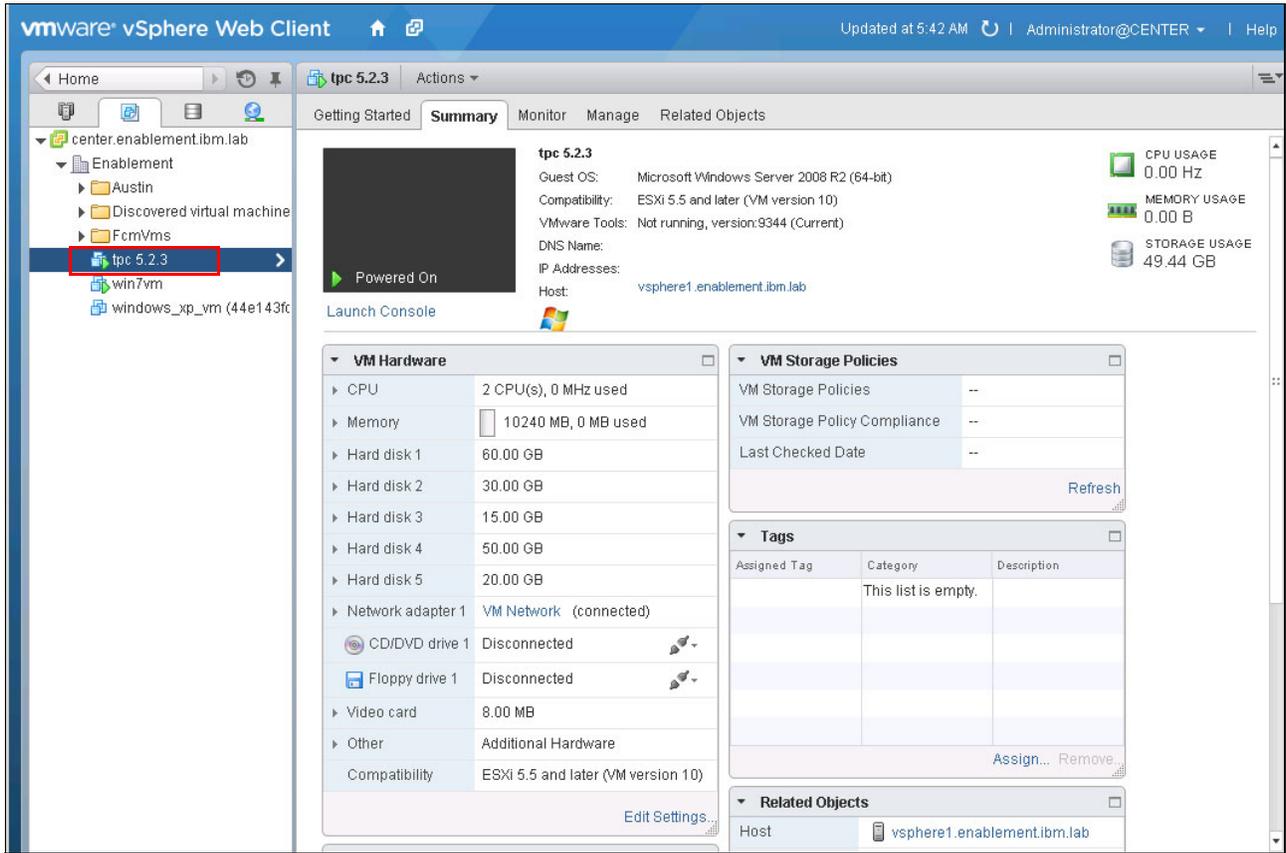


Figure 5-41 vSphere view of the virtual machine starting up

While the virtual machine is starting, we can look in the SAN Volume Controller GUI at the running task and see that the volume is still copying the data back to the source volume, or data store, although the virtual machine is running (Figure 5-42).

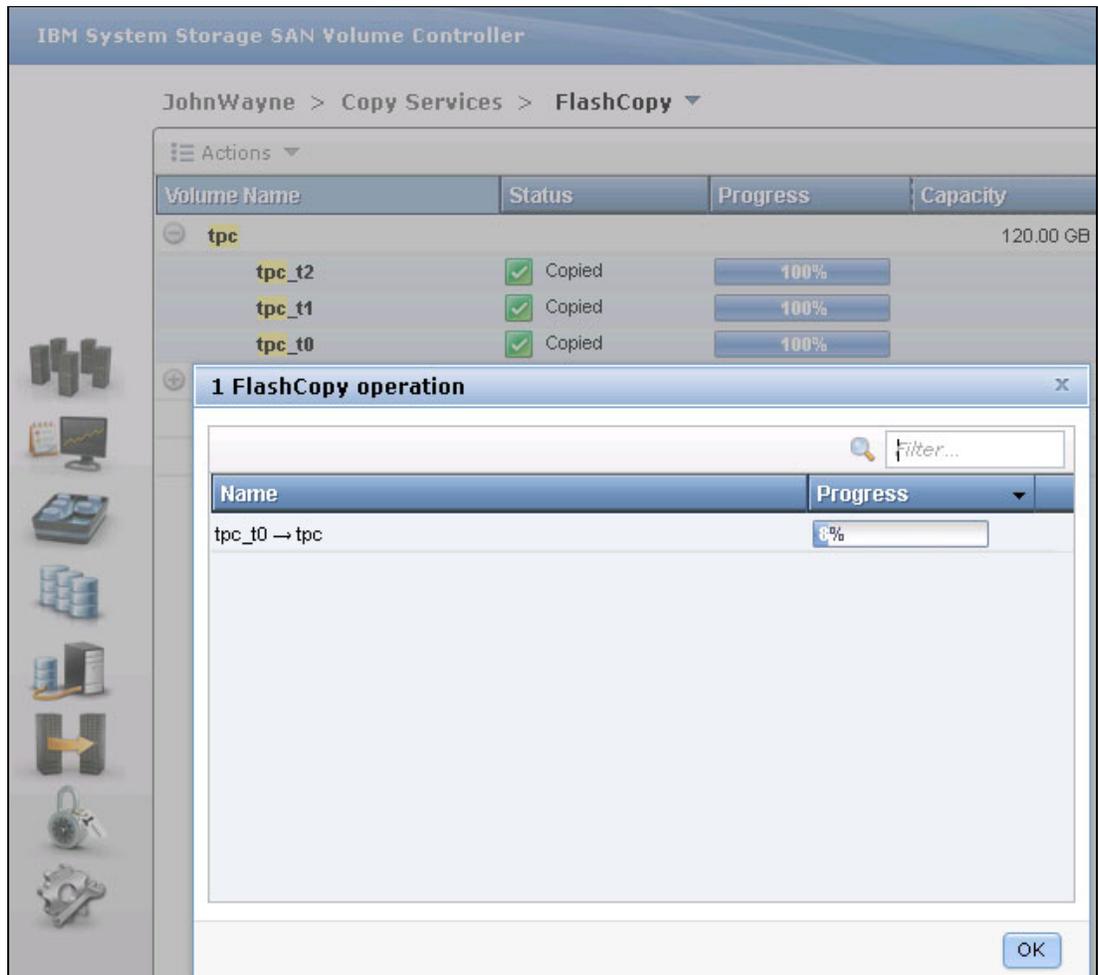


Figure 5-42 Flash back operation in progress

The last task is to log in to the virtual machine and issue the **restart** database command with the write resume option. To accomplish this, click **Start** and select **IBM DB2 → Command Line Processor** (Figure 5-43).

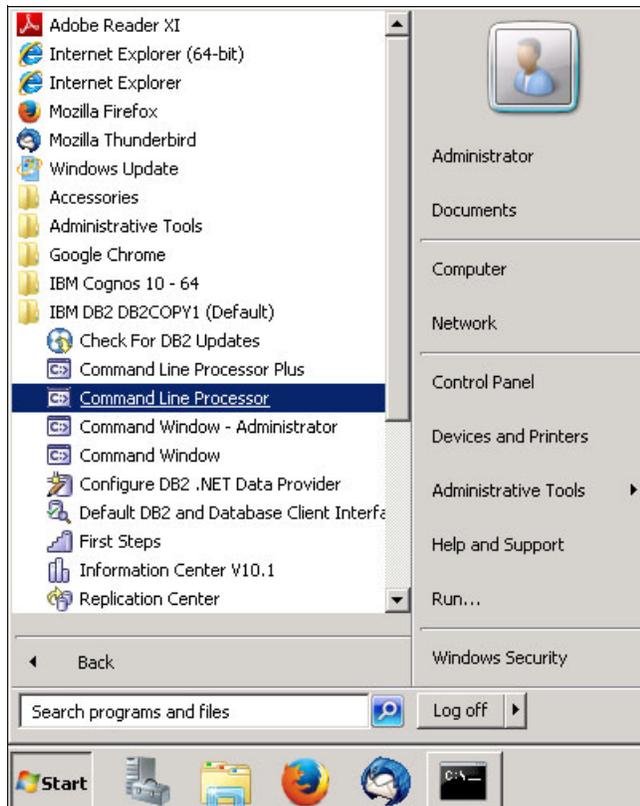


Figure 5-43 Launch the DB2 command line

From command prompt, issue the **restart DB tpcdb write resume** command (Figure 5-44).

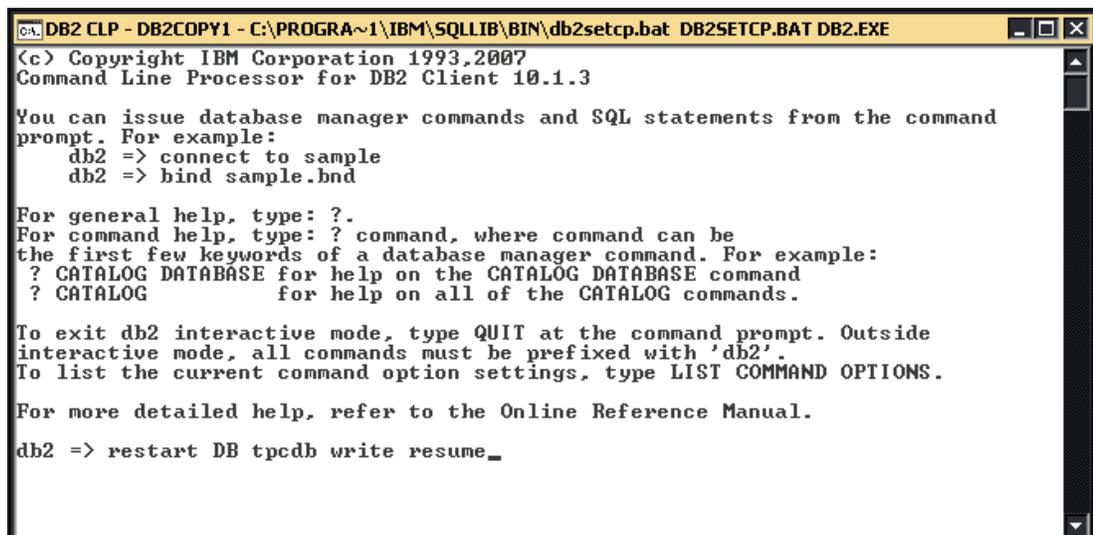


Figure 5-44 Restart the database to allow writes.

After the command completes successfully, again log in to the Tivoli Storage Productivity Center server (Figure 5-45).

```

C:\DB2 CLP - DB2COPY1 - C:\PROGRA~1\IBM\SQLLIB\BIN\db2setcp.bat DB2SETCP.BAT DB2.EXE
(c) Copyright IBM Corporation 1993,2007
Command Line Processor for DB2 Client 10.1.3

You can issue database manager commands and SQL statements from the command
prompt. For example:
db2 => connect to sample
db2 => bind sample.bnd

For general help, type: ?.
For command help, type: ? command, where command can be
the first few keywords of a database manager command. For example:
? CATALOG DATABASE for help on the CATALOG DATABASE command
? CATALOG          for help on all of the CATALOG commands.

To exit db2 interactive mode, type QUIT at the command prompt. Outside
interactive mode, all commands must be prefixed with 'db2'.
To list the current command option settings, type LIST COMMAND OPTIONS.

For more detailed help, refer to the Online Reference Manual.

db2 => restart DB tpcdb write resume
DB20000I The RESTART DATABASE command completed successfully.
db2 =>
  
```

Figure 5-45 Command completed successfully

You are returned to Tivoli Storage Productivity Center viewing the Copy Relationship reports (Figure 5-46).

The screenshot shows the Tivoli Storage Productivity Center interface. On the left is a navigation pane with categories like Home, Storage Resources, Server Resources, Network Resources, and Advanced Analytics. The main area is titled 'Volumes' and shows a summary: 212 Normal, 0 Warning, and 0 Error. Below this is a table of volume details.

Name	Pool	Status	Capacity	Copy Relationship
tpc	pool2	Online	120.00	Source
tpc_t0	pool3	Online	120.00	Target
tpc_t1	pool3	Online	120.00	Target
tpc_t2	pool3	Online	120.00	Target

Figure 5-46 Source and target volume report in Tivoli Storage Productivity Center



Provisioning

Storage provisioning is a known activity for storage administrators. It includes frequent and repetitive tasks, which must be run in a predefined order to be successful:

- ▶ Create storage pools
- ▶ Allocate logical volumes
- ▶ Create Fabric zones
- ▶ Define hosts and ports to storage
- ▶ Assign logical volumes to hosts
- ▶ Install multipath device driver on host

Although storage provisioning seems a simple process of assigning storage, usually in the form of server disk drive space, and these processes can be complex. The administrator must account for both the performance of the newly assigned capacity and the overall storage area network (SAN) performance. Capacity and performance planning are required to avoid bottlenecks and lack of resources; a deep knowledge of the technology is needed to be able to explore all its benefits. Doing all of this without Storage Resource Management (SRM) software can be difficult in medium and large storage environments.

This chapter describes how to use the *Provision Storage wizard* in IBM SmartCloud Virtual Storage Center to simplify the way storage is provisioned in an IT environment. Many tasks are involved when a new request for storage is received by the administrator, and completing them takes time. With the Provision Storage wizard, the request involves less information and a shorter amount of time to accomplish and close.

The following topics can help you better understand and use the Provision Storage wizard in the IBM SmartCloud Virtual Storage Center:

- ▶ Automated and cloud provisioning
- ▶ Planning and organizing
- ▶ Service classes
- ▶ Capacity pools
- ▶ Provisioning and sharing volumes
- ▶ Provisioning storage to cloud and to VMware

6.1 Provisioning overview

Several activities must be accomplished when provisioning storage to application servers. These activities can take from hours to days or even weeks to complete, delaying the deployment of new applications and overloading the storage administration staff. The assignment of capacity to servers or virtual machines is a highly manual process, which requires careful planning for obtaining the best results and not adversely affecting the existing workloads.

The steps to provision storage must be done in a specific order to be successful. Redundant data paths must be provided to prevent outages and disaster recovery situations, performance objectives must be met, and appropriate physical data protection must be considered. As a result, several areas are susceptible to human errors.

This is where automated storage provisioning, provided by Storage Resource Management (SRM) software, can help: automating repetitive activities in order to lower the risk of errors, adding analytics so the characteristics of the environment are used for better decisions, and reducing the time to process the requests. The storage administration staff then becomes free for other important activities such as working more proactively with capacity planning, or evaluating new storage technologies that can benefit their businesses.

6.1.1 Automated provisioning

The best way to avoid errors in repetitive actions is by automating them. This way, a standard sequence of activities have more predictive results with a higher level of success. The same concept also applies to the storage provisioning.

Automation can significantly simplify the task of provisioning storage capacity. Each step is automated and recommended practice rules regarding zoning, device configuration, and path selection can be applied automatically. The benefits are increased responsiveness to business requirements, lower administration costs and higher application availability.

With the introduction of a *storage services catalog*, automation becomes even more consumable. Now users can request volumes or file shares and receive adequate service levels based on their profiles. The storage services catalog is created in the IBM SmartCloud Virtual Storage Center through templates called *service classes*. For more information see 6.1.6, “Service classes” on page 149.

With the use of the service classes and optionally capacity pools, storage provisioning requests are run rapidly, assigning capacity to servers with the required quality of service. The same definitions in the storage environment through IBM SmartCloud Virtual Storage Center also facilitate the implementation of cloud provisioning, as the next section describes.

6.1.2 Cloud provisioning

Tivoli Storage Productivity Center provides cloud provisioning capabilities through the Cinder driver for OpenStack environments and the vSphere Web Client extension for VMWare vSphere. Both methods require the use of service classes.

By defining service classes, the Tivoli Storage Productivity Center administrator can provide the OpenStack or vSphere administrator with various provisioning options, based on capacity and also performance and reliability.

Tivoli Storage Productivity Center Cinder driver

With the Tivoli Storage Productivity Center Cinder driver, you can provision block storage by using Tivoli Storage Productivity Center service classes in an OpenStack environment. Service classes that are defined in Tivoli Storage Productivity Center are available to OpenStack as volume types of block storage. For more information about how OpenStack and Tivoli Storage Productivity Center interact, see 2.5.1, “OpenStack software” on page 41.

When requesting a new volume in OpenStack, and a volume type that corresponds to a Tivoli Storage Productivity Center service class is selected, the OpenStack Cinder node will send a bundle of information to the Tivoli Storage Productivity Center server through the Storage Management API for Clouds (SMAC) API. Information in this bundle includes either or both worldwide port name (WWPN) and iSCSI initiator information, if available, and also includes host name, requested storage capacity, and service class information. If only one connection protocol, Fibre Channel or iSCSI, is available, Tivoli Storage Productivity Center will use only that connection. If both protocols are available, Tivoli Storage Productivity Center will first try the protocol specified as `preferred_protocol` in the `cinder.conf` file. The default is to use Fibre Channel first.

Note: The `cinder.conf` configuration file is placed in the `/etc/cinder` folder in the server where the Cinder driver was installed.

Tivoli Storage Productivity Center then uses this information to create a new volume on an appropriate subsystem, based on the service class definition. After the volume is created successfully, Tivoli Storage Productivity Center then returns a bundle of information back to the Cinder node through the SMAC API. The information included in this bundle is volume identifier information and connection information.

At this point, the OpenStack Cinder node passes this information to the OpenStack Nova node, and the Nova node will finish attaching the volume, provisioned by Tivoli Storage Productivity Center, to the OpenStack instance.

Tivoli Storage Productivity Center vSphere Web Client extension

With the Tivoli Storage Productivity Center vSphere Web Client extension, you can provision block storage in a vSphere environment.

The VMware vSphere Web Client extension communicates with the Tivoli Storage Productivity Center server through the SMAC API, similar to the Cinder driver. Information passed to the Tivoli Storage Productivity Center server includes block storage size, service class name, and capacity pool name.

If capacity is available, the Tivoli Storage Productivity Center server will then create a new volume on an appropriate subsystem, based on the information provided. After the volume is created, Tivoli Storage Productivity Center will also assign the volume to the hypervisor or, if a cluster, all the hypervisors in the cluster through Fibre Channel.

For an example of provisioning with the vSphere Web Client extension, see 6.2, “Use case: Provisioning by using Tivoli Storage Productivity Center vSphere plug-in” on page 163.

6.1.3 Tivoli Storage Productivity Center: Benefits of using agentless server

The benefits of using the *agentless server* feature of Tivoli Storage Productivity Center include provisioning and volume mapping reporting, and volume or application monitoring.

Provisioning and volume mapping reporting

With the agentless server feature in Tivoli Storage Productivity Center, you can provision volumes and see a view of mapped storage on a remote server without requiring deployment of a Storage Resource Agent (SRA).

This way is useful in situations where you cannot or do not want to deploy an SRA either for security restrictions in providing administration credentials, or to avoid loading a production server with agent code.

Figure 6-1 shows the server named vsc-db02. It was defined to Tivoli Storage Productivity Center as an agentless server.

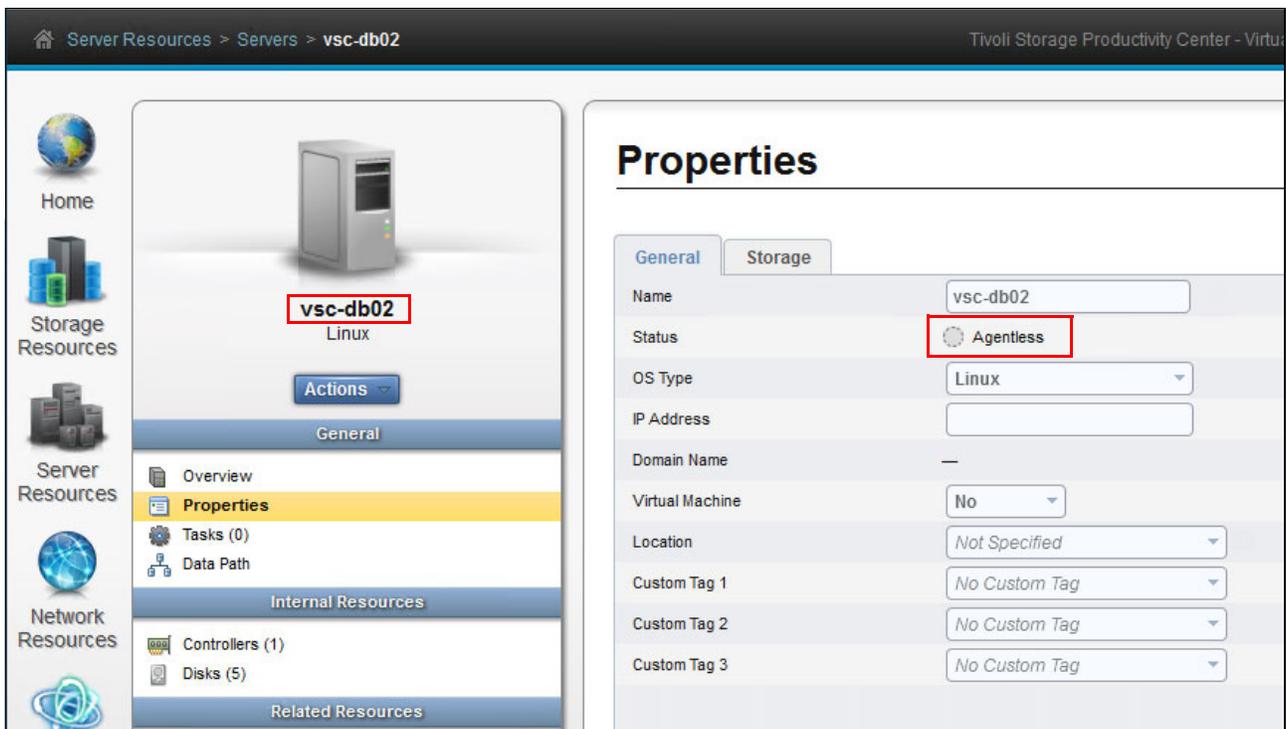


Figure 6-1 Properties panel of the agentless server named vsc-db02

Figure 6-2 shows that volumes that are mapped to this server and from which storage systems, the capacity of those volumes, and the number of paths to those volumes. This information is useful when troubleshooting performance issues on a specific volume or for a specific application. By using the agentless feature, you can narrow the search to which server the volume is attached, and to which application is using that volume.

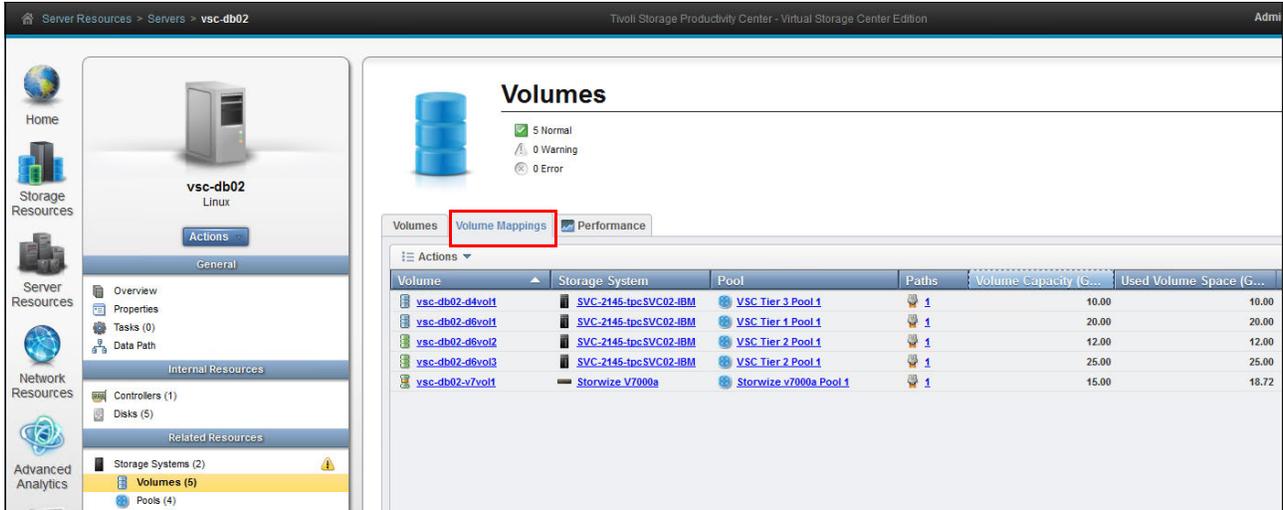


Figure 6-2 Volumes mapped to a server

The agentless server feature also allows you to provision storage directly to the server and choose what service class and capacity pool the volume is provisioned from, as shown in Figure 6-3 and in Figure 6-4 on page 146.



Figure 6-3 Provision storage

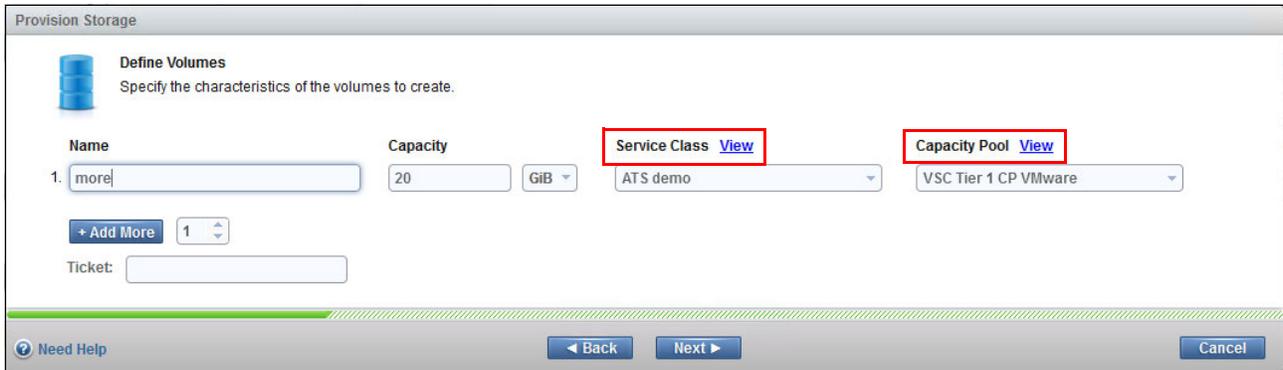


Figure 6-4 Volume definition

Volume or application monitoring

The agentless server can be added to your list of monitored servers without deploying an SRA. This will allow you to view usage and performance of storage that is mapped to that server as shown in Figure 6-5.

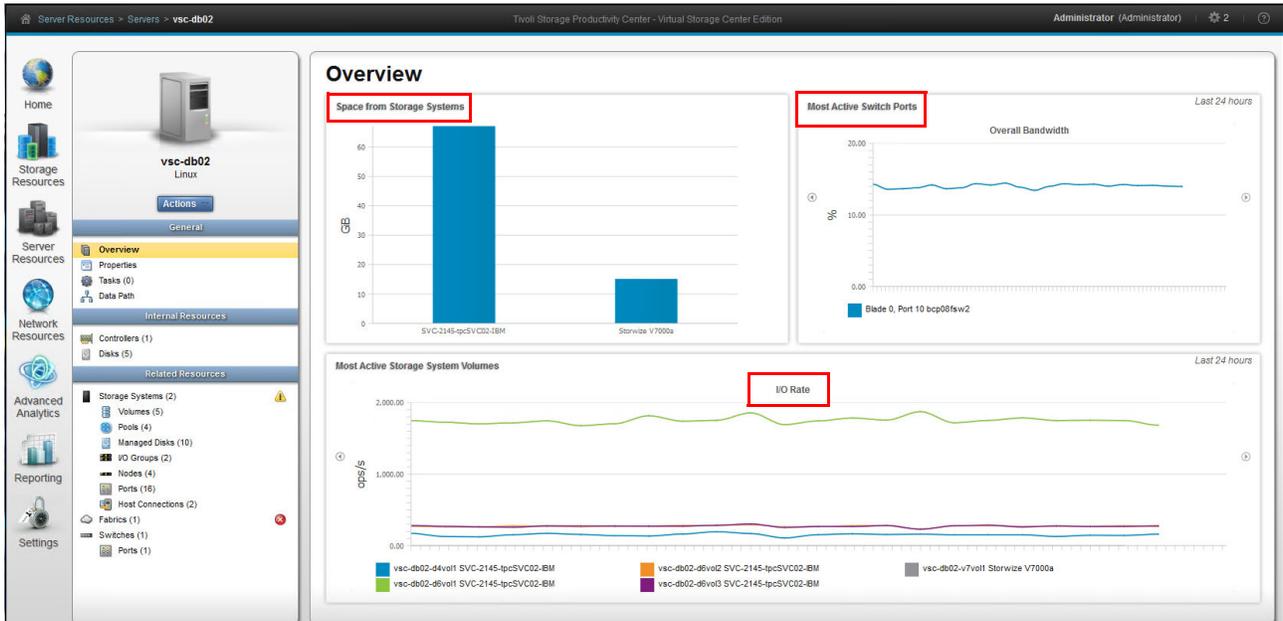


Figure 6-5 Agentless server overview

The agentless server feature can be beneficial for problem determination when an application experiences performance issues, or to help determine which server or application is driving high I/O or latency for a specific volume. By defining a server with the agentless feature, you can quickly determine which volumes are mapped to that server and which volumes are experiencing performance issues, as shown in Figure 6-6 on page 147.

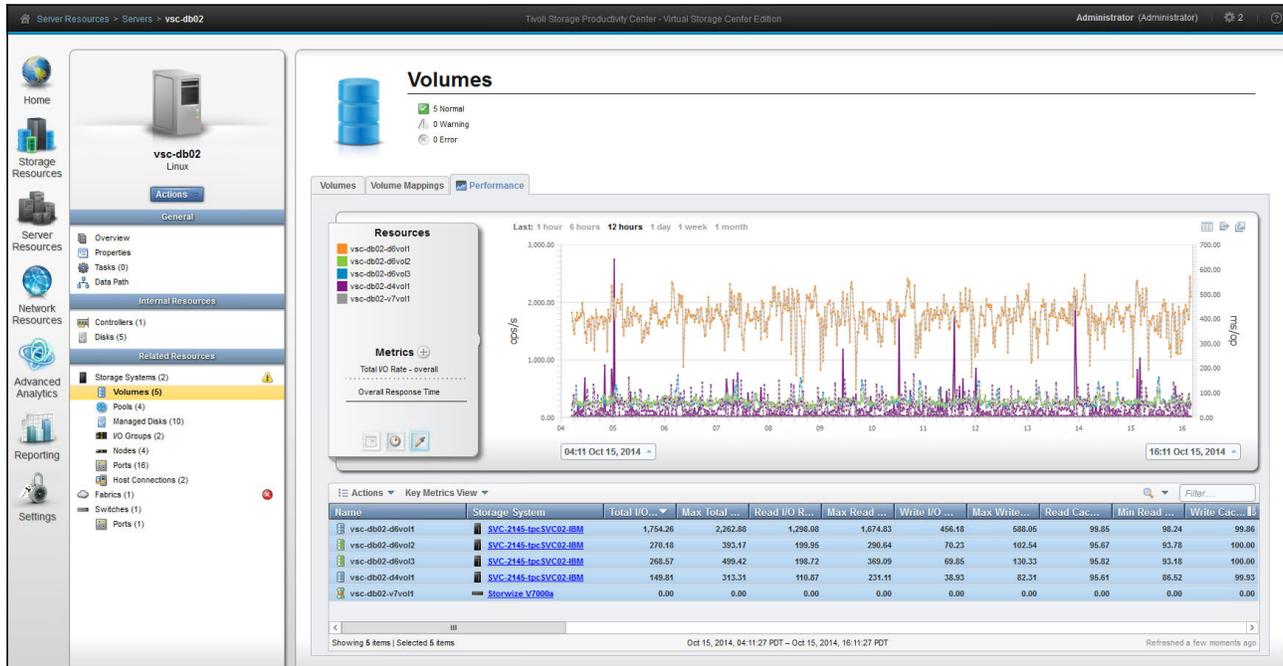


Figure 6-6 Agentless server volume performance

6.1.4 Planning for provisioning

When planning for storage provisioning, administrators must identify various attributes of their storage environments, such as these attributes:

- ▶ Existing pools and their unique characteristics (disk technology, RAID type, storage vendor, and subsystem type)
- ▶ Relative performance between the existing pools in order to assign them to a tier
- ▶ Logical groups of pools to optionally limit the provisioning of capacity from these groups (capacity pool)
- ▶ User profiles allowed to create provisioning requests, schedule, and run them
- ▶ Desired characteristics of each service class to be created (for example, requires thin provisioning, uses virtualization, has specific multipath policy for servers, is to perform automatic zoning, and so on)

The following sections explore these attributes, so administrators can plan accordingly before implementing automated storage provisioning with IBM SmartCloud Virtual Storage Center.

6.1.5 Organizing your storage environment into tiers

As a prerequisite step for cloud configuration and provisioning, you must assign storage pools to tiers. You can access a set of panels in Tivoli Storage Productivity Center web GUI, which explains details of cloud concepts. To access these panels from the navigation pane, select **Advanced Analytics** → **Provisioning** → **Learn the concepts**.

Storage tiering is a step toward defining service classes and provisioning volumes that require a certain tier level. It allows you to optimize the placement of volumes. It is also used in the Tivoli Storage Productivity Center optimization tasks (Analyze Tiering and Balance Pools).

Considerations for tiering

Carefully consider the organization of your storage environment and allowing for easily assigning separate categories of data to separate types of storage. One method to facilitate this process is to initially assign a tier level to all storage pools in your environment.

Although the tiers are used for only SAN Volume Controller and the Storwize family of products, for the optimization function, provisioning is supported even without SAN Volume Controller or Storwize products. Therefore, setting up the tiers for all storage pools in your environment makes sense. Even if you only perform provisioning at the SAN Volume Controller level, you can still use the tiers of back-end storage pools for reporting, filtering, or documentation.

Tip: A good practice is to avoid using Tier 10 if possible; most likely, you will *not* need all 10 tiers. When you start to use reporting, and sort a report by the label, the display will be similar to the following list, which is most likely not the preferred format:

- ▶ Tier 1
- ▶ Tier 10
- ▶ Tier 2
- ▶ Tier 3

A sample storage categorization is as follows:

- ▶ Tier 1. Leave this level available for future uses.
- ▶ Tier 2. SSD disk pools and flash disks pools
- ▶ Tier 3. Leave this level available for future uses.
- ▶ Tier 4. Hybrid pool
- ▶ Tier 5. Leave this level available for future uses.
- ▶ Tier 6. FC and SAS disk pools
- ▶ Tier 7. Leave this level available for future uses.
- ▶ Tier 8. SATA disk pool

Tivoli Storage Productivity Center V5 has 10 tiering levels

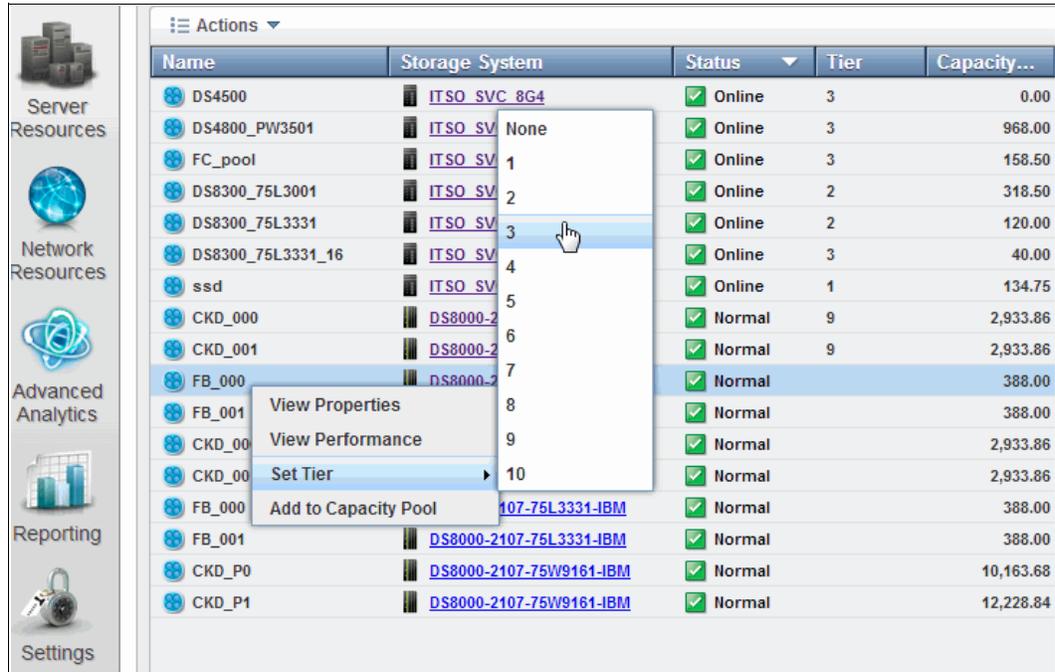
With Tivoli Storage Productivity Center V5, the 10 tiering levels of storage pools are available: tier 1 (best performing tier) through tier 10 (least performing tier). You can use as many levels of these tiers as you want, based on the various storage subsystems and disk technologies in your environment.

In the storage pools tiering process, consider those technologies not present in your storage environment, but that might be added in the near future. In this way, you are leaving space among tier levels for assignment later so that you do not need to reconfigure tiers and service classes if new technologies are added to your environment.

Assigning tiers

To assign a tier level to a storage pool, complete the following tasks:

1. Select **Storage Resources** → **Pools** from the navigation pane.
2. Right-click a pool (selecting multiple pools is also possible), select **Set Tier**, and select a tier level (Figure 6-7).



Name	Storage System	Status	Tier	Capacity...
DS4500	ITSO SVC 8G4	Online	3	0.00
DS4800_PW3501	ITSO SV	Online	3	968.00
FC_pool	ITSO SV	Online	3	158.50
DS8300_75L3001	ITSO SV	Online	2	318.50
DS8300_75L3331	ITSO SV	Online	2	120.00
DS8300_75L3331_16	ITSO SV	Online	3	40.00
ssd	ITSO SV	Online	4	134.75
CKD_000	DS8000-2	Normal	5	2,933.86
CKD_001	DS8000-2	Normal	6	2,933.86
FB_000	DS8000-2	Normal	7	388.00
FB_001	DS8000-2	Normal	8	388.00
CKD_00	DS8000-2	Normal	9	2,933.86
CKD_00	DS8000-2	Normal	10	2,933.86
FB_000	107-75L3331-IBM	Normal	10	388.00
FB_001	DS8000-2107-75L3331-IBM	Normal	10	388.00
CKD_P0	DS8000-2107-75W9161-IBM	Normal	10	10,163.68
CKD_P1	DS8000-2107-75W9161-IBM	Normal	10	12,228.84

Figure 6-7 Storage pool tier assignment

Tips:

- ▶ You can assign a tier to a pool on almost every storage pool table that gets displayed anywhere in the web GUI.
- ▶ You can filter and sort the table by storage system to easily find the pools where you want to set up tiers.

6.1.6 Service classes

Service classes enable provisioning automation through infrastructure abstraction, delegating the determination of the *best fit* for a storage resource to Tivoli Storage Productivity Center. Tivoli Storage Productivity Center accounts for all attributes of the service class that are specified in a provisioning request, and also current storage resource utilization (space, performance, and status) in order to identify the most appropriate resource for the new volume or share.

Service classes are a key point in mapping business requirements (capacity, accessibility, performance, and availability) in infrastructure capabilities (media type, disk technologies, RAID levels, encryption, compression, and thin provisioning).

Two types of service classes are available:

► **Block-storage service classes**

A block-storage service class describes attributes and capabilities of block storage resources. When you provision volumes, you specify the requirements by using a block-storage service class. Based on the requirements of the service class, Tivoli Storage Productivity Center identifies a storage pool for the volume.

Tivoli Storage Productivity Center V5.2 provides the following three predefined block-storage service classes. Although the classes are predefined, you might need to change them or adjust your tiers, RAID levels, and so on.

- Gold: Defined for mission-critical applications (highest-performing storage)
- Silver: Defined for applications in production (high-performing storage)
- Bronze: Defined for non-mission-critical applications (standard storage)

► **File-storage service classes**

- NormalIsolation: (normal isolation file storage) The file system from which the NAS share is provisioned can contain other NAS shares. Shared storage is allowed.
- EnhancedIsolation. (enhanced isolation file storage) The file system from which the NAS share is provisioned cannot contain other NAS shares. Dedicated storage required.

To determine which storage systems (block and file) are supported for provisioning, see the following web page. At the web page, select the version you want in the **Supported Products** → **Storage** column:

<http://www.ibm.com/support/docview.wss?&uid=swg21386446>

Tip: Starting with Tivoli Storage Productivity Center V5.2.1, you can use the candidate storage tab of the service class dialog to see the matching pools.

To access the Service Classes pane (Figure 6-8), use the navigation menu to select **Advanced Analytics** → **Cloud Configuration**, and then click **Work with Service Classes**.

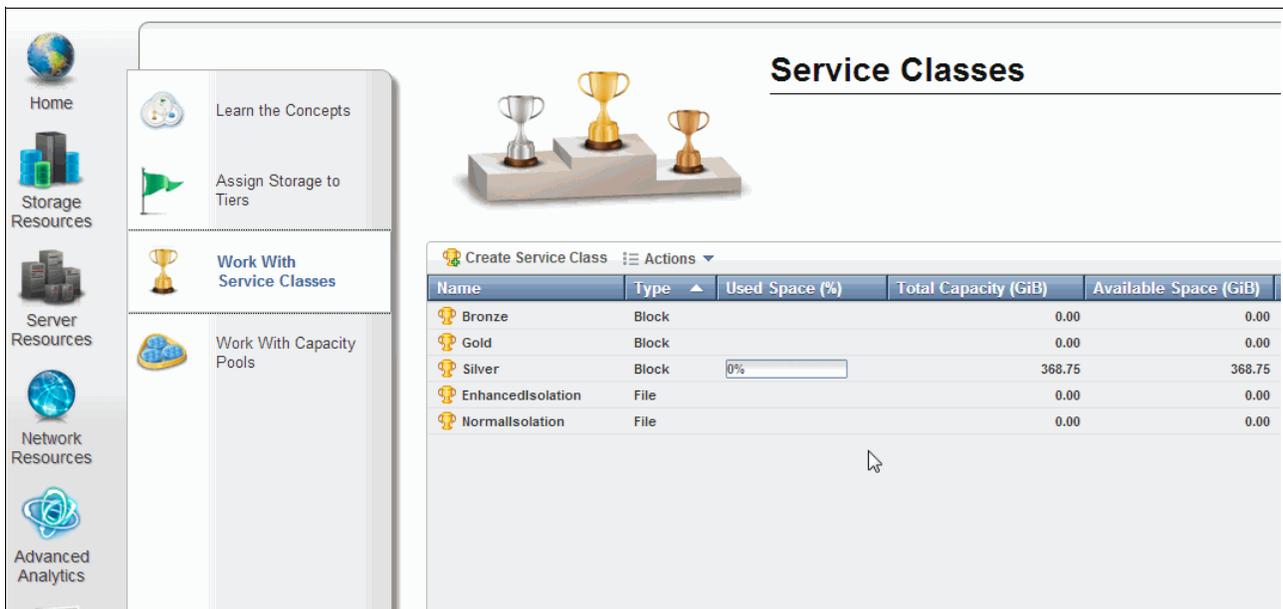


Figure 6-8 Service Classes pane

Note: If capacity is indicated in the Unavailable Storage column, this indicates storage where the status of the pool of storage system has issues, so it will not be used for provisioning.

From the Service Classes pane, you can view, edit, or delete existing classes. To define a new service class, click **Create Service Class** at the top of the Service Class list.

Note: To create a new block-storage service class, the IBM SmartCloud Virtual Storage Center (VSC) license is required.

Block-storage service classes configuration

From the Service Classes pane, double-click a service class or right-click and select **View/Modify**. Figure 6-9 shows the General Service Class properties pane for a block-storage service class.

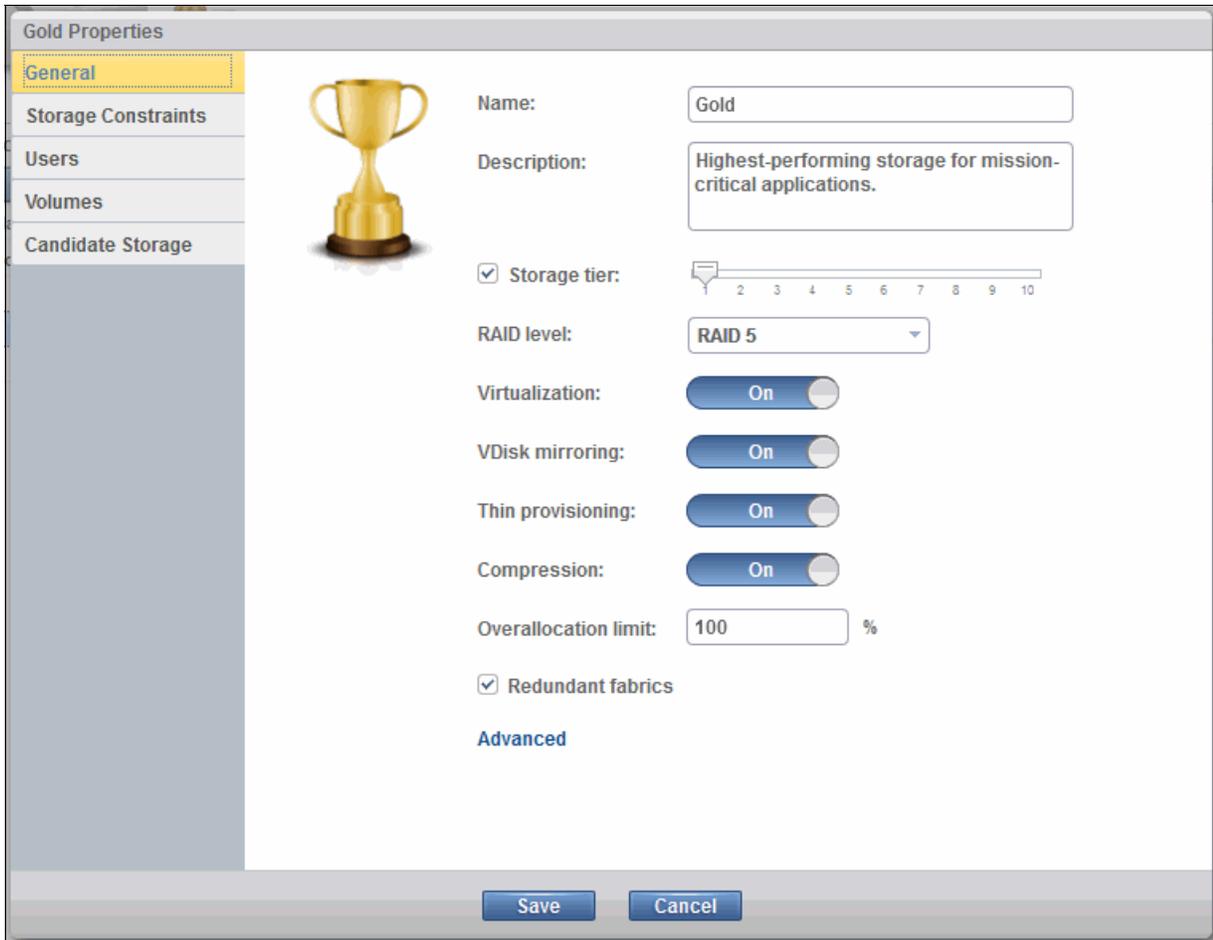


Figure 6-9 Block-Storage Service Class Properties pane: General

From this pane, you can customize the service class by editing its attributes.

Table 6-1 describes the General Block-Storage Service Class attributes and the related resources requirements.

Table 6-1 Block-Storage Service Class General attributes

Attribute	Resource requirements
Storage Tier	If enabled, storage pool must already be assigned to a tier value within the tier range that is specified in the service class.
RAID level	Storage pool's RAID level must match (select Any for exclude filtering on a RAID level).
Virtualization	On: Pool must reside on SAN Volume Controller or V7000. Off: Pool must not reside on SAN Volume Controller or V7000.
VDisk mirroring	On: Provisioned volumes are mirrored onto a second storage pool. Off: Provisioned volumes are not mirrored. (This option is enabled when Virtualization is set to On.)
Thin Provisioning	On: Pools need to allow Thin Provisioning. Off: None (except for XIV, where you must set Soft Space equal to Capacity to prevent thin provisioning).
Compression	On: Provisioned volumes are compressed. Off: Provisioned volumes are not compressed. (This option is enabled when Thin Provisioning is set to On. ^a)
Overallocation limit	XIV: Soft Space/Capacity (Soft Space divided by Capacity) must be less than the specified value. Other: "Virtual Allocation" must be lower than the specified value.
Encryption	On: Pool must be on a DS8000, encrypted, and configured in the same Encryption Group as is specified in the service class. Off: Pool must be not encrypted. ^b
Redundant Fabric	Checkbox selected. Full redundant paths through a minimum of two fabrics are used. Checkbox not selected. All available paths will be used (even single paths).
Resource tags	Storage resources or parent storage system needs to have all specified tags assigned.

- a. Tivoli Storage Productivity Center can create only compressed volumes in I/O groups that have at least one compressed volume already. If there is no I/O group with a compressed volume, Tivoli Storage Productivity Center considers this as though compression is not enabled on the SAN Volume Controller, Storwize V7000, or Storwize V7000 Unified system. This methodology is used to protect from a system that might have different node hardware; therefore, be sure to run compression only on certain I/O groups, or in similar situations.
- b. At the time of the writing of this book, if encryption is turned on, storage can be provisioned only directly from a DS8000, which has the corresponding encryption group configured.

Click **Advanced** to get to the pane for setting advanced properties (Figure 6-10 and Figure 6-11 on page 154). Set the properties on the pages of these tabs:

► Thin Provisioning tab

This page of this tab differs in its display depending on the virtualization switch selection in the General Properties pane (whether virtualization is *on* or *off*).

- If virtualization is *on* (see Figure 6-10)

Note: This display is available only if, on the General Properties pane, the Thin Provisioning option is set to **On**.

In this case, the tab indicates SAN Volume Controller and Storwize V7000. From the page you can set the initially allocated space. If the **Auto-expand** option is selected, you can define the granularity of the expansion and the warning level that will trigger a SAN Volume Controller alert.

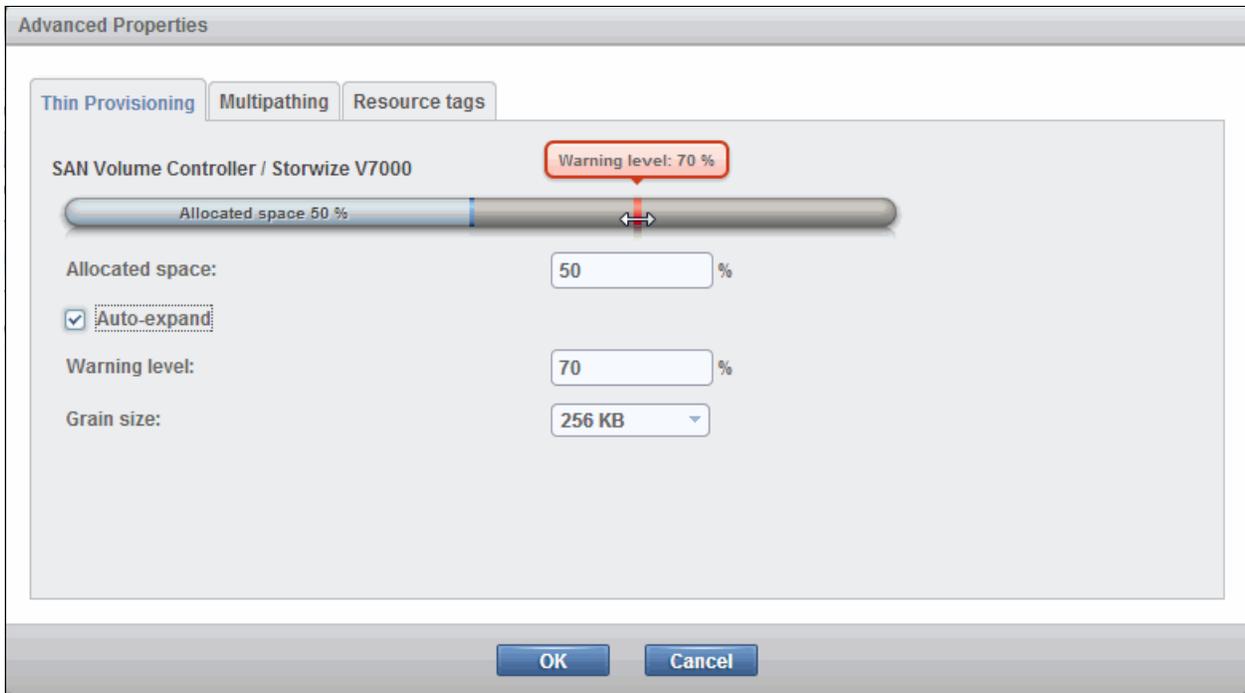


Figure 6-10 Thin Provisioning tab: Virtualization On

- If virtualization is *off* (see Figure 6-11)
In this case, the tab indicates XIV System. You can select the locking behavior of the pool in case it runs out of space.

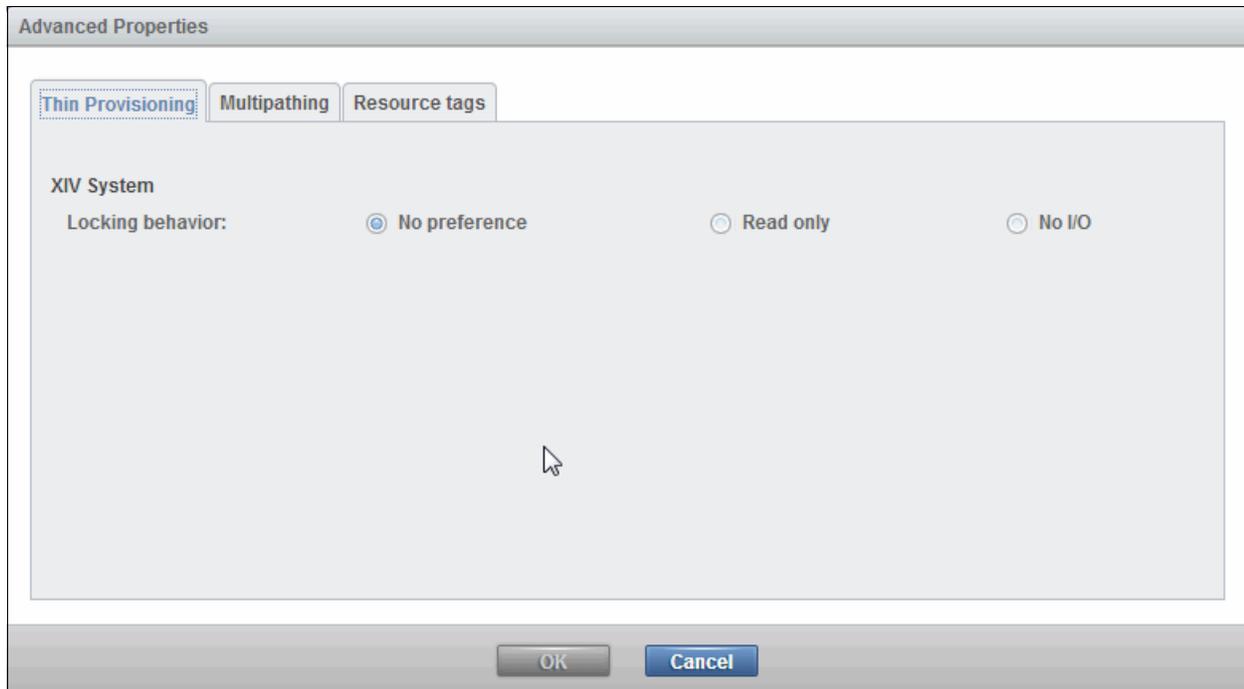


Figure 6-11 Thin Provisioning tab: Virtualization Off

- Multipathing tab

On the page of this tab (Figure 6-12 on page 155), you can select a multipathing policy (Load balancing, Round robin, or Fail-over), VMware vSphere policy (Default, Round robin, or Most recently used), and the number of paths that will be defined during provisioning (Auto, 4, 5, 6, 7, or 8).

Note: If **Auto** is selected, four paths are configured for IBM storage virtualizer, and two paths are configured for other storage systems.

Figure 6-12 on page 155 shows the Multipathing page, where the requirement conditions that must be met to use the multipath policy are listed.

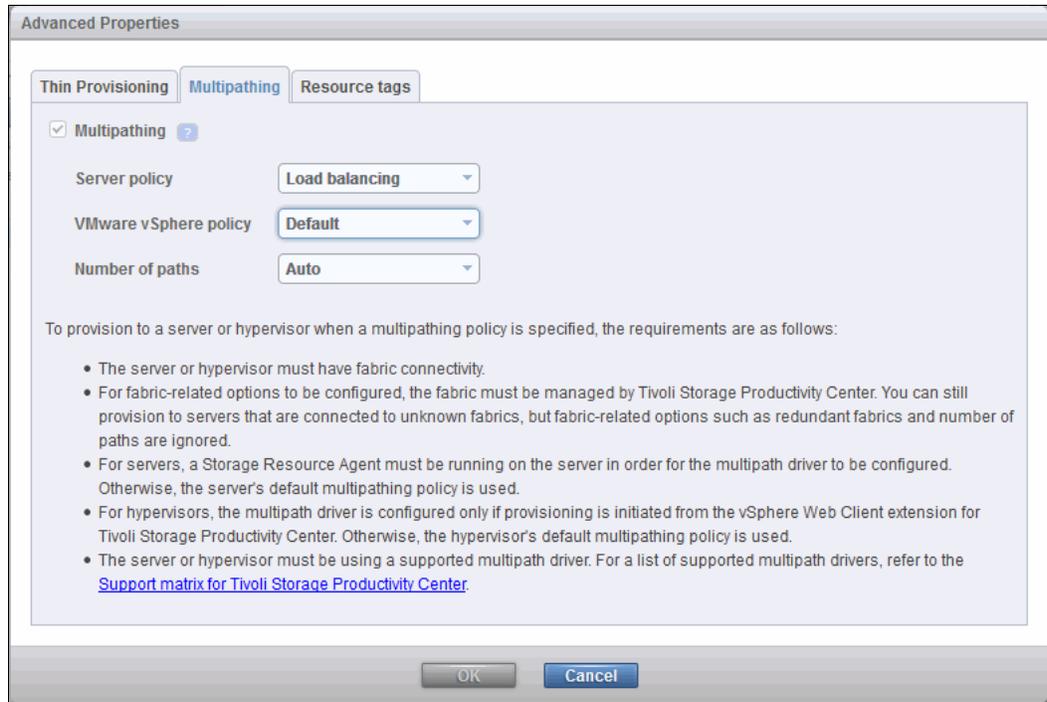


Figure 6-12 Block-Storage Service Class Advanced Properties pane

► Resource tags tab

Resource tags are used to refine the candidates for provisioning. You can define up to three resource tags from the tags that are available for selection in the drop-down box, or you can create your own tags by typing them in the input field. If resource tags are specified for the service class, only pools that have all the same tags are candidates for provisioning.

Figure 6-13 on page 156 shows the Resource tags page and some sample tags that can be used with a block service class.

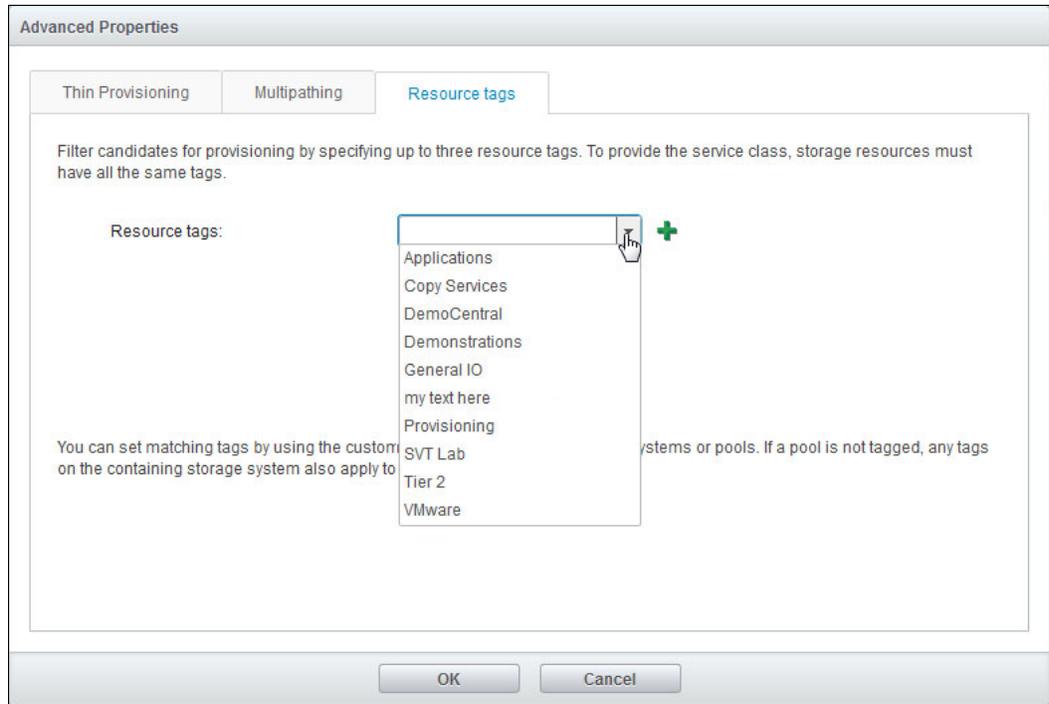


Figure 6-13 Resource tags available for block service class

File-storage service classes configuration

Figure 6-14 shows the **General** Service Class properties pane for a file-storage service class. To access this pane, go to the Service Classes pane, double-click a file-storage service class, or right-click and select **View** or **Modify**.

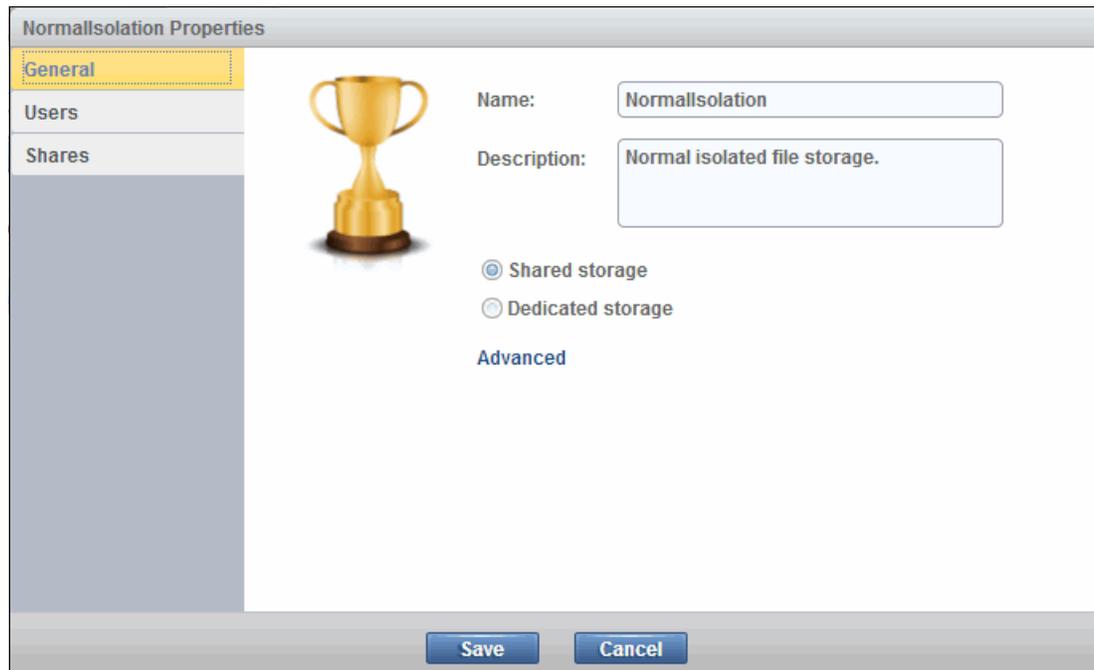


Figure 6-14 File-Storage Service Class Properties pane: General

From this pane, you can customize the service class by editing its attributes.

Table 6-2 list general file-storage service class attributes and related resource requirements.

Table 6-2 File-storage service class general attributes

Attribute	Resource requirements
Shared storage	Any SONAS or Storwize V7000 Unified file system with free space available, or unused SONAS Network Shared Disk (NSD) of type “Data, Metadata”.
Dedicated storage	Unused SONAS NSD of type “Data, Metadata”.
Resource tags	Storage resources or parent storage system needs to have all specified tags assigned.

Click **Advanced** to open the Advanced Properties pane and the two tabs shown in Figure 6-15.

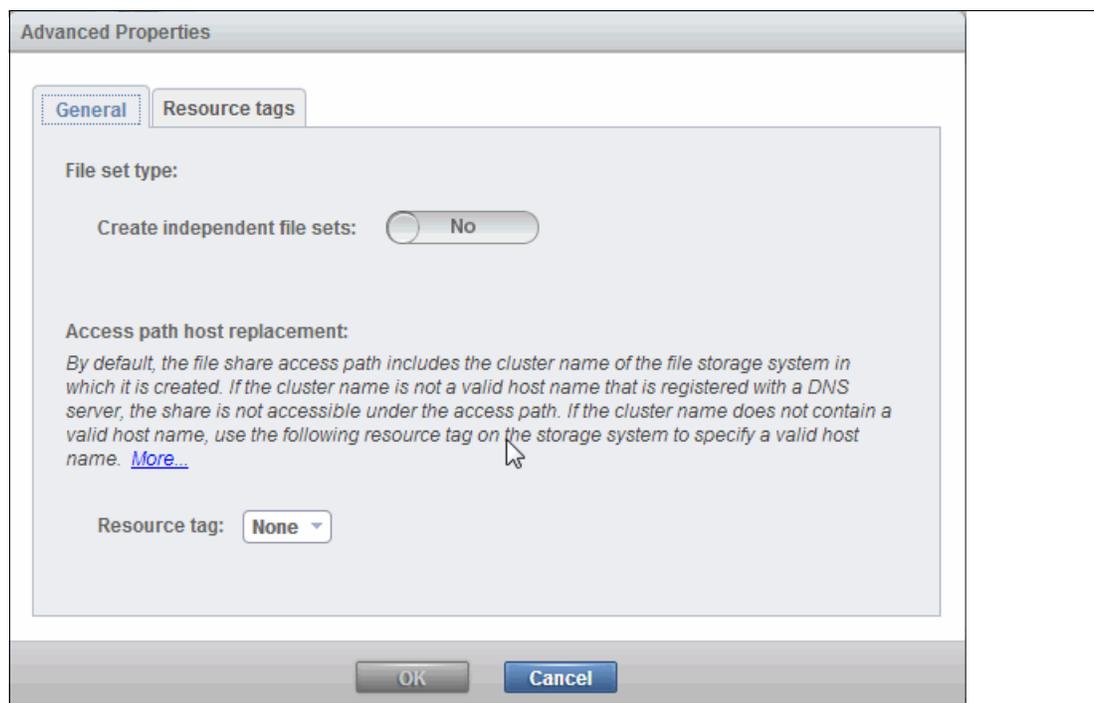


Figure 6-15 File-storage service class properties pane: Advanced

Set the properties on the pages of these tabs:

► General tab

On the page of this tab, you can set these properties:

- Specify whether you want to create an independent file set with its own allocated inodes. Otherwise, the file set is created as a dependent file set, and is allocated on the file system. Other considerations to think about with this decision about the file set type include snapshots, quotas, and Tivoli Storage Productivity Center alerts.
- Choose to set the access path host replacement to the custom tag that specifies the replacement host name. When the share is provisioned, the access path that is returned by Tivoli Storage Productivity Center includes the replacement host name, if one is specified on the custom tag for the storage system. If the storage system does not specify a value for the custom tag, the cluster name is used in the access path.

► Resource tags tab

This tab has the same functionality as the Resource tags tab for block-storage service classes (see “Block-storage service classes configuration” on page 151). Figure 6-16 shows the Resource tags page and some sample tags that can be used with a file service class.

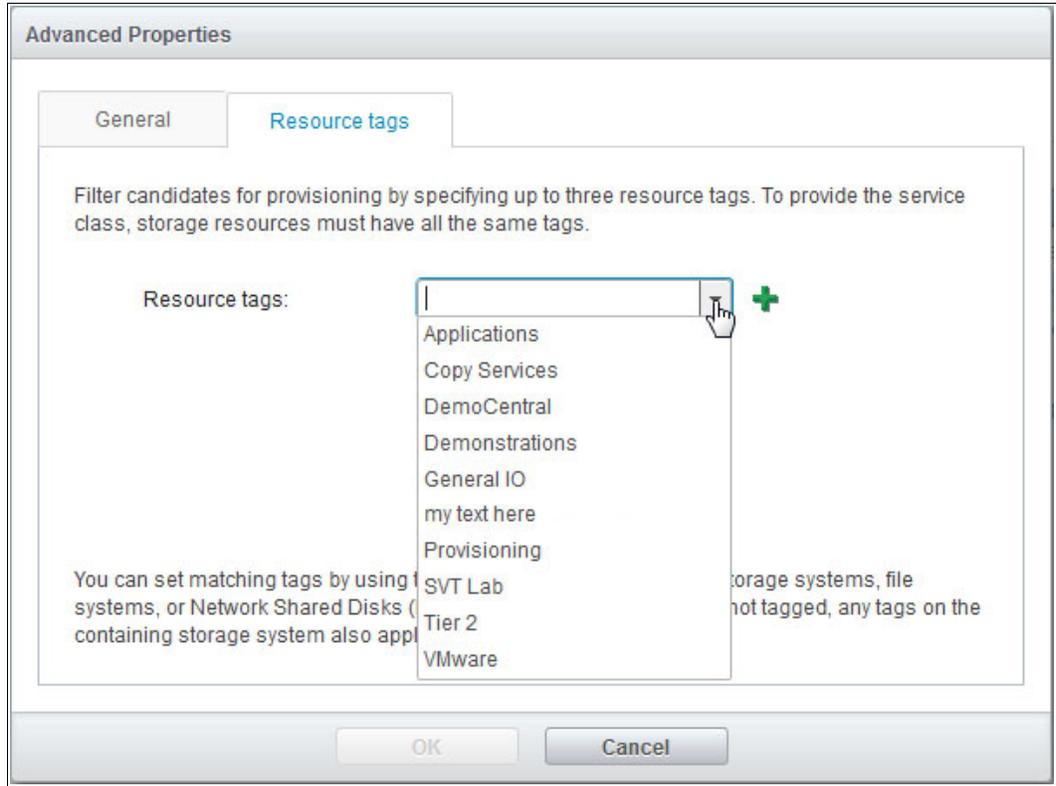


Figure 6-16 Resource tags available for file service class

Service class and users permissions

Tivoli Storage Productivity Center administrator can grant users the permission to provision by using the service class. The administrator can also specify whether scheduling or running provisioning tasks that are created by using the service class requires administrator approval.

To access the service class user permission pane, click **Users** in the navigation pane of the service class properties window. In our environment, for example, we defined a user with a Monitor Role, called TPCoperator, and allowed the user to define a provisioning task on the Bronze service class. See Figure 6-17 on page 159.

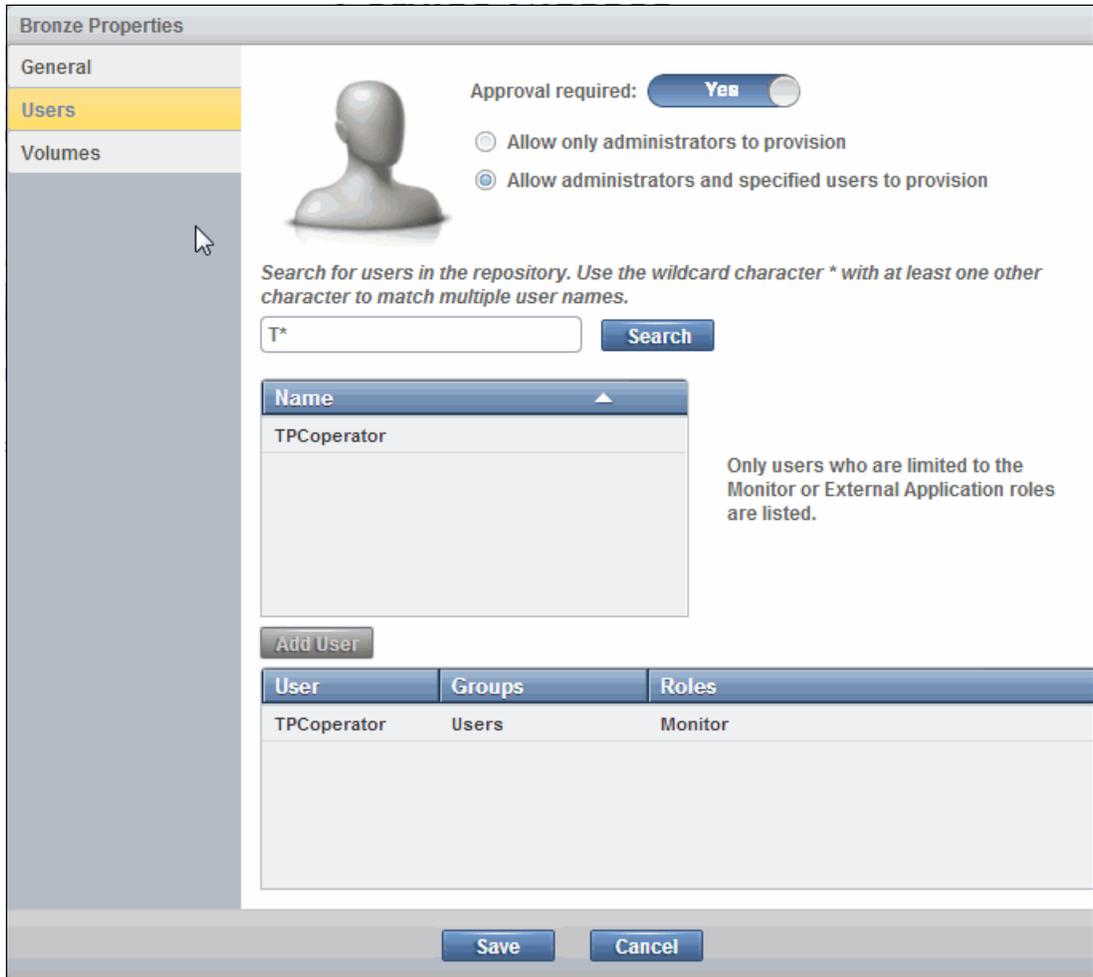


Figure 6-17 Block-Storage Service Class Properties pane: Users

Because the **Approval required** properties is set to **Yes**, the TPCoperator user can only define and save the task. An administrator can later schedule or run it.

Note: If **Approval required** is set to **No**, the defined user setting for TPCoperator, in addition to its monitoring role, can define and save the task, and also schedule or run it.

Optional: Associate capacity pools with the service class

A service class can be optionally associated with one or more capacity pools. See 6.1.7, “Capacity pools” on page 161 for details about capacity pools.

If capacity pools are defined, the Storage Constraints entry will be available in the navigation pane of the Service Class window. See Figure 6-18.

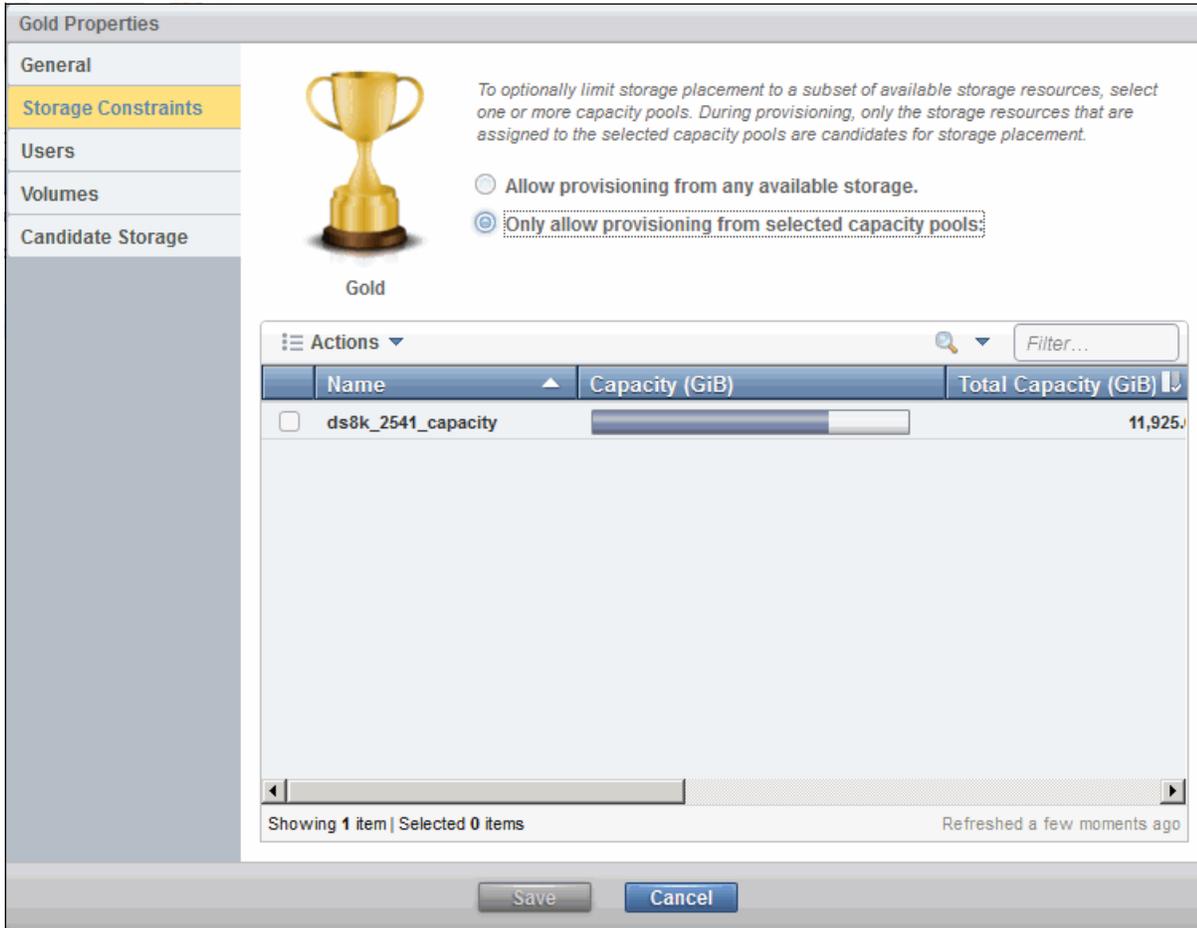


Figure 6-18 Storage Constraints pane

Candidate storage

Storage pools that satisfy all requirements of a service class are listed in the Candidate Storage pane (Figure 6-19). All criteria must be satisfied or the storage pool will not be listed. In the example, `test_service_class` was created with the requirement of storage tier 10 at any RAID level. Only the volumes that met all criteria are displayed.

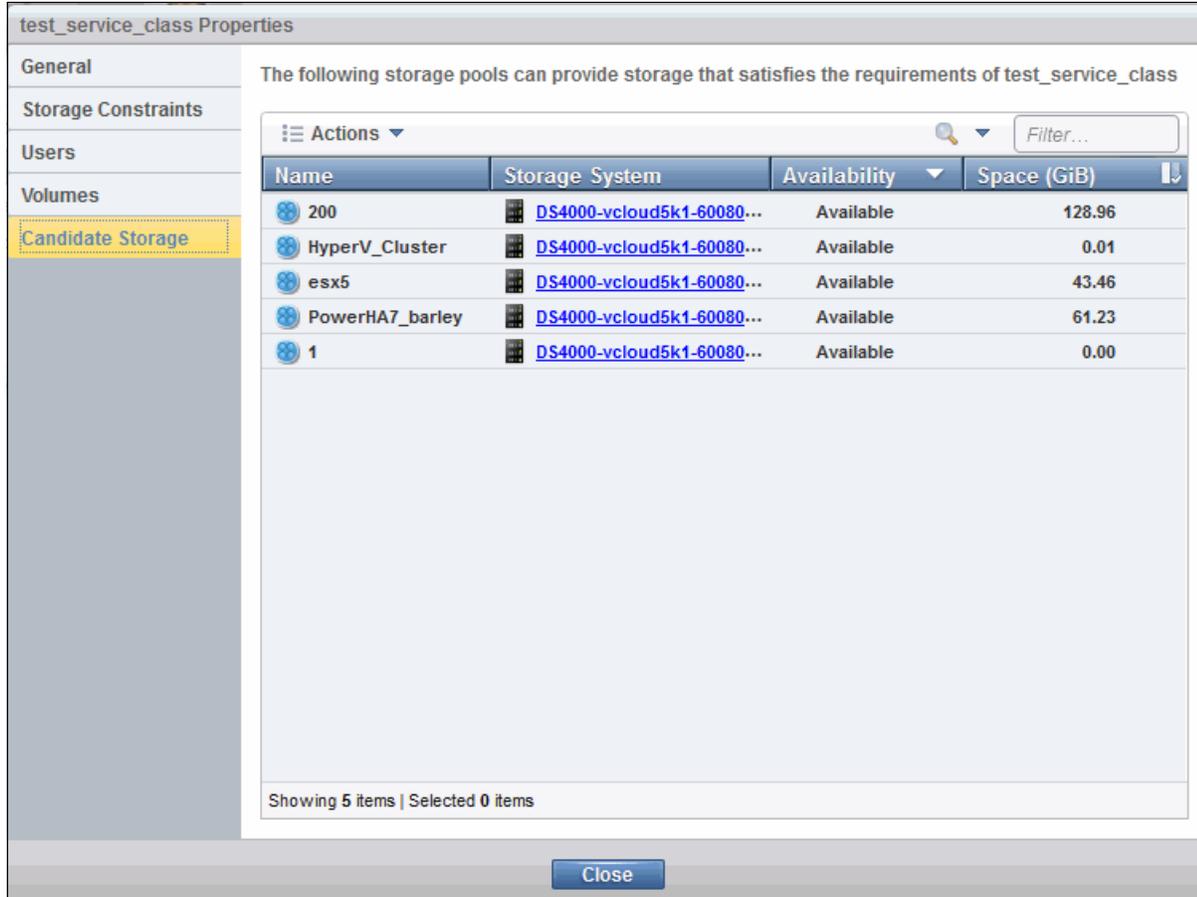


Figure 6-19 Service class candidate storage

6.1.7 Capacity pools

A capacity pool is a logical grouping of the following resources:

- ▶ Storage systems
- ▶ Storage pools
- ▶ File systems of file storage systems
- ▶ IBM Scale Out Network Attached Storage (SONAS) Network Shared Disks (NSDs)

Organizing storage resources in separate capacity pools in any way that serves the required business needs is possible. For example, it can be used to separate storage resources that are installed in geographically separate sites, or that must be allocated for separate divisions (and also for separate customers).

By organizing resources in capacity pools, you can track the storage use for each division separately, and restrict provisioning requests to the appropriate set of storage resources, by restricting the service classes to specific capacity pools.

Optional: The use of capacity pools is optional.

To access the Capacity Pools pane, complete the following steps:

1. From the navigation menu, select **Advanced Analytics** → **Cloud Configuration**.
2. Click **Work with Capacity Pools** as shown in Figure 6-20.

From this pane, you can select the available resources in your environment that you can assign to a capacity pool, by clicking the corresponding link.

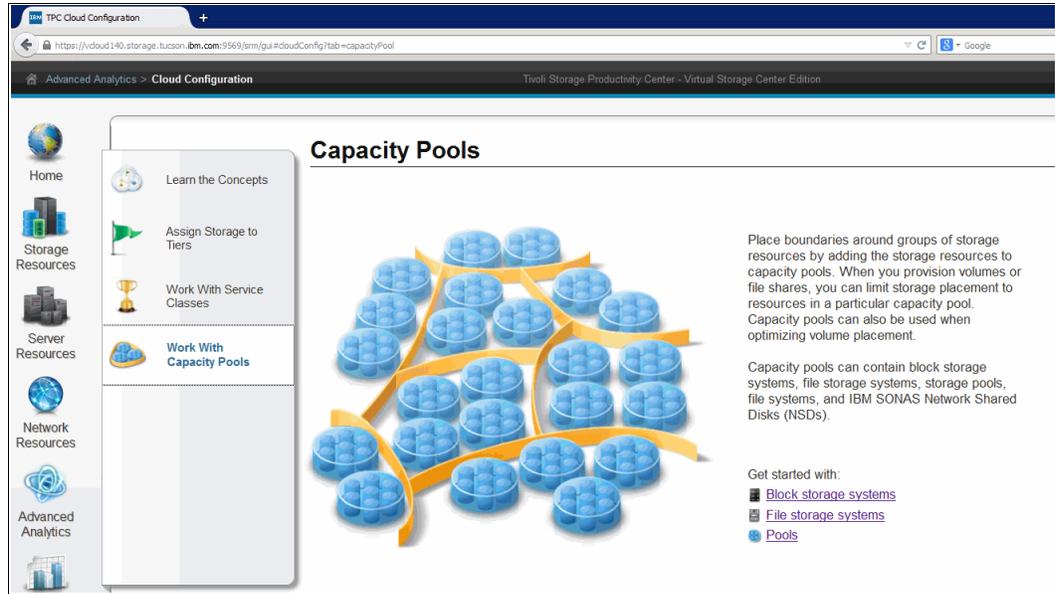


Figure 6-20 Capacity Pools pane

To assign a resource to a capacity pool, complete the following steps:

1. Go to the resource pane, right-click the resource, and select **Add to Capacity Pool**.
2. If your environment does not have any capacity pools, the Create Capacity Pool pane opens (Figure 6-21).

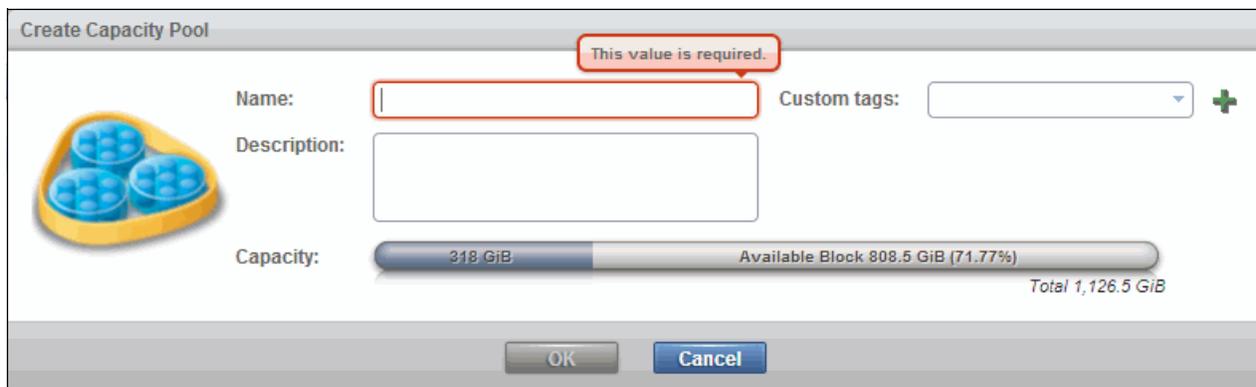


Figure 6-21 Create Capacity Pool pane

3. In the Create Capacity Pool pane, you define a new capacity pool. enter a name for the capacity pool and optionally a description and up to three tags.

When you add a storage system to a capacity pool, note that any storage pool, file system, or IBM SONAS NSD that is an internal resource of that storage system is also indirectly assigned to the capacity pool.

Restriction: A resource can be assigned to only one capacity pool. When you attempt to add more resources to a capacity pool, and those resources are already assigned to a different capacity pool, Tivoli Storage Productivity Center displays a message that lists the resources and their capacity pool assignments. When a message is displayed, ensure that you want to change the capacity pool assignments for the listed resources.

4. If capacity pools are already defined, the Adding Resources pane opens (Figure 6-22). Select a capacity pool and click **Save**.

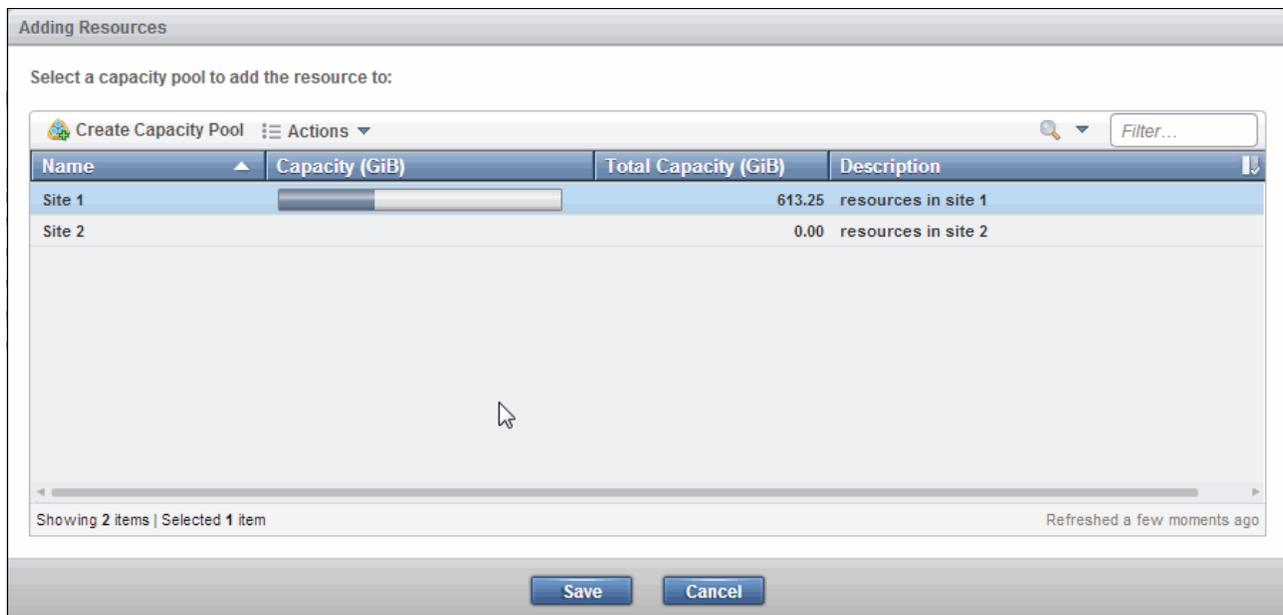


Figure 6-22 Adding Resources pane

6.2 Use case: Provisioning by using Tivoli Storage Productivity Center vSphere plug-in

This use case describes an example of how Virtual Storage Center (VSC) can be used so that the *VMware administrator* can provision storage without requiring intervention from the *storage administrator*.

This use case demonstrates how a VMware administrator can provision storage by using the Tivoli Storage Productivity Center vSphere plug-in with minimal interaction of the storage administrator. This is not intended to be a detailed setup process.

We completed the following steps in preparation for this use case:

- ▶ Configured a data source for the VMware vSphere environment, either a single ESX server or VMware vSphere server, to the Tivoli Storage Productivity Center server.
- ▶ Configured the data source for the storage subsystem. In this case we are using SAN Volume Controller, which was defined to the Tivoli Storage Productivity Center Tivoli Storage Productivity Center server.
- ▶ Created a user ID on the Tivoli Storage Productivity Center server that we used to define the Tivoli Storage Productivity Center vSphere plug-in to the vSphere web GUI. This user ID was also authorized to allow provisioning permissions when we defined the service class on the Tivoli Storage Productivity Center server.
- ▶ Created a service class and assigned capacity pools on the Tivoli Storage Productivity Center server.
- ▶ Registered the Tivoli Storage Productivity Center vSphere plug-in on the vSphere server.

For details about the steps, see the following web page:

http://www.ibm.com/support/knowledgecenter/SSNE44_5.2.4/com.ibm.tpc_V524.doc/fqz0_t_vm_deploying_extension_locally.html?lang=en

We used the following steps:

1. Configure the VMware vSphere environment to the Tivoli Storage Productivity Center server, as shown in Figure 6-23. We use the *oden* ESX server name throughout this case.



Figure 6-23 VMware ESX servers as shown in Tivoli Storage Productivity Center GUI

2. Define the data source for the storage subsystem that is being used for the back-end storage for our VMware data stores. For this case, we use a Storwize V7000 named *Storwize V7000-2076-v7000-storea-IBM* (Figure 6-24 on page 165).

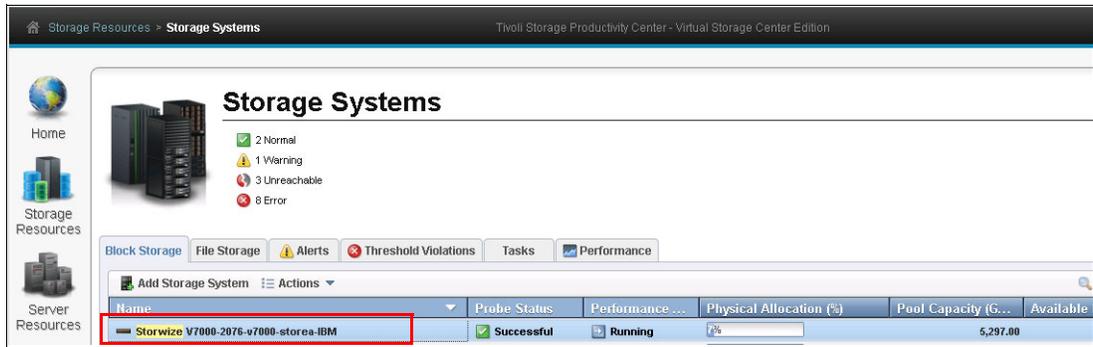


Figure 6-24 Storage subsystem data source as shown in Tivoli Storage Productivity Center

3. Define a group and user account on the Tivoli Storage Productivity Center server that we use for our service class, then we add the group in the Tivoli Storage Productivity Center GUI. For this case, the group name is *vmware* and the role that is assigned to the group is *External application*, as shown in Figure 6-25.



Figure 6-25 User Management in Tivoli Storage Productivity Center

4. Define *vmware* as the capacity pool name (1 in Figure 6-26) and assign storage (2) to it.

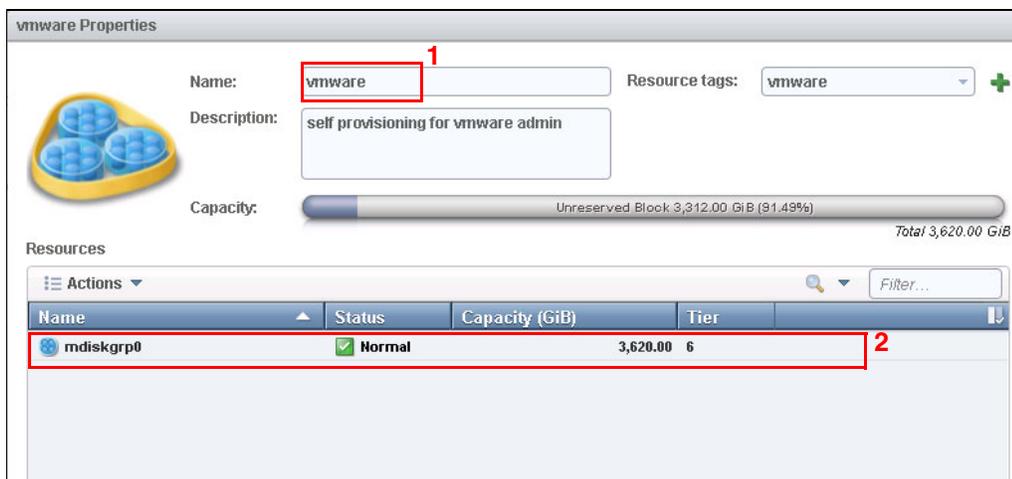


Figure 6-26 Capacity pool properties page

5. After the capacity pool is defined, create a service class named *vmware* (Figure 6-27).

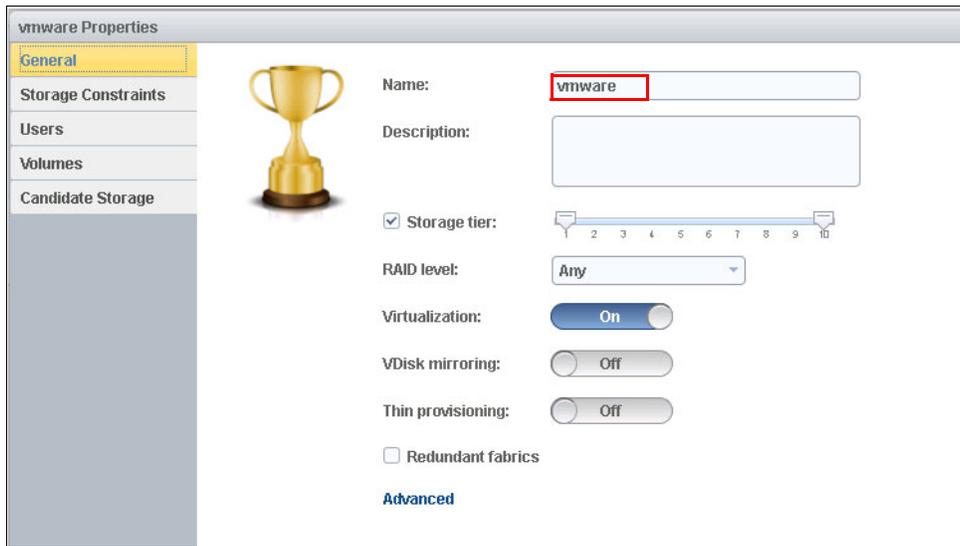


Figure 6-27 Service class general properties panel

6. Assign the capacity pool to the service class (Figure 6-28).

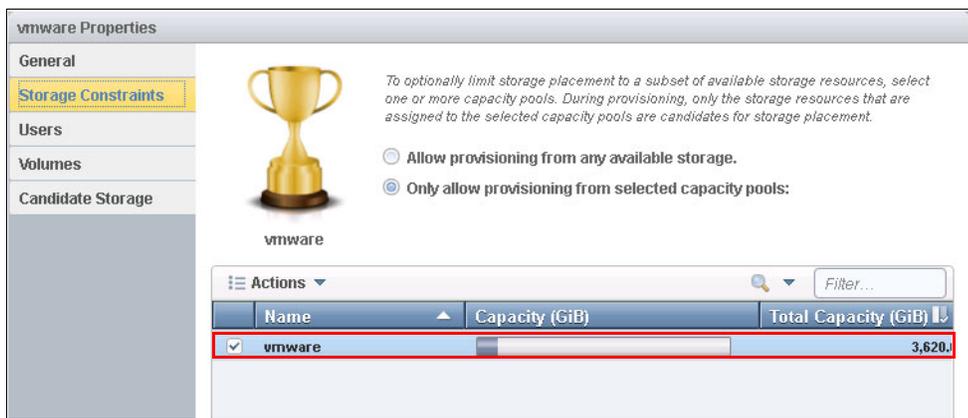


Figure 6-28 Capacity pool named *vmware* assigned to service class named *vmware*

7. We also define the user with *provisioning permission* to this service class (Figure 6-29).

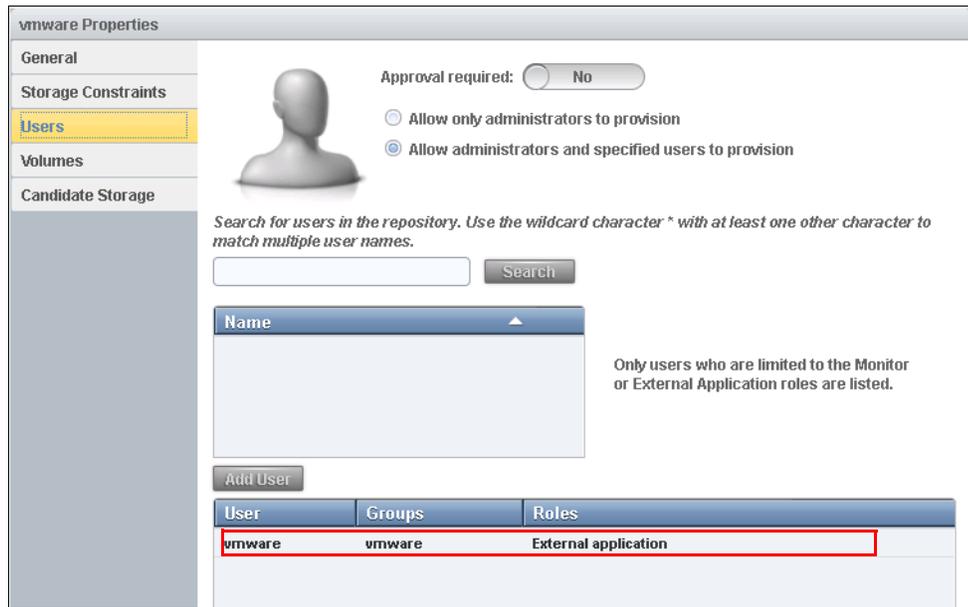


Figure 6-29 Restricting service class access to a specific user

8. After we configure all the items on the Tivoli Storage Productivity Center server, we register the Tivoli Storage Productivity Center vSphere plug-in on the VMware vSphere server (Figure 6-30).

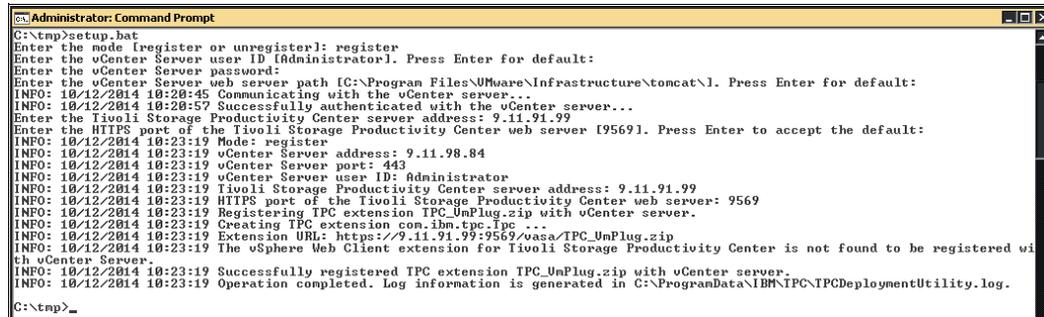


Figure 6-30 The plug-in registration

9. After the plug-in is registered, we log in to the VMware vSphere Web Client and save the user ID and password we want the vSphere server to use to connect to the Tivoli Storage Productivity Center server for the provisioning tasks (Figure 6-31).

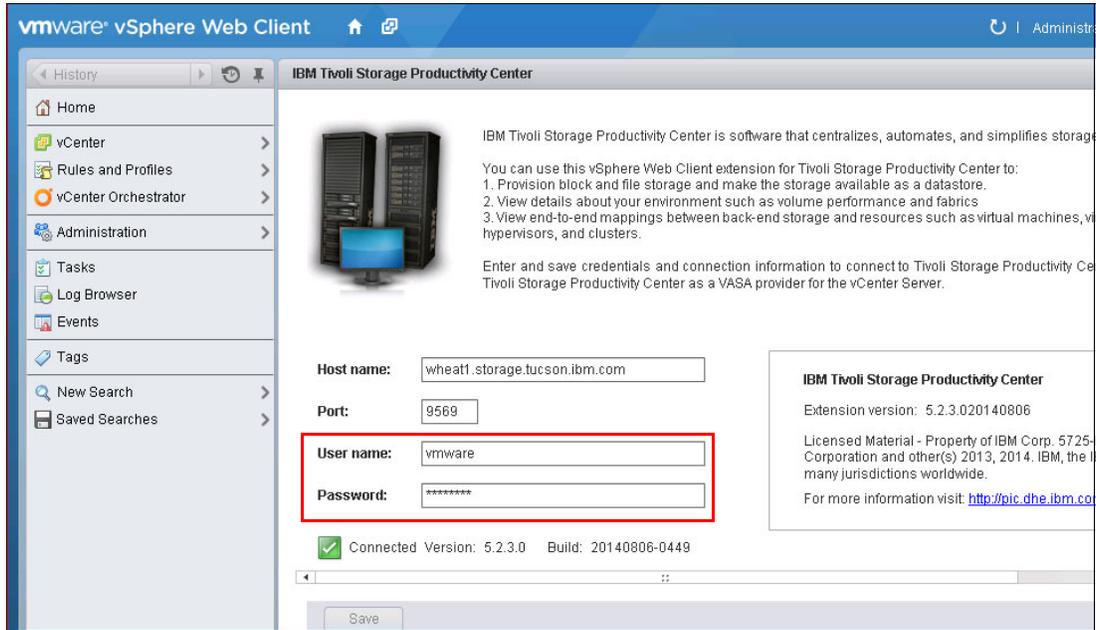


Figure 6-31 Tivoli Storage Productivity Center user ID defined in the vSphere web client

10. Now that our Tivoli Storage Productivity Center server and our vSphere Web Client are configured, we are able to provision storage from the vSphere Web Client, which is based on the service class, capacity pool, and user permissions we just defined. In this use case, we provision a 5 GB volume to the ESX server named *oden*. To accomplish this, we right-click on **oden**, and then select **All TPC Actions** → **Provision Block Storage**, as shown in Figure 6-32 on page 169.

Note: In this type of scenario, only the designated storage pool can be provisioned. Even if more storage enclosures or pools are available in the same V7000, those cannot be managed by the Tivoli Storage Productivity Center vSphere plug-in.

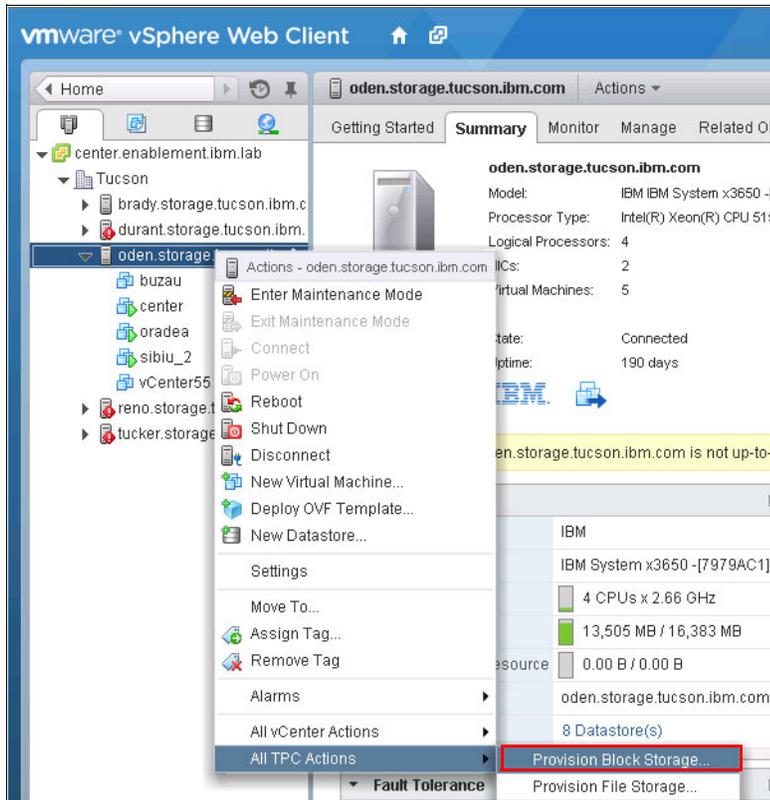


Figure 6-32 Provision action in the vSphere web client

11. This action opens a *provisioning pane*, in this example **Provision Block Storage**. This is where you can choose the size for the volume, service class, and capacity pool you want to provision storage from. In this use case, we give vmware user access to only one service class and one capacity pool (Figure 6-33).

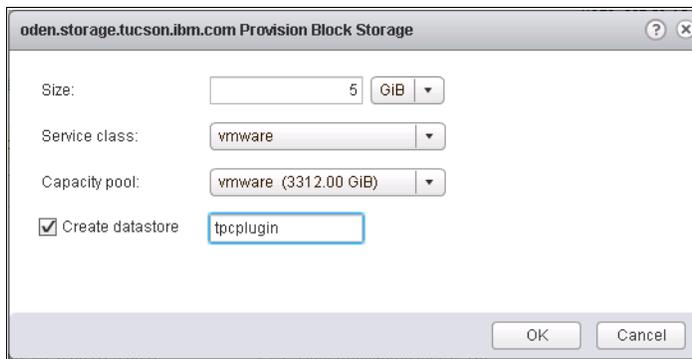


Figure 6-33 Provisioning a volume and creating a data store

12. After executing the task, we look in the Tivoli Storage Productivity Center GUI to see that the provisioning task is running (Figure 6-34).



Figure 6-34 Running provisioning task as seen in Tivoli Storage Productivity Center

13. In several minutes, the provisioning task is complete. We can now view the newly created volume and data store in the vSphere web GUI (Figure 6-35).

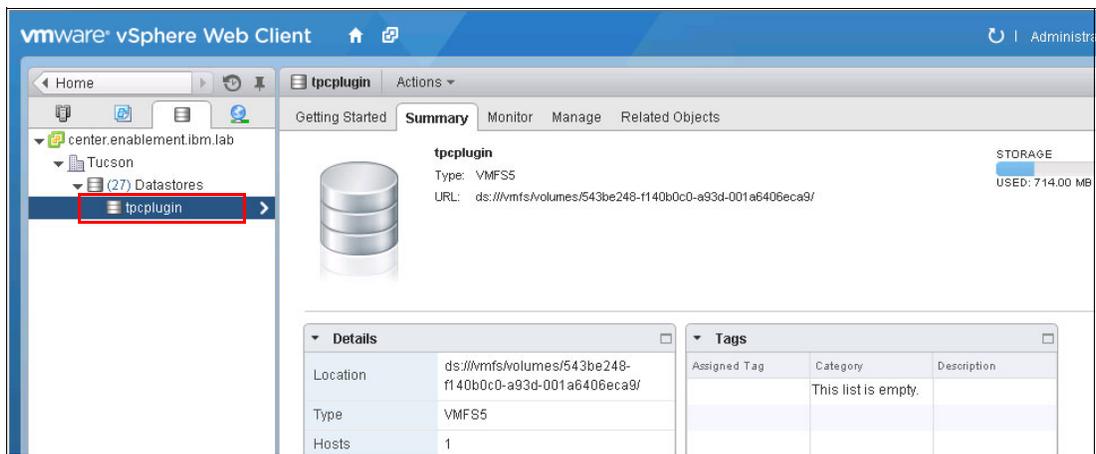


Figure 6-35 Newly created 5 GiB data store.

In this use case, we demonstrate how customers can provision a volume and create a data store by using the integration that provided by the Tivoli Storage Productivity Center vSphere plug-in. We also show how to restrict who has access to provision storage and what class of storage we can restrict the users to.

Note: In addition to the Tivoli Storage Productivity Center vSphere plug-in, the vStorage API for Array Integration (VAAI) is also supported for provisioning storage.



Storage optimization

In this chapter, we describe storage optimization functions that are available with IBM SmartCloud Virtual Storage Center (VSC). Storage optimization functions help you to optimize your storage environment by improving performance and better utilizing storage resources.

Storage optimization functions use real performance data of the managed storage environment. By using this data, relative activity score of storage resources is calculated. According to the activity score, Tivoli Storage Productivity Center, the storage management interface, proposes recommendations made by VSC, which you can then run in your virtualized environment.

7.1 Storage optimization functions and processes

Storage optimization functions in VSC are part of advanced storage analytics, which help you to improve performance of your storage environment and to better use storage resources. By using the advanced analytics, storage optimization functions can do these tasks:

- ▶ Storage optimization: Balance the workload of volumes across storage pools
- ▶ Volume optimization: Move volumes from a higher tier to a lower tier and vice versa
- ▶ Volume transformation: Transform volumes, for example, convert volumes from fully allocated to thin-provisioned or compressed, or vice versa.

Storage optimization functions work on a volume level in a virtualized environment where the scope of optimization functions are within one storage virtualizer (SAN Volume Controller cluster or Storwize V7000). If you have one storage virtualizer in your environment that is running production systems and another storage virtualizer that is running test and development systems, optimization is done for each storage virtualizer separately.

Several steps are required before you can use storage optimization functions to optimize an environment:

- ▶ Set the tier level of the storage pools that you want to analyze.
- ▶ Probe the storage virtualizers.
- ▶ Collect performance data to gauge the utilization percentage for pools and the average workload activity of the volumes.

Note: For more details about advanced analytics and storage optimization, see *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204.

Setting tier levels

Tivoli Storage Productivity Center provides 10 tier levels that can be assigned to storage pools. For storage optimization functions you need to set only a tier for storage pools of storage virtualizers (SAN Volume Controller or Storwize V7000). Even if you are not using optimization functions, a good practice is to use tier levels; tiering allows you also to group, sort, and filter similar storage pools and create reports based on the tier level.

Setting tier levels is done in Tivoli Storage Productivity Center web GUI from navigation pane. To assign a tier level to a pool, see “Assigning tiers” on page 149.

Probing and collecting data for storage virtualizers

Storage optimization functions require regular data collections for each storage virtualizer. By default, when you add a device through the Configure Device Wizard, you configure a time for probe and performance collections. Probe jobs run against each device to update the asset level details known about each device. Performance jobs run against each device to collect performance details of the asset within the array. You can also modify the start and stop times for these jobs on the details page for the array.

To check data collection jobs for storage virtualizer, complete the following tasks:

1. Select **Storage Resources** → **Storage Systems** from the navigation pane.
2. Double click the Storage Systems for which you want to check data collection jobs.
3. From Storage System details pane, click **Data Collection**; the Data Collection pane shows details of the probe and performance monitor jobs (Figure 7-1 on page 173).

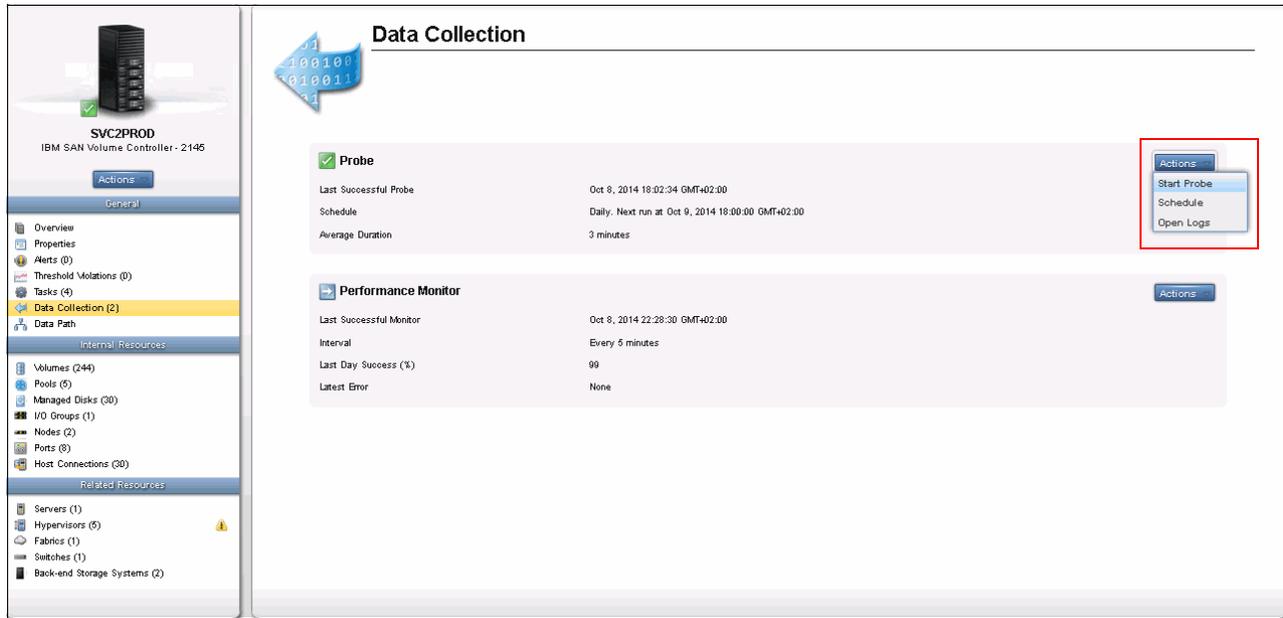


Figure 7-1 Data Collection jobs

If probe jobs are not running for the selected resource, select **Actions** → **Start Probe** (Figure 7-1) to manually start a probe. The Start Probe action is available for the resources that you select if at least one of the resources meets the following criteria:

- ▶ A probe job is defined for the resource
- ▶ The probe job is enabled
- ▶ The probe job is not currently running

Probes are data collection jobs; they collect status and asset information about the monitored resources in your environment. When you add a storage resource to Tivoli Storage Productivity Center, a probe is automatically defined to run to collect status and asset information about the monitored resource. You can also schedule the probe job to run when appropriate for your environment.

Note: Probe jobs must run at least every day, but we suggest to start them manually before optimization tasks to be sure that you collect the most current information about your storage environment. If some changes occur in your storage resources, they will be collected with the probe job.

Collecting and analyzing performance data

Performance monitors collect data about storage virtualizer pools to provide a realistic estimate of the average workload activity of the volumes. When you use the Analyze Tiering wizard to analyze the tiering of volumes, performance data must be collected about the pools on the storage virtualizers that you select for analysis, and about the storage virtualizer pools that you select as target pools for the volumes that are analyzed. The collected performance data is used to determine the workload activity of the pools. The most active and least active pools are identified by comparing the activity of each pool to the average activity of the pools on the same tier and in the same storage system.

To determine the relative activity of the pools on the same tier and on the same back-end storage system, the following values are calculated:

- ▶ The current activity level of the pool
- ▶ The activity deviation percentage of the pool

Tip: On the Pools page, the activity level of the pool is shown in the Activity column. The difference between the activity level of the pool and all of the other pools on the same tier and storage system is shown in the Activity Deviation (%) column.

The formulas that are listed in Table 7-1 calculate the activity level and the activity deviation percentage for pools.

Table 7-1 Formulas for calculating the activity level and activity deviation percentage values for pools

Value calculated	Formula that is used in the calculations
Activity level of the pool	$[Read\ I/O\ Rate \times (1 - Read\ I/O\ Cache\ Hit\%)] \div Total\ Pool\ Capacity$
Activity level of the pool on XIV Systems	$(Total\ I/O\ Rate \div Total\ Capacity)$
Activity deviation percentage of the pool	$[(Pool\ Activity\ Level - Average\ Activity\ Level) \div Average\ Activity\ Level] \times 100$ <ul style="list-style-type: none"> ▶ A positive value indicates that the relative activity level of the pool is above average. ▶ A negative value indicates that the relative activity level of the pool is below average.

If the activity deviation percentage of the pool is in the range of <-10% to >10%, the pool is considered to be balanced. If the activity deviation percentage of the pool exceeds the deviation threshold of 10%, the pool is a candidate for balancing.

The minimum period for collecting performance data for storage optimization functions is one day but the preferred period for collecting performance data is 14 days or more. The period for collecting the performance data can provide an accurate reflection of the regular workload activity of the volume.

If, for example, the collected performance data covers a period of extreme workload activity, the average that is estimated does not reflect the regular workload activity of the volumes. Insufficient performance data, or performance data that does not reflect the regular workload activity of a volume, might affect the accuracy of the recommendations that are provided by the analysis.

To better understand how the storage optimization process is done and how analyzing tiers and balance pools functions work, see Figure 7-2 on page 175. It shows a sample storage environment that consists of four tiers and nine storage pools.

Capacity pools: Use of capacity pools is optional and is not shown in Figure 7-2. A capacity pool is a logical grouping of the following resources:

- ▶ Storage systems
- ▶ Storage pools
- ▶ File systems of file storage systems
- ▶ IBM SONAS Network Shared Disks (NSDs)

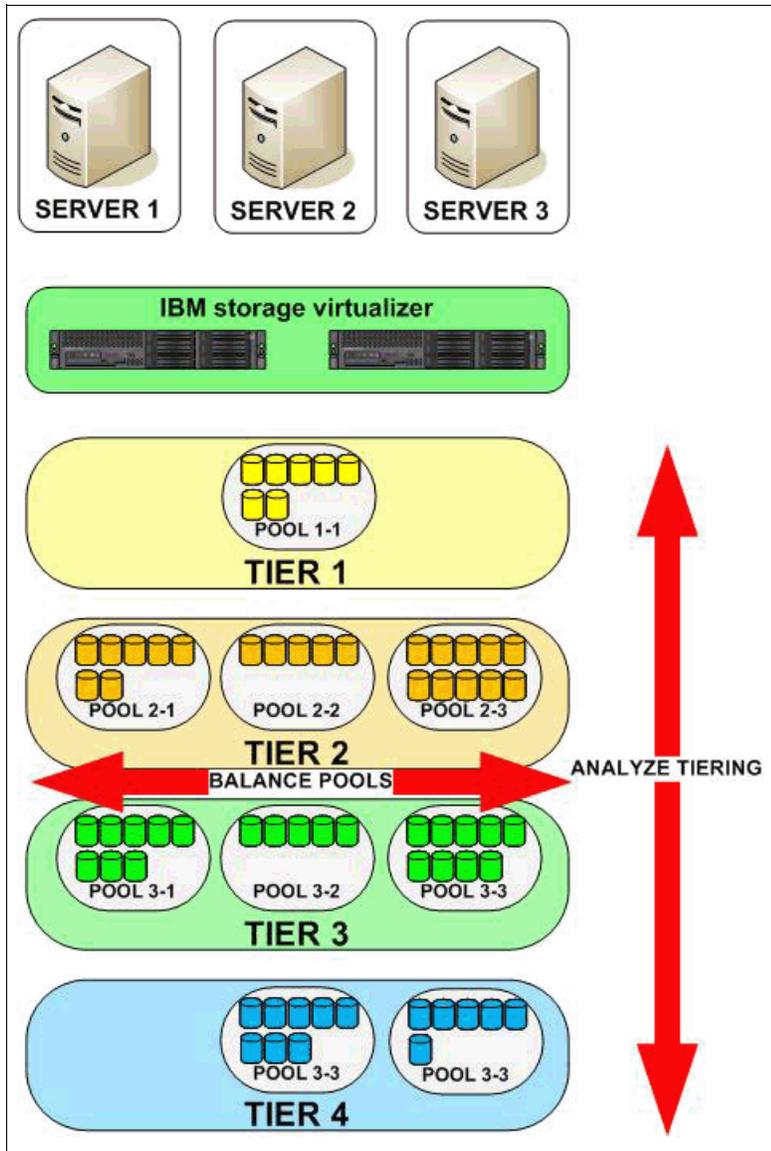


Figure 7-2 Storage optimization

The *balance pools* function is used to balance the workload of volumes across pools on the same tier. The pools are analyzed and recommendations are generated to move the volumes from pools with high-activity values to pools with low-activity values. For example in Figure 7-2 if you are balancing pools in Tier 3, a recommendation could be to move some volumes from Pool 3-1 and Pool 3-3 if the workload activity on those pool is higher than on Pool 3-2. In this example workload will be distributed within same tier.

The *analyze tiering* function provides a simple and unified optimization of volume placement in storage environment. For example, as shown in Figure 7-2, you might try to first balance the workload across Tier 2 to distribute the workload evenly across all Tier 2 pools. If however no balancing is required, you might consider to *analyze tiering* at the volume level to move volumes from Tier 2 up or down a tier based on the current activity of the volumes or pools.

The *volume transformation* function is also an optimization function. It is used to move volumes between pools and to convert volumes from fully allocated to thin-provisioned or compressed volumes, or vice versa.

The *storage optimization* process is done in the following steps:

1. Select resources for optimization.

The first phase of the storage optimization process is to select the resources. You can initiate the optimization tasks from many places in the Tivoli Storage Productivity Center web-based GUI either through the actions menus or when you right click an object. Depending on the type of object you selected (storage system, pool, volume, or server) you might not see all functions. For example, if you just recently selected volumes, the balance pool function is not available.

These are the contexts from which you can start the analysis:

- Server (either with SRA or Agentless)
- Hypervisors
- Storage systems
- Pools
- Volumes

With the exception of some panels in the Advanced Analytics menu, you can start the optimization from any panel that lists volumes or pools.

2. Define policy and specify parameters.

This part is specific to the type of optimization that you are running. We documented this for the two functions separately here:

- 7.2, “Balance Pools” on page 178
- 7.3, “Analyze Tiering” on page 185

3. Run the analysis.

The analysis first checks some prerequisites and then opens a wizard that displays informational messages. You can enter information such as thresholds. When you finish, you click **Analyze**. An analysis task is then created and runs in the background. If you do need to do other work, you can close the dialog, and return to that task later. The task is available in the context of the devices that are related to the task, and also on the Task tab of the Storage Systems and Tasks panel within the Home menu.

After the analysis completes and the results are displayed, you can change the default name of the analysis task to a more meaningful name. If you closed the wizard, you can open the results of the analysis task from one of the task panels. From the results of the analysis task, you can also take the action to schedule the analysis part to run repeatedly every scheduled number of days.

4. Review the recommendations.

Review the results of the analysis task. Either the wizard is still open, or you can go to a task panel, and double-click an analysis task to review the results.

5. Execute recommendation or schedule the execution to run later

If the recommendations are suitable, you can let Tivoli Storage Productivity Center implement them. Click **Execute**. Otherwise, you can set up a one-time scheduling task by selecting **Schedule** → **Execution**. Because this is a one-time task, it cannot be repeated.

The execution of the task is based on the VDisk mirror functions. Tivoli Storage Productivity Center is actually adding a VDisk copy, synchronizing it, and removing the initial copy (in the same way that Tivoli Storage Productivity Center is doing for volume transformations). While the execution is running, you can pause, cancel, or resume the task.

Storage optimization process for all three functions is described in the following sections:

- ▶ 7.2, “Balance Pools” on page 178
- ▶ 7.3, “Analyze Tiering” on page 185
- ▶ 7.4, “Volume transformation” on page 197

Easy Tier considerations with Tivoli Storage Productivity Center optimization and provisioning

The main difference between storage optimization and Easy Tier is that storage optimization works on volume level, and Easy Tier works on extent level.

Easy Tier monitors the host I/O activity and latency on the extents of all volumes with the Easy Tier function turned on in a multitier storage pool over a 24-hour period. It then creates an extent migration plan that is based on this activity, and it dynamically moves high activity or hot extents to a higher tier within the storage pool. It also moves extents whose activity dropped off, or cooled, from the high tier back to a lower tier. Because this migration works at the extent level and not at the volume level, it is often referred to as *sub-LUN migration*.

Storage optimization monitors the activity and workload of all volumes and pools. By analyzing the performance data of storage environment, it moves volumes with low workloads from higher and more expensive tiers to lower and less expensive tiers. By moving the volumes it optimizes the storage environment.

The Easy Tier function is suggested if you want to put a volume in an Easy Tier pool, if only a portion of its extents are hot and the remainder of the volume is fairly cold. If you have volumes that are typically hot or cold throughout the extents, you can consider using storage optimization to move them up or down a tier.

Consider the following information regarding Easy Tier usage and Tivoli Storage Productivity Center optimization and provisioning:

- ▶ Easy Tier does not provide any initial volume placement options; Tivoli Storage Productivity Center provisioning does.
- ▶ Easy Tier does use an exponential moving average during its calculation, so it does look at more than a day, but earlier performance monitor statistics get “reduced” in their importance.
- ▶ Easy Tier does not actually try to improve volume performance, but it tries to avoid volume hot spots. The result is that some volumes get faster and others not, but there is no real influence that you can enforce. For example, a test volume might consume much of the SSD and flash capacity, and leave little to a production volume.
- ▶ Because Easy Tier might optimize a volume based on the heat per extent, a situation can happen in which the Tivoli Storage Productivity Center assumption about the IOPS that are distributed across the complete volume might be wrong and might lead to wrong recommendations.

Table 7-2 compares SAN Volume Controller Easy Tier and Analyze Tiering function.

Table 7-2 SAN Volume Controller Easy Tier versus Analyze Tiering

Characteristic	SAN Volume Controller Easy Tier	Analyze Tiering
Purpose	Find and optimize hottest extents.	Move workload between pools.
Optimization strategy	Avoids creation of hot spots on MDisks, based on “knowledge” of microtiers. Acts only if a large variation of the response times (skew) exists.	Multiple Strategies: <ul style="list-style-type: none"> ▶ Default: move volumes out of tier/pool if activity limit is exceeded. ▶ Advanced: depending on policy settings (I/O rate or I/O density, and age).
Analysis	Monitors cumulative response time per MDisk (in the same pool). Runs continuously.	Monitors activity score per pool (in the same tier) over multiple days On-demand or scheduled.
Granularity	Extent.	Volume. But analysis can be initiated for storage system, pools, volumes, servers, or hypervisors.
Boundary/Type of pool	Hybrid pools (tiering within pools also called microtiering).	One or more tiers (each tier can be multiple pools).
Analysis time frame	Cannot be adjusted.	Can be adjusted.
Automation/Control	Completely automatic.	Semi-automated tool for lifecycle management. Range of tiers is determined by service class.
Initial tier placement	Depends on available capacity and cannot be controlled.	Tier determined by service class settings and current workload.
Move/Swap	One tier at a time.	Volume can “jump” across multiple tiers.
Life Cycle Management	No	Yes
Also included	Balancing of MDisks within pool.	Balancing workload across multiple pools of the same tier level.

7.2 Balance Pools

The Balance Pools function (wizard) is used to balance the workload of volumes across storage pools in the same tier. It analyzes the pools performance, and according to recommendations done on pool activity, volumes are moved from pools with high-activity values to pools with low-activity values. With this option, a more balanced workload is achieved across the pools within same tier.

Balance Pools function is supported with the following storage systems:

- ▶ IBM SAN Volume Controller
- ▶ IBM Storwize V7000
- ▶ IBM Storwize V7000 Unified
- ▶ IBM Storwize V5000

Important:

- ▶ Any storage that is supported by SAN Volume Controller or Storwize, and that is configured as a storage pool (managed disk group) in the storage system, can be used with this function. This is because the function works on the SAN Volume Controller or Storwize level.
- ▶ Collecting performance data for the back-end storage systems (which can be also a storage system not from IBM) is unnecessary because the performance data is collected on the storage virtualizers.

Considerations for using balance pools

Consider this information when you use the Balance Pools function:

- ▶ You select pools, not volumes (like in Analyze Tiering), and you must select at least two pools per storage system, per tier.
- ▶ The analysis is always based on the primary copy of a volume or VDisk, because that is the volume receiving the read I/Os.
- ▶ If you have a multiple-site configuration (SAN Volume Controller stretched cluster), be careful when you select the target pools for this optimization so that Tivoli Storage Productivity Center will not move the volumes of a local server into another location. Doing this can result in a higher response time between storage and server, although the back-end is better utilized. Therefore do not mix pools of different locations.

Note: You can always use the pools custom tags to specify a location manually so that you can easily filter when you select pools from a list of pools.

- ▶ The Balance Pools function differs from the SAN Volume Controller Perl rebalance script as shown in Table 7-3. There are Scripting Tools for SAN Volume Controller including a Perl script for rebalancing of the virtualized storage across the underlying storage, which can be downloaded from this site (requires an IBM ID for downloading):

<http://ibm.co/1c9h0Gr>

Table 7-3 Comparing Balance Pools and re-balance script

Characteristic	Tivoli Storage Productivity Balance Pools	SAN Volume Controller Perl re-balance script
Boundary	Across pools	One pool
Purpose	Analyze and optimize volume performance	Avoid hotspots simply by re-striping extents across all MDIsks, without considering actual performance numbers.
Granularity	Volumes	Extents

Tip: You can use the SAN Volume Controller Perl re-balance script with older SAN Volume Controller versions. Since SAN Volume Controller version 7.3, the balancing is done automatically based on the performance rather than only the capacity and there is no need to use the script.

Steps for balancing pools

To use the Balance Pools function (wizard) and redistribute volume workload across pools on the same tier, complete the following steps:

1. Check that the prerequisites are in place:
 - Probe has run and data about storage virtualizer is collected.
 - Performance monitor is running and data is collected.
 - Storage pools are assigned to a tier.
2. Select two or more pools on the same tier.
3. Define policy and specify parameters for the analysis. In the policy, complete these steps:
 - Include or exclude volumes in mirrored volume relationships.
 - Specify the number of days that are used to estimate the activity levels of the pools.
 - Specify whether you want to restrict the placement of volumes in capacity pools to storage pools in the same capacity pool. This option is available only if one or more of the pools that are being analyzed belong to capacity pools.
 - Specify whether volumes that are assigned to the same hypervisor or server must be placed in the same destination pool.
 - Optional: Click **Advanced balancing** to set an activity limit for the pools on each tier
4. Run the analysis.

A recommendation is generated according to the defined policy.
5. Review the recommendation.
6. Start or schedule the recommended task.

Details about the steps are in 7.5, “Use case: Balance Pools” on page 200.

When to use Balance Pools: Three scenarios

Here are three situations where you might want to use the Balance Pools function.

Scenario 1

You recently provisioned new volumes to your server from Pool 2 in Tier 2 and performance data shows that the pools within this tier are not balanced. The performance data is shown as activity level of the pools, which is calculated with the formula in Table 7-1 on page 174. Because you are running more of a workload on Pool 2 (activity level is much higher on Pool 2, than on Pool 3), Tier 2 is likely to be used in an unbalanced way (Figure 7-3 on page 181).

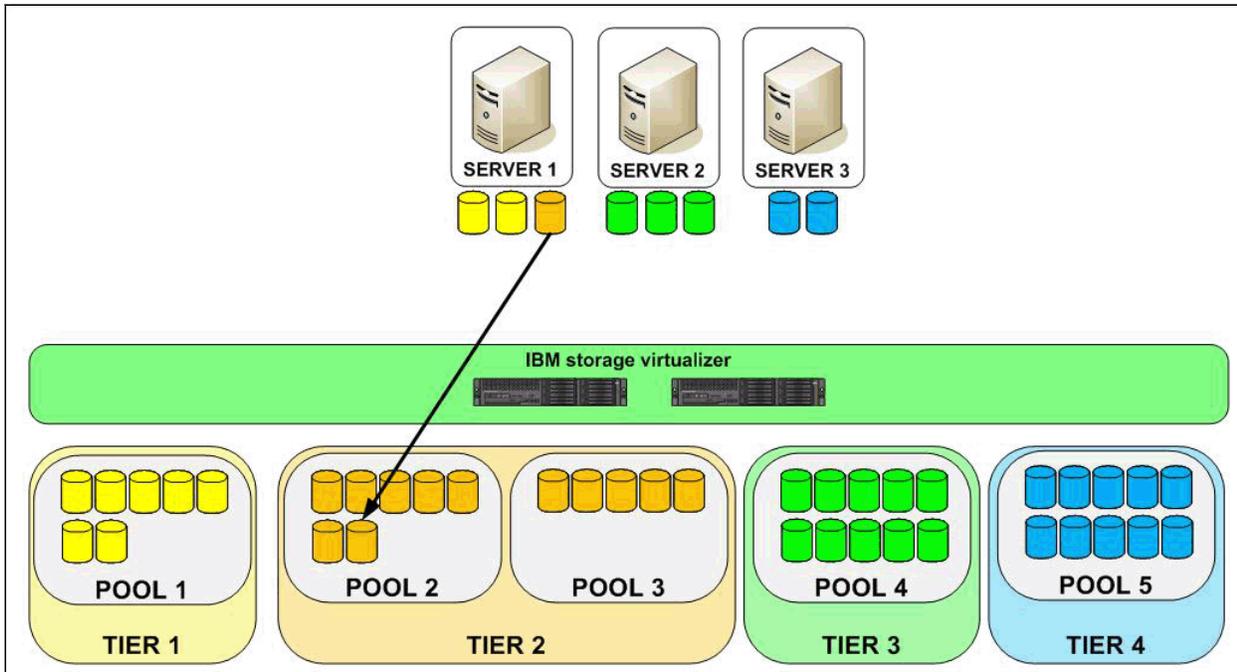


Figure 7-3 Scenario 1: Balance Pools

The Balance Pools function first analyzes the pools in Tier 2 (Figure 7-4).

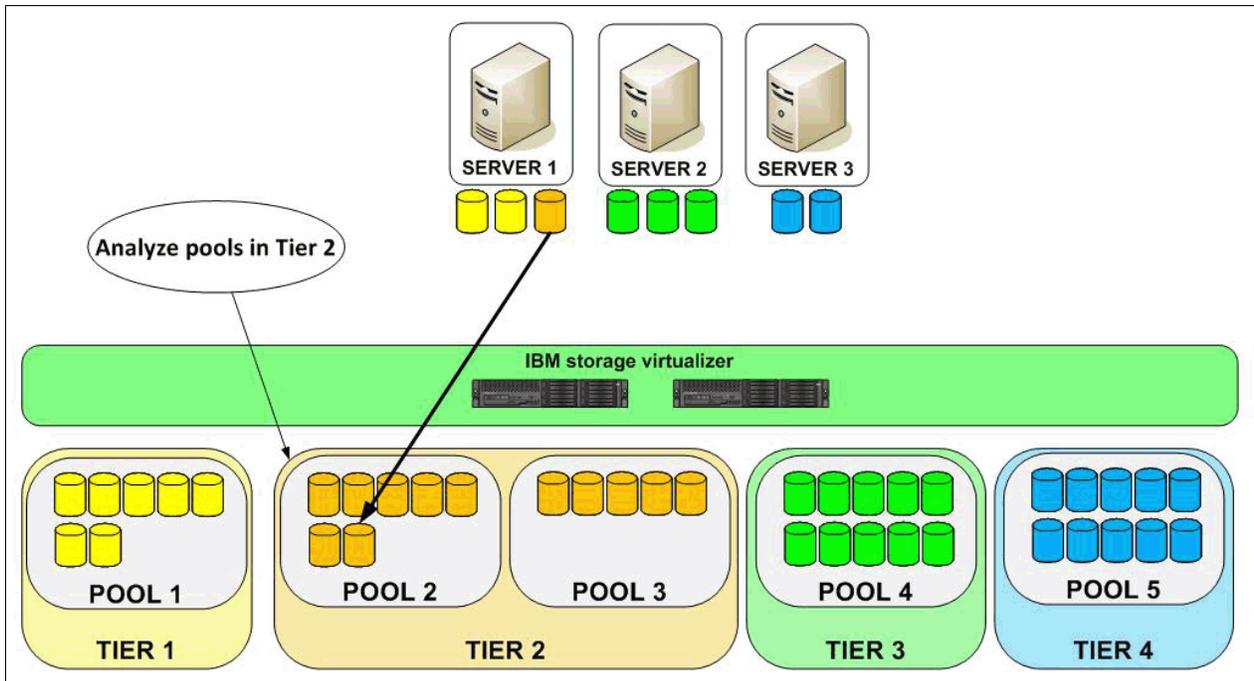


Figure 7-4 Scenario 1: Balance Pools analysis

According to the analysis, the Balance Pools function recommends which volumes should be migrated so that each pool in the tier receives approximately the same workload, and thus avoids hot spots.

After you review the recommendation, start or schedule the execution task (Figure 7-5), which will move volumes from Pool 2 to Pool 3. The virtual disk copy function is used to move the volumes, the workload is not disrupted.

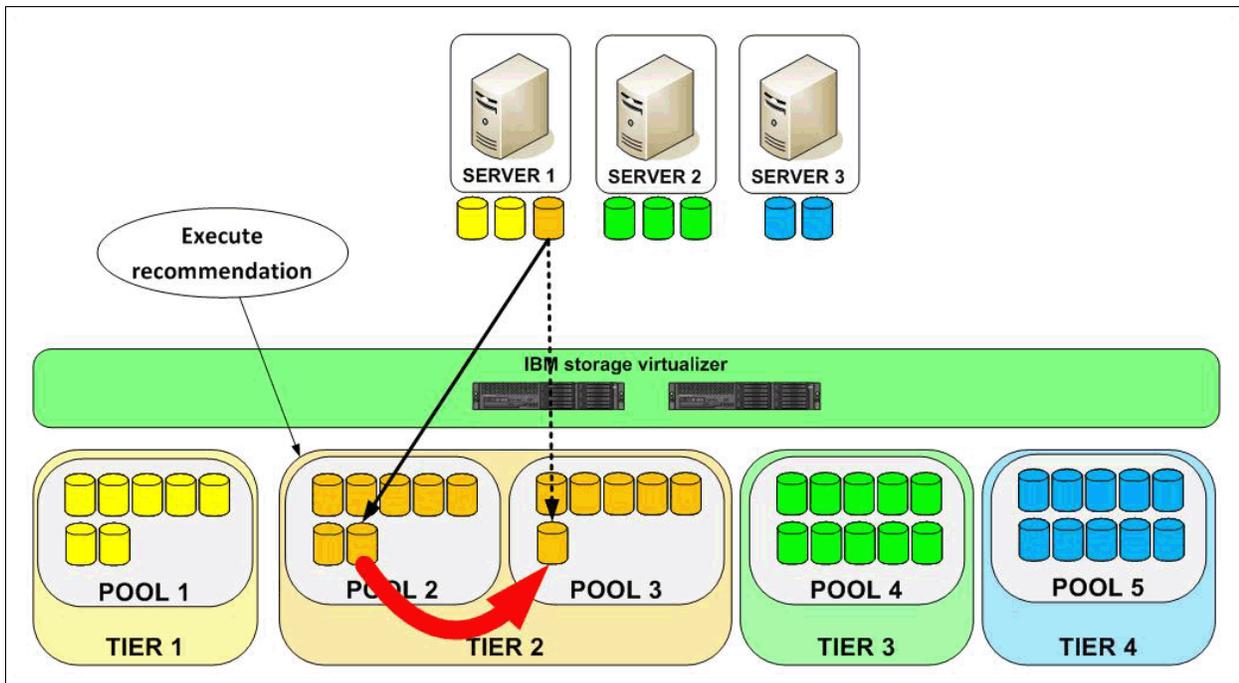


Figure 7-5 Scenario 1: Balance Pools execution task

After the optimization execution task completes, volumes are moved and the storage pools will be balanced (Figure 7-6).

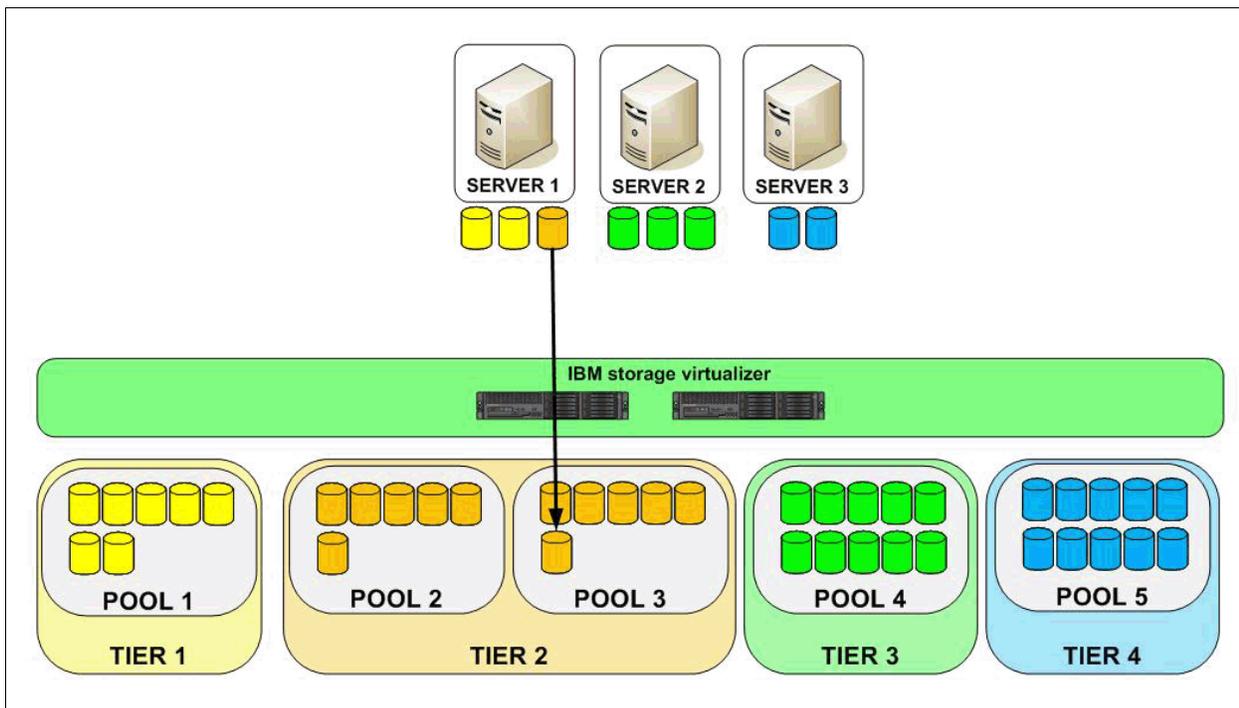


Figure 7-6 Scenario 1: Balance Pools completed

Scenario 2

You recently added a new storage pool (Pool 4) to your environment and it was set up and assigned in the same tier as your existing storage pool (Figure 7-7).

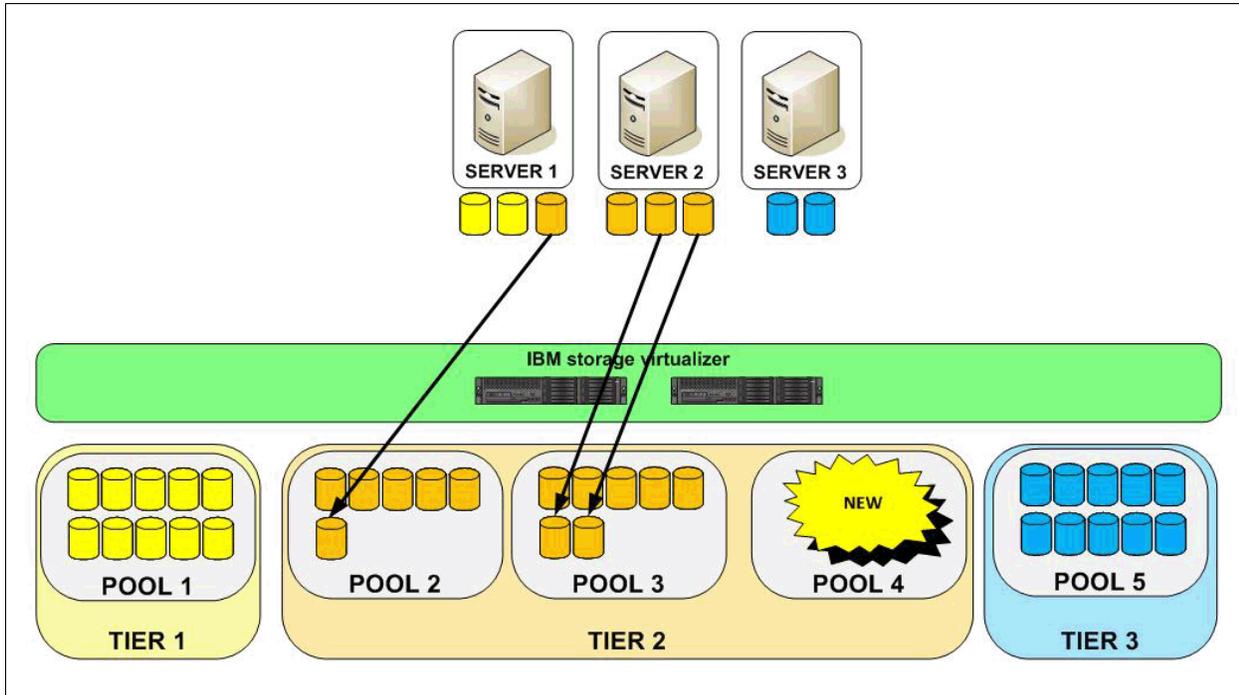


Figure 7-7 Scenario 2: Balance Pools

Because the workload is running only on Pool 2 and Pool 3, Tier 2 is likely to be used in an unbalanced way. The Balance Pools function first analyzes the pools (Figure 7-8).

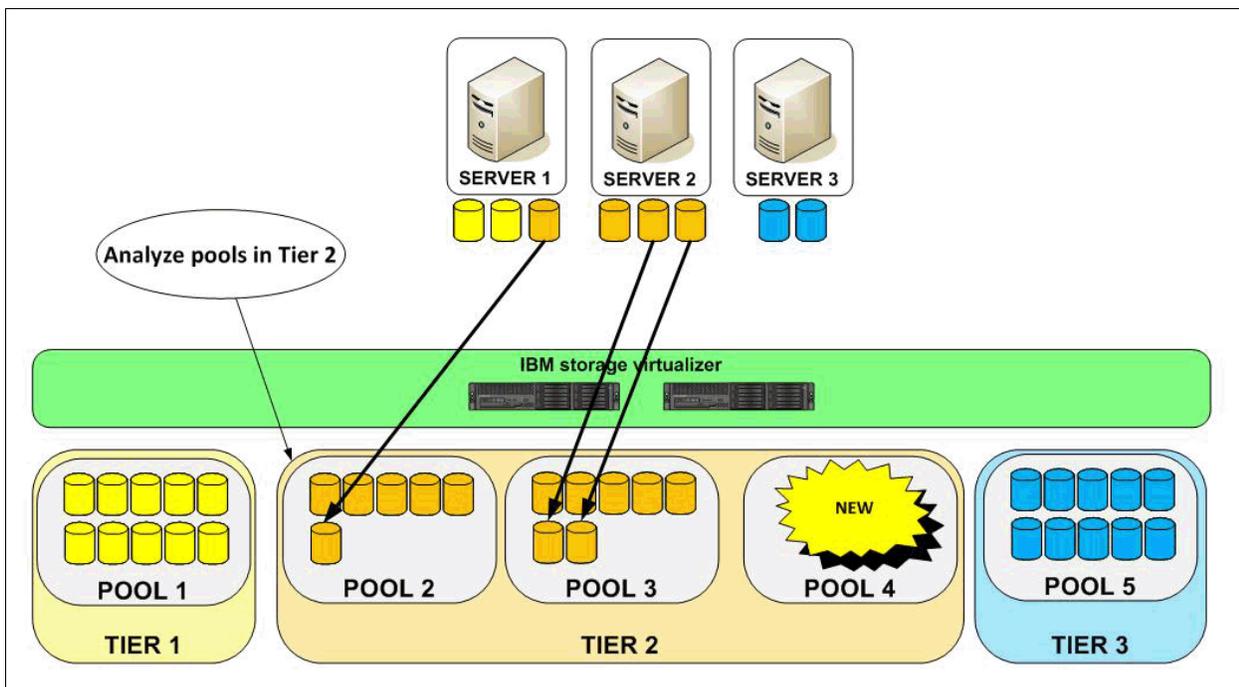


Figure 7-8 Scenario 2: Balance Pools analysis

According to the analysis, the Balance Pools function recommends which volumes should be migrated so that each pool in the tier receives roughly the same workload, and thus avoids hot spots. After you review the recommendation, start or schedule the execution task (Figure 7-9), which will balance pools and move volumes from Pool 2 and Pool 3 to Pool 4. The virtual disk copy function is used to move the volumes and the workload is not disrupted.

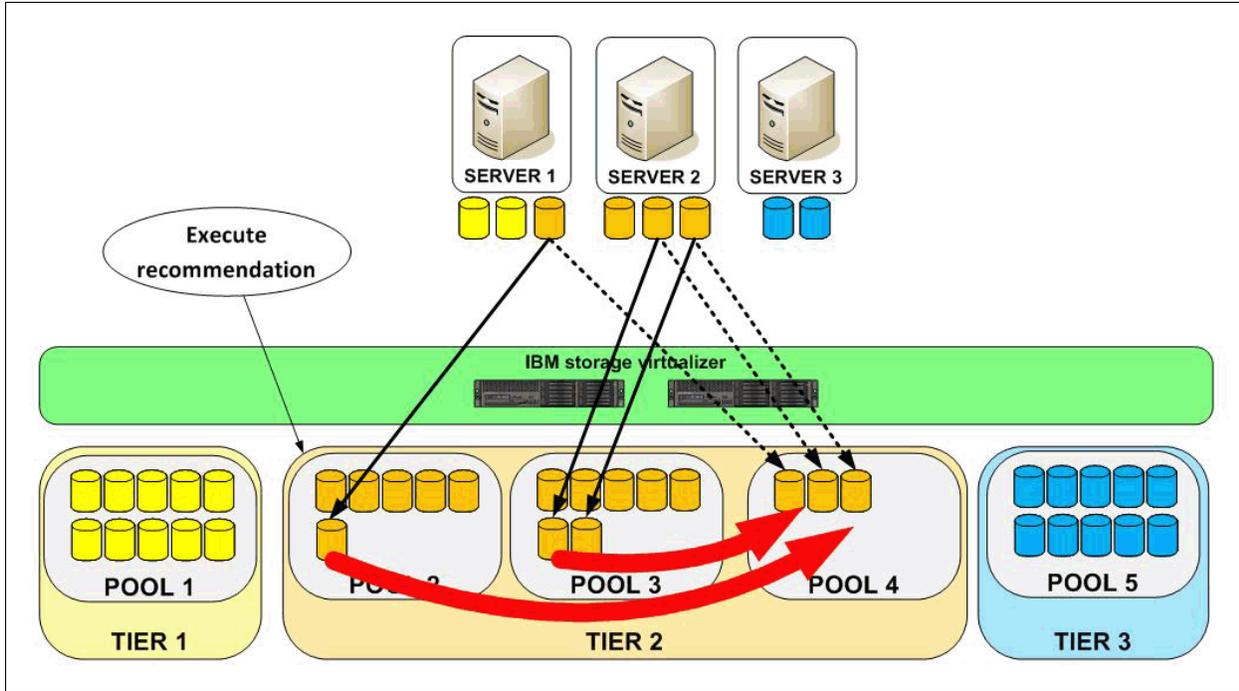


Figure 7-9 Scenario 2: Balance Pools execution task

After the optimization execution task completes, volumes are moved and the storage pools will be balanced (Figure 7-10 on page 185).

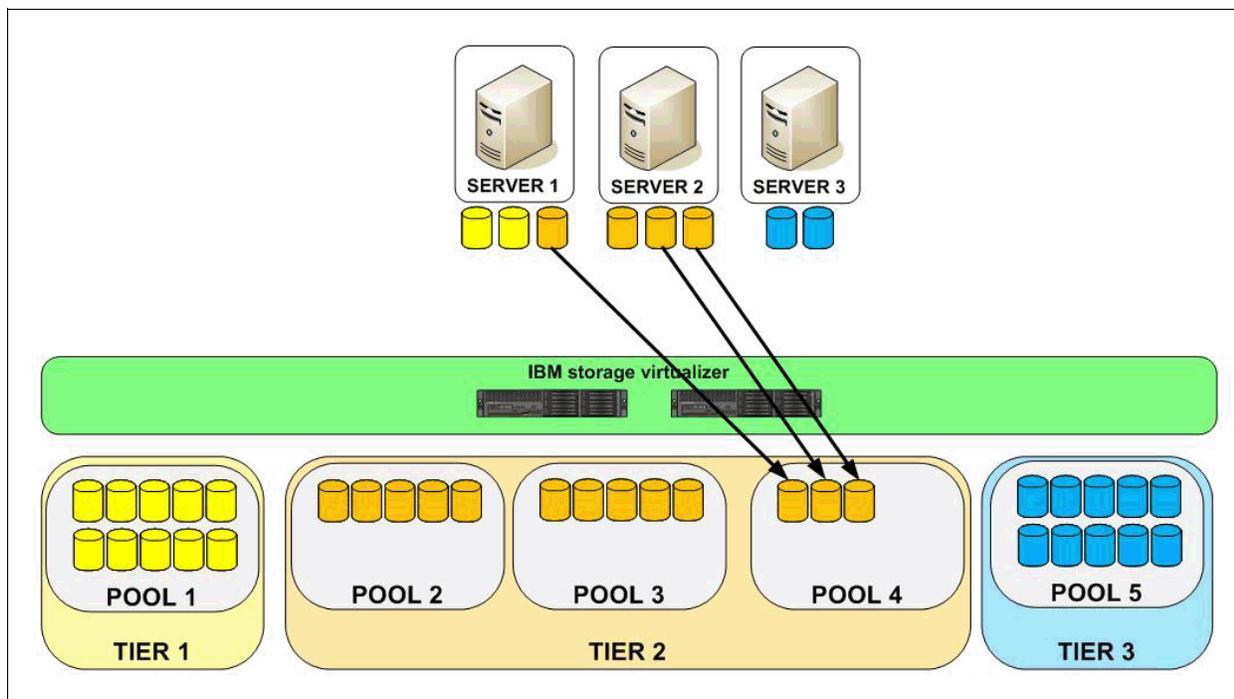


Figure 7-10 Scenario 2: Balance Pools completed

Scenario 3

As workloads change over time, you can let Tivoli Storage Productivity Center run a *balance analysis* on a set schedule and see if there is potential to optimize the distribution of the volumes. According to recommendations, you can start or schedule the execution task.

7.3 Analyze Tiering

The Analyze Tiering function (wizard) is used to optimize the placement of volumes on storage tiers. Based on the performance data, information about back-end storage technology and conditions that are set in tiering policies, volumes are analyzed and recommendations are generated. After you review the recommendations, you can execute the recommendations to move the volumes on the tiers that best match the workload requirements.

Introduction

When *Analyze Tiering* is used, these concerns are considered by functions and by the user:

- ▶ Performance capability constraints can exist. Even if a storage pool has sufficient physical capacity for many more storage volumes, the additional I/O load of these volumes might be such that one or more of the storage components (for example, the backing subsystem) becomes overwhelmed. This results in degraded performance for all storage volumes in the storage pool. Tivoli Storage Productivity Center allows the specification on an Activity Limit to help avoid such situations.
- ▶ Although multiple pools in the same tier are likely to be using the same (or similar) disk technology, the actual storage pool performance scales with the number of disk drives. Tivoli Storage Productivity Center's activity score measure normalizes non-cache I/O activity by storage pool capacity as a basic approximation for this.

When you use Analyze Tiering functions, Tivoli Storage Productivity Center looks at the workload of the selected volumes or pools (and the storage pools that the selected volumes belong to), and also the current workload and the capability of the target pools that were specified in the analysis task wizard. Tivoli Storage Productivity Center will run an analysis and provide recommendations for the movement of volumes, if it can find any better placement.

The default and advanced options

You can use Analyze Tiering function with default or advanced options:

► **Default options**

With default options, a balance algorithm is used, which will move volumes to a different tier (if available) if the current tier cannot be balanced.

► **Advanced options**

With advanced options, you can fine-tune your tiering and act, even before limits are reached, by trying to find a more optimal placement for a volume. You do this by providing minimum thresholds for I/O rate or I/O density, and file usage that volumes need to meet in order to qualify to be placed in a certain tier.

Calculations: To better align with the activity score calculation, the I/O rate of a volume is determined by retrieving, over the specified time range, the volume's average daily read I/O, write I/O, and *read cache hit* percentage and then calculating:

$$\text{write I/O rate} + \text{read I/O rate} * (1 - \text{read cache hit \%})$$

This same I/O rate calculation is used for the numerator when determining a volume's I/O density:

$$\text{I/O Rate} / \text{capacity in GiB}$$

Use default options if you do not know what the good values are for the advanced options thresholds. If you have pools, volumes, and applications that require special handling or should never be included in an analysis, consider using the advanced options.

For both options you specify an activity limit for the destination pools. Volumes are not added to destination pools if they cause the activity level of the pools to exceed the activity limit that you want to specify for pools. It is a contingency value that you can specify as an upper boundary so that you do not overload a pool, by moving volumes into a target pool.

Working with the default and advanced options

If you start the analysis by selecting several volumes, Tivoli Storage Productivity Center will determine which pools they belong to. If there is more than one pool per tier, the default options will be used to balance pools before making any up or down tiering suggestions. The process is as follows:

1. Starting with the lowest tier of storage, the source pools are balanced.
2. If the pools cannot be balanced, the most-active volumes are moved to a higher tier of storage. This step does not apply to pools on the highest tier of storage.
3. The source pools are balanced again.
4. If the pools cannot be balanced, the least-active volumes are moved to a lower tier. This step does not apply to pools on the lowest tier of storage.
5. The source pools are balanced again.
6. Steps 1 - 5 are repeated until the highest tier is balanced.

Regardless which option you choose to optimize storage, you must set an activity limit for each tier of storage. Activity limits are set to maintain the performance capability of the destination pools. If you are unsure what activity-limit value to use, consider the Tivoli Storage Productivity Center reported maximum, and average activity values in relation to your understanding of your storage device's performance. If no performance problems exist, set the activity limit somewhat higher than either the maximum or average value (for example, 20). If performance problems do exist, set the activity limit somewhat lower than either the maximum or average value (for example, -20). If you are unsure, set the activity limit equal to the current maximum value.

How Analyze Tiering works

Here are the basic functions of Analyze Tiering:

- ▶ You can analyze tiering by these components:
 - Servers: Analyze tiering of volumes on storage virtualizers that are connected to servers
 - Hypervisors: Analyze tiering of volumes on storage virtualizers that are connected to hypervisors
 - Storage virtualizers: Analyze tiering of volumes on storage virtualizers
 - Storage pools: Analyze tiering of volumes on storage pools
 - Volumes: Analyze tiering of volumes
- ▶ Analysis starts at the lowest tier (tier 10) through to the highest tier (tier 1).
- ▶ Analysis always tries to optimize the storage within a tier level first by balancing pools, before making a recommendation to move a volume up or down a tier. You might find recommendations to move a volume within a tier.
- ▶ Tivoli Storage Productivity Center looks only at the selected pools or volumes and the specified targets. It never makes a recommendation outside of the selected source and target pools.
- ▶ No performance data from the back-end storage systems is required for the optimization.
- ▶ From the specified target pools, Tivoli Storage Productivity Center works only with pools that meet the following conditions:
 - The pool must be online.
 - The pool must be in a non-error state.
 - The pool must have sufficient available space.
- ▶ If you schedule the optimization run to be executed at a later time, Tivoli Storage Productivity Center does the following basic checks, but does not run the analysis again:
 - Check for sufficient space.
 - Check that the volume is still in the same source pool.
 - If the volume is using VDisk mirror, the status is checked.
- ▶ During analysis, the activity score of a destination pool must not exceed the activity limit value.
- ▶ Default and advanced options:
 - Default options: During the analysis, Tivoli Storage Productivity Center uses the new calculated average and maximum activity for all storage pools within the same tier. In addition, a desired activity limit must be calculated based on the sum of the maximum read I/O rate and write I/O rate operations that you want to specify as limits, divided by the average capacity of all the pools on the same tier.

- Advanced options: In addition to the data from the Automatic mode, I/O density or I/O rate with minimum threshold level and percentage of file accessed and the period of accessing the files are used for tiering analysis.
- ▶ Tivoli Storage Productivity Center is using the VDisk mirror function to move a volume from one pool to another. This is online and transparent to the application, and can even be used if the pools are using different extent sizes.
- ▶ For volumes that are already using VDisk mirroring, the primary copy gets analyzed. When you execute a recommendation for a mirrored volume, Tivoli Storage Productivity Center will delete the primary copy and create a new copy in the recommended location. You can choose which of the volume copies will be set as the primary copy after completing the execution. For more information see 4.2.3, “Enhanced data availability” on page 92.

Volume collocation

The Analyze Tiering function minimizes the exposure of servers or hypervisors to multiple back-end storage systems by collocating volumes that are assigned to the same hypervisor or server.

For example when you want to analyze the volumes that are in storage pools on a Storwize V7000 storage virtualizer with different back-end storage systems, be sure that the volumes in the same storage pool that are assigned to the same server or hypervisor are kept together. With the Analyze Tiering option, you enforce the collocation of volumes and you prevent the placement of related volumes in destination pools that might be on multiple back-end storage systems.

In the Analyze Tiering wizard and the Balance Pools wizard, you can enforce the collocation of volumes that are in the same source pool, and that are assigned to the same hypervisor or server.

Additional suggestions

Before you implement the Analyze Tiering function, also consider this information:

- ▶ Tiering Analysis can be set up in a way that you can use capacity pools as boundaries for recommendations. You may also choose whether to enforce service class restrictions.
- ▶ Although moving volumes across virtualization clusters is not possible, you can select multiple virtualization clusters in one analysis task.
- ▶ Be aware that Tivoli Storage Productivity Center Tiering Analysis looks at only performance and not availability. Therefore, when you select pools as target pools, be sure that they provide the same level of availability as the source pools.

If you consider one pool to be more available than another pool, you can use the capacity pool concept to group the pools. You can then define to only make recommendations within the boundaries of capacity pools.

- ▶ If you are using SAN Volume Controller Easy Tier pool, and Tivoli Storage Productivity Center recommends to move a volume from a SAN Volume Controller Easy Tier pool down to a pool that is not an Easy Tier pool, check the SAN Volume Controller heat map by using the Storage Tiering Advisor Tool (STAT) to confirm that this volume can really be moved down. The I/O density or the file age calculation can sometimes lead to a decision that is not optimal.
- ▶ Tivoli Storage Productivity Center uses Secure Shell (SSH) sessions to communicate with the SAN Volume Controller or Storwize storage system. The number of available SSH sessions are limited to ten with recent versions of the SAN Volume Controller software. As a result, do not run too many tasks in parallel, or Tivoli Storage Productivity Center might use all the sessions.

SAN Volume Controller stretched cluster considerations

Consider the following information when you use an SAN Volume Controller stretched cluster configuration.

- ▶ Volume movement is implemented by using SAN Volume Controller VDisk mirroring. If you are using SAN Volume Controller VDisk mirroring in stretched cluster environments, Tivoli Storage Productivity Center must drop one of the VDisk copies first, before it can implement any recommendation. You can argue that this might compromise the availability of a volume, but SAN Volume Controller limit is to have a maximum of two VDisk copies per volume.
- ▶ The optimization wizard asks if you want to include mirrored volumes.
- ▶ Tivoli Storage Productivity Center does not currently analyze and optimize both copies. Tivoli Storage Productivity Center always deletes the primary copy of a volume, and creates a new copy in the recommended pool. During the definition of the optimization task, you can choose which of the volume copies should act as the primary copy after the task is completed:
 - If the new copy will act as the primary copy, your application can benefit from the optimization, but the other copy (which stays the secondary copy) is left in the original tier.
 - If the secondary becomes the primary, your application does not immediately benefit from the optimization, but now this copy receives the real workload. It is likely to be optimized in the next optimization run.
- ▶ You can use capacity pools to group the storage pool for each site even if you do not plan to use any cloud configuration. This enables you to limit Tivoli Storage Productivity Centers analysis to make only up and down tiering suggestions within one site. You can still use a single job for the analysis.

Important: If you use the capacity pools to group the storage pool for each site, you might find that during provisioning, Tivoli Storage Productivity Center will not create the volume copies in two separate locations. That is because the Tivoli Storage Productivity Center is lacking a site concept and what you define for optimization might not work for provisioning.

Considerations for using Analyze Tiering

Consider the following information for using Analyze Tiering:

- ▶ Tivoli Storage Productivity Center is always moving full volumes from one tier to the other, so Tivoli Storage Productivity Center tiering is not the same as the SAN Volume Controller and Storwize Easy Tier function.

Note: All movement of storage will be contained within the same storage system.

- ▶ The analysis is always based on the volume copy with preferred read because that is the volume receiving the read I/Os.
- ▶ The analysis is a two-phase task:
 - a. In the first phase, you select the resources and parameters, and Tivoli Storage Productivity Center will run an analysis. Because analyzing the resources can take time, Tivoli Storage Productivity Center also provides scheduling capabilities.
 - b. In the second phase, review and execute the recommendations where Tivoli Storage Productivity Center can actually implement the recommendations for you; you can do this immediately or create a schedule to be run at a more convenient time. Always review the recommendations before you execute them.

Steps for analyzing tiers

To analyze tiers and move the volume workload across tiers, complete the following steps:

1. Check that the prerequisites are in place:
 - Probe has run and data about storage virtualizer is collected.
 - Performance monitor is running and data is collected.
 - Storage pools are assigned to a tier.
2. Select volumes or pools for tiering analysis and determine the placement of optimized volumes by selecting one or more target pools.
3. Define a policy where you choose how you want to tier storage.

If you want to tier volumes based on the workload requirements of the volumes, you can set minimum thresholds for each tier of storage. You can specify minimum thresholds for I/O density or I/O rate, and file usage. You can also combine minimum thresholds for I/O density and file usage, and for I/O rate and file usage. The workload of the volumes is evaluated to determine whether the volumes require re-tiering. If you want to balance pools and restrict the re-tiering of volumes to pools that cannot be balanced across each tier, you do not specify tiering criteria. You must also set an activity limit for each tier of storage.

4. Run the analysis.

A recommendation is generated according to defined policy on selected pools and volumes.
5. Review the recommendation.
6. Start or schedule the recommended task.

Details about the steps are described in 7.6, “Use case: Analyze Tiering” on page 210.

When to use Analyze Tiering: Three scenarios

Here are three situations when you might want to use the tiering analysis.

Scenario 1

Over time, workloads might change or the server that is requesting volumes might have overestimated or underestimated requirements, so the volumes can no longer be located in the optimal storage pool (Figure 7-11 on page 191).

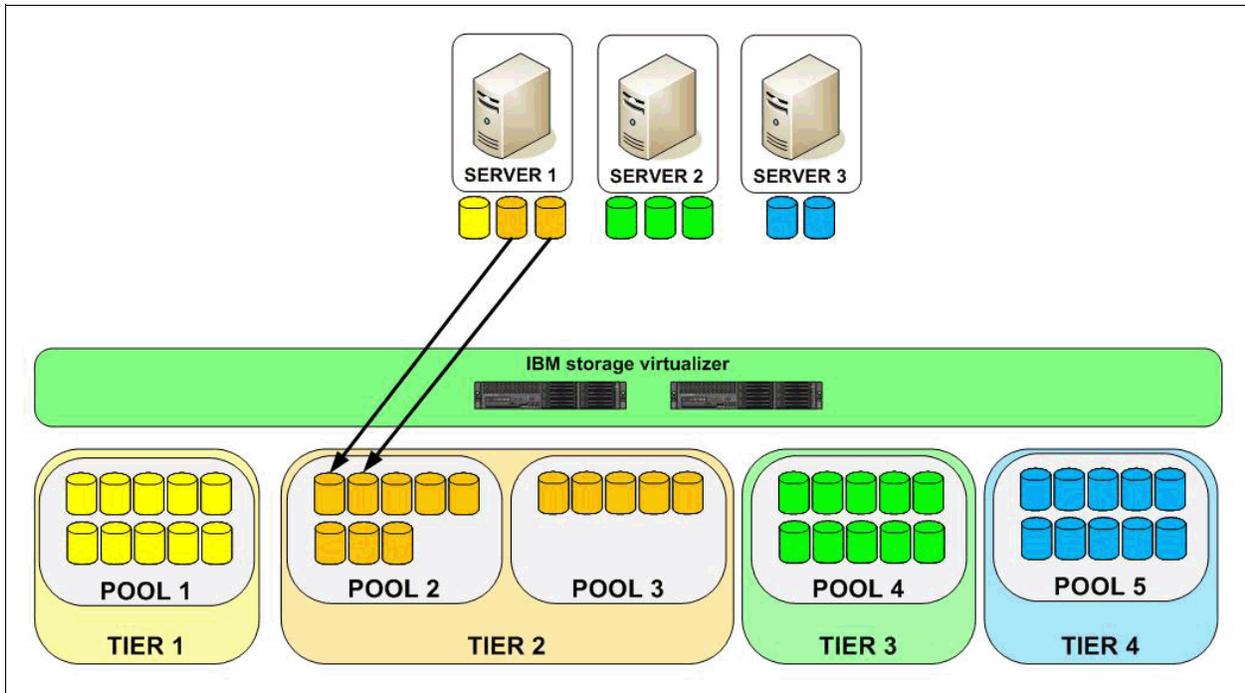


Figure 7-11 Scenario 1: Analyze Tiering

In this scenario, you want to perform Analyze Tiering for the two volumes in Pool 2. The analysis in this scenario strives to optimize the storage within a Tier 2 level first by balancing pools, before making a recommendation to move a volume up or down a tier. You start the Analyze Tiering function for two volumes in Pool 2 (Figure 7-12).

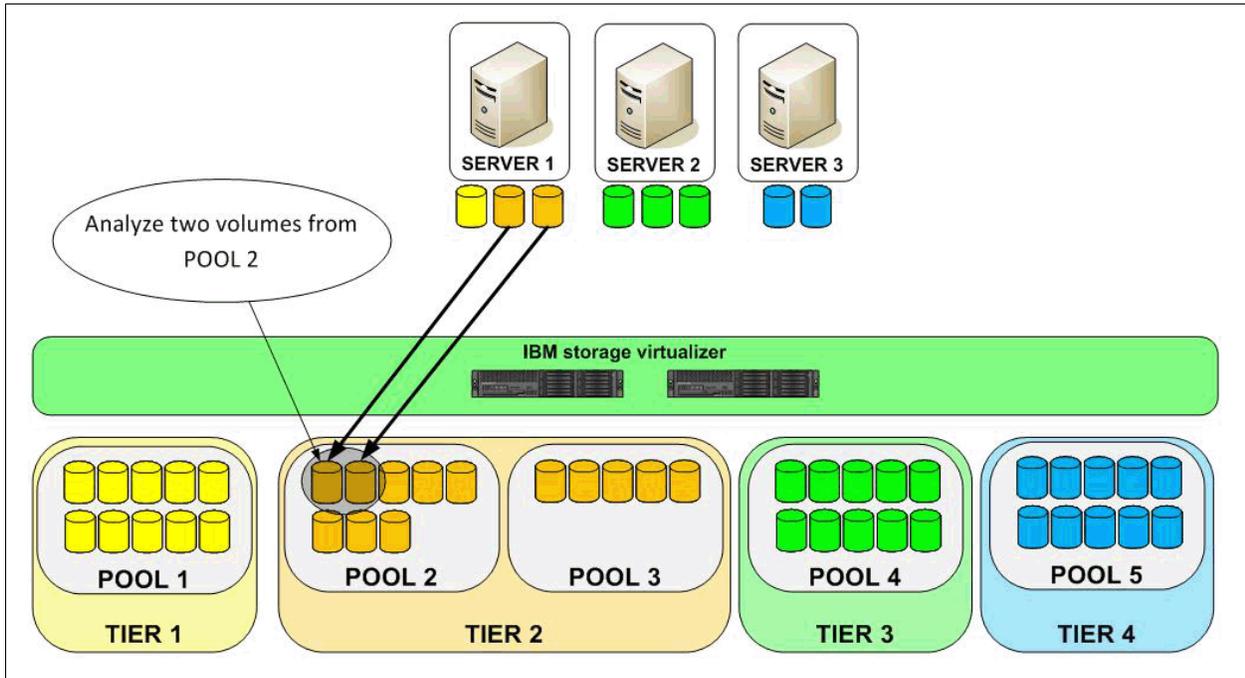


Figure 7-12 Scenario 1: Analyze Tiering analysis

According to the analysis, the Analyze Tiering function recommends where the volumes should be migrated to in order to balance the workload. After you review the recommendation, start or schedule the execution task (Figure 7-13), which in this scenario is to move volumes from Pool 2 to Pool 3 and balance the pools. The VDisk copy function is used to move the volumes and the workload is not disrupted.

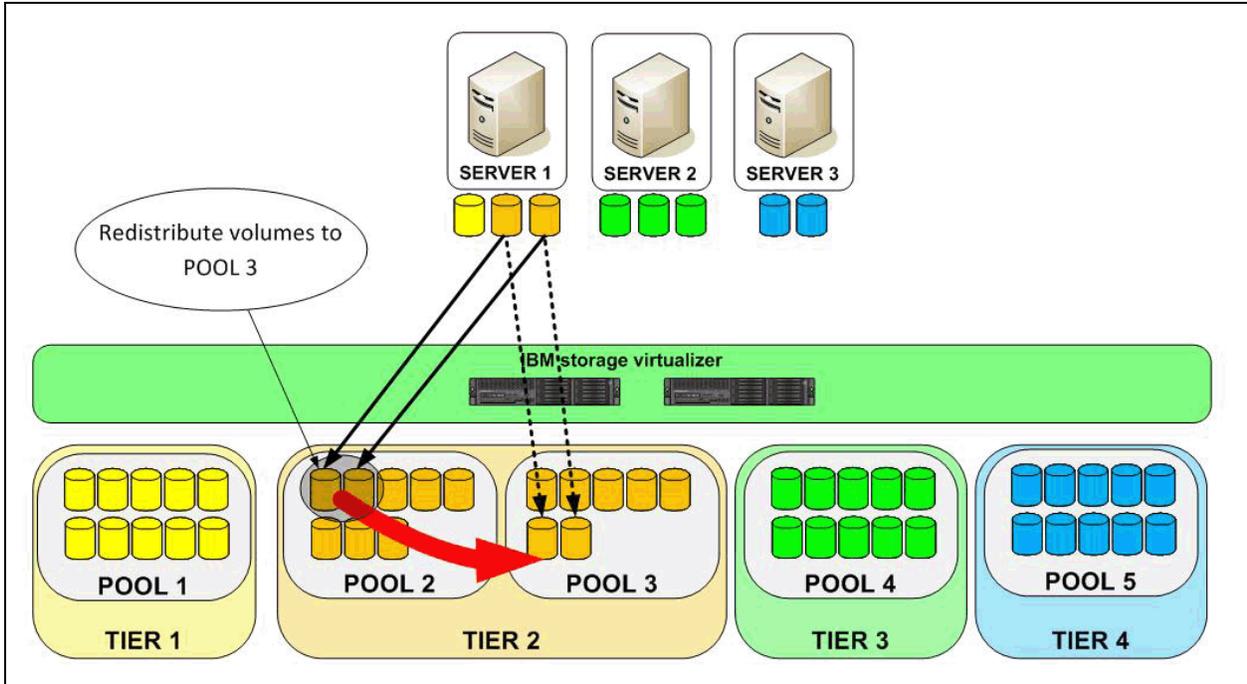


Figure 7-13 Scenario 1: Analyze Tiering redistributing volumes

After the execution task completes, volumes are moved to Pool 3 and the workload is running normally and balanced (Figure 7-14).

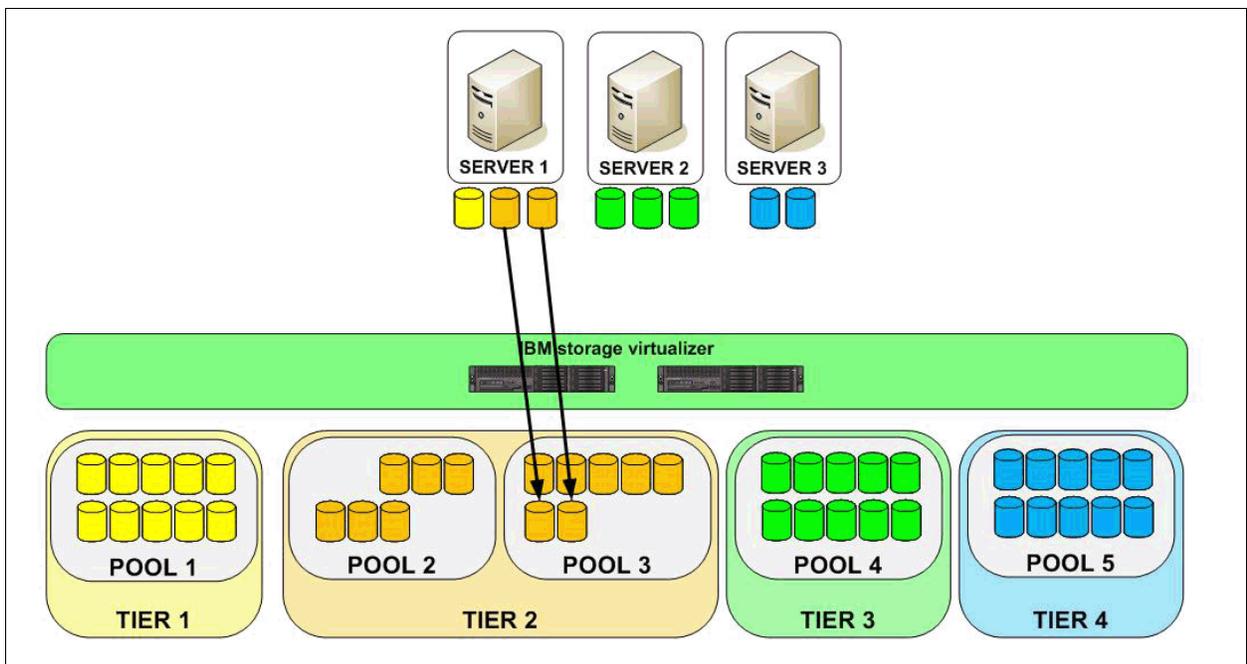


Figure 7-14 scenario 1: Analyze Tiering completed

Scenario 2

If you have a performance problem for one set of volumes, you can use this function to determine whether to move those volumes to a higher tier level. In this example, two volumes have performance problems (Figure 7-15).

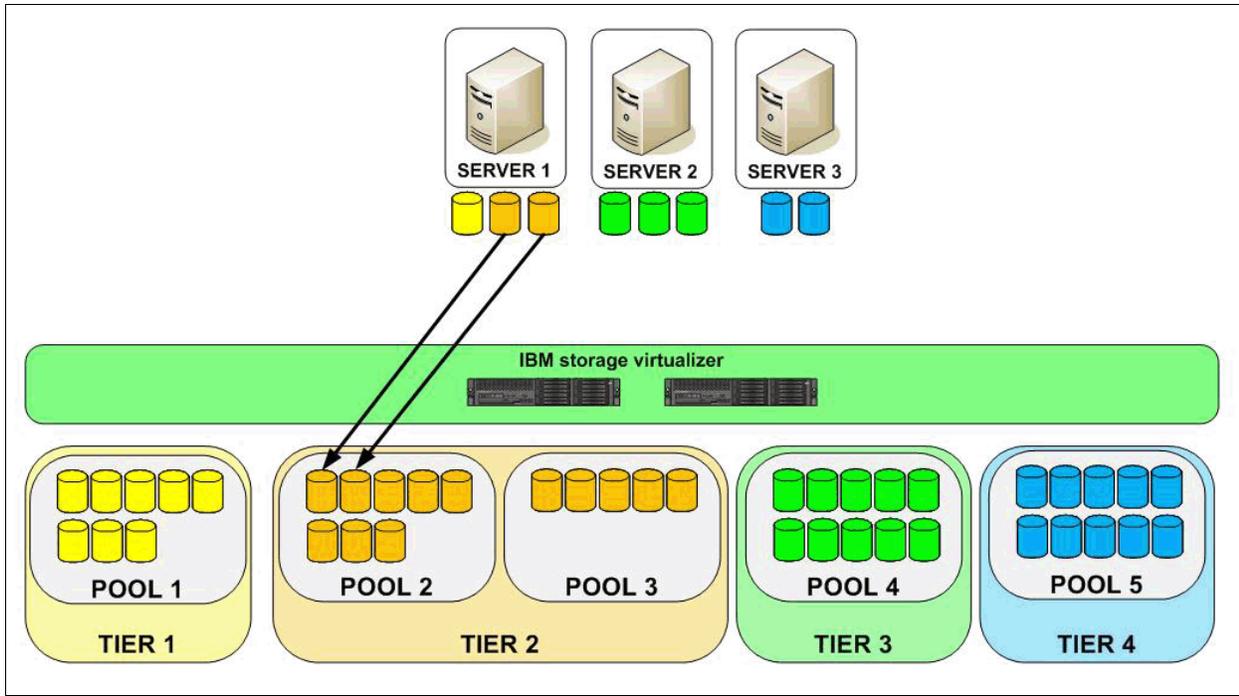


Figure 7-15 scenario 2: Analyze Tiering

To determine the placement of these two volumes, select target pools and set thresholds such as I/O rate or I/O density to Analyze Tiering (Figure 7-16).

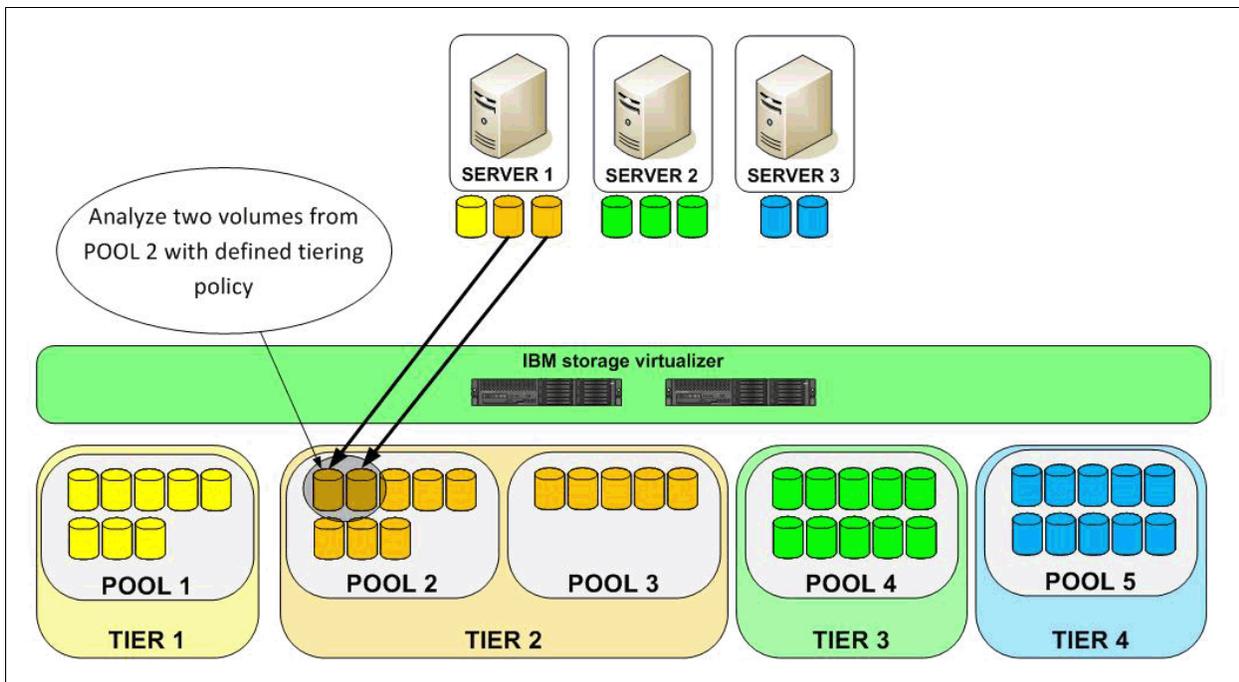


Figure 7-16 Scenario 2: Analyze Tiering analysis

According to the analysis, the Analyze Tiering function recommends moving the volumes to a higher tier. After you review the recommendation, start or schedule the execution task (Figure 7-17). The recommendation in this scenario is to move volumes from Tier 2 to Tier 1 and improve performance of selected volumes. The VDisk copy function is used to move the volumes, and the workload is not disrupted.

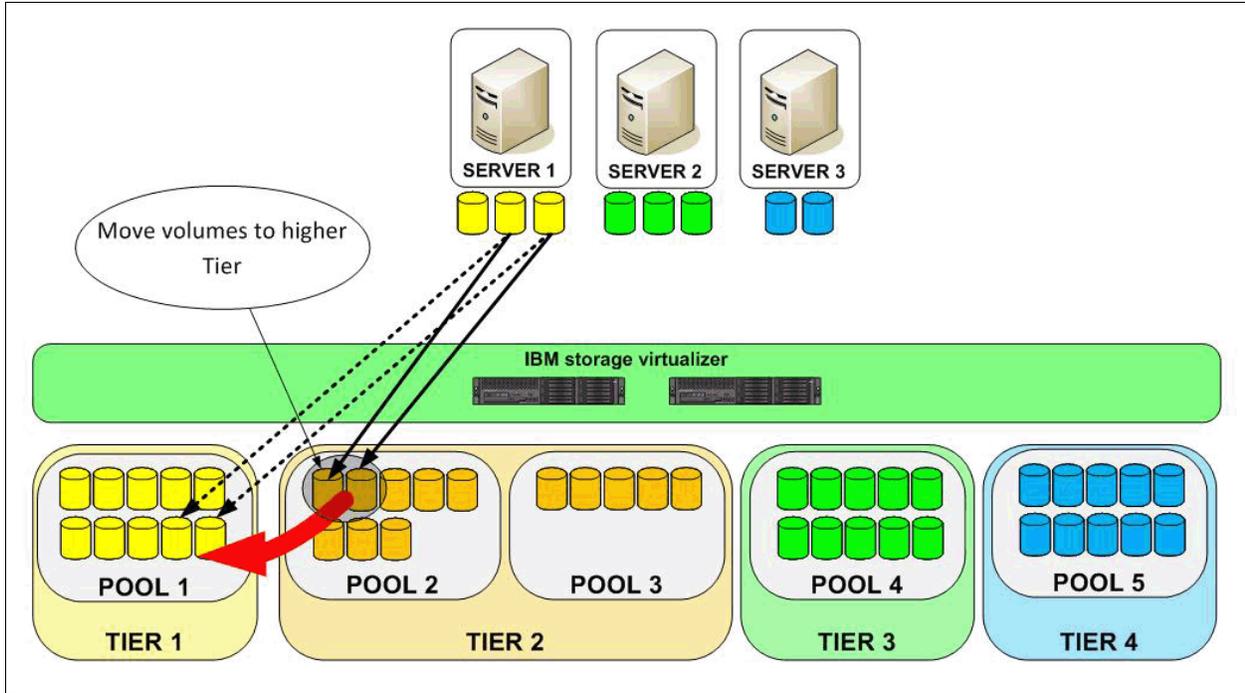


Figure 7-17 Scenario 2: Analyze Tiering, moving volumes to higher tier

After the execution task completes, volumes are moved to Tier 1 and the workload runs normally (Figure 7-18 on page 195).

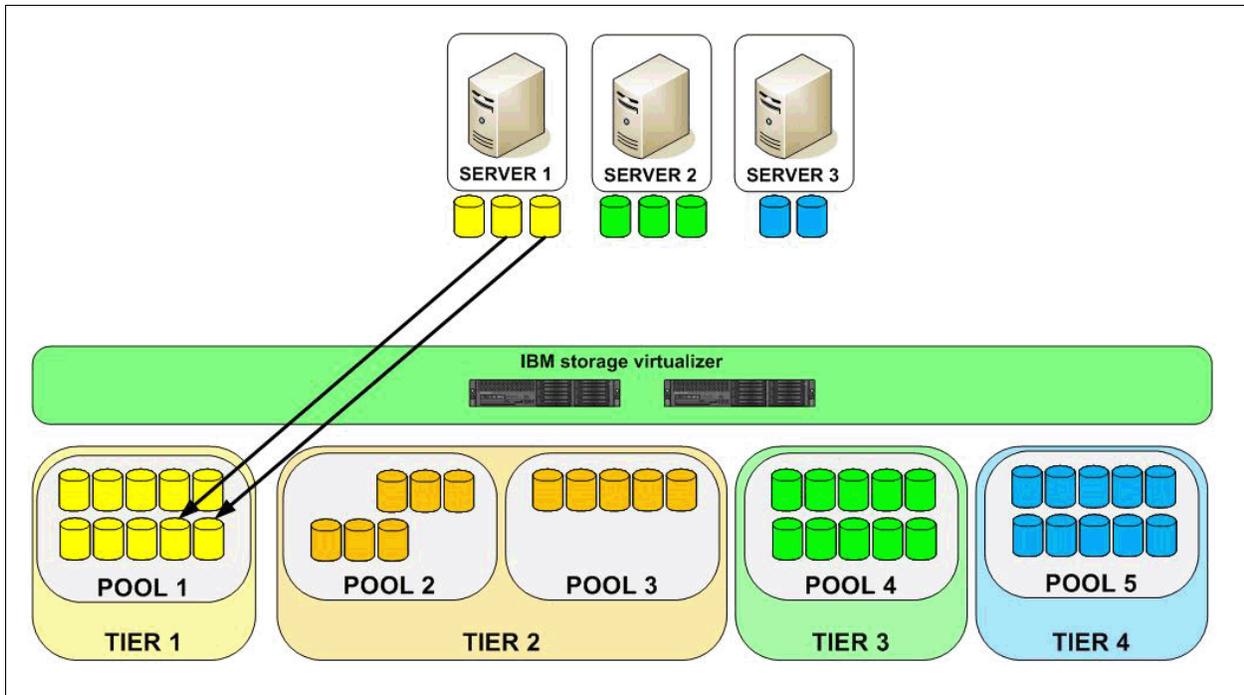


Figure 7-18 Scenario 2: Analyze Tiering completed

Scenario 3

Perhaps you allocated volumes on a high performance tier because there was free capacity at that time (Figure 7-19). Over time, the tier can fill up, so you must continuously check to determine if volumes should be moved to another tier. In this scenario, you can set up Tivoli Storage Productivity Center so that the analysis phase runs regularly (for example, every one to 14 days).

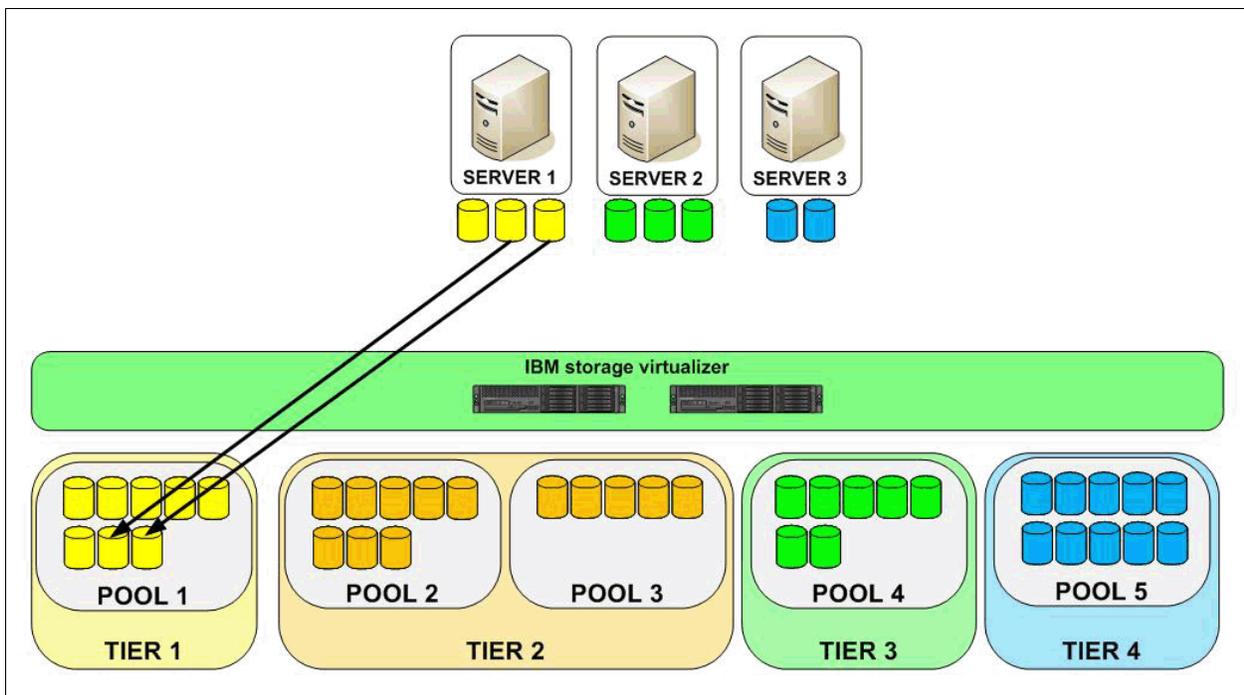


Figure 7-19 Scenario 3: Analyze Tiering

After the analysis runs (Figure 7-20), where you selected Tier 2 pools and Tier 3 pools as a target pools, a recommendation is provided about moving the volumes to a lower tier.

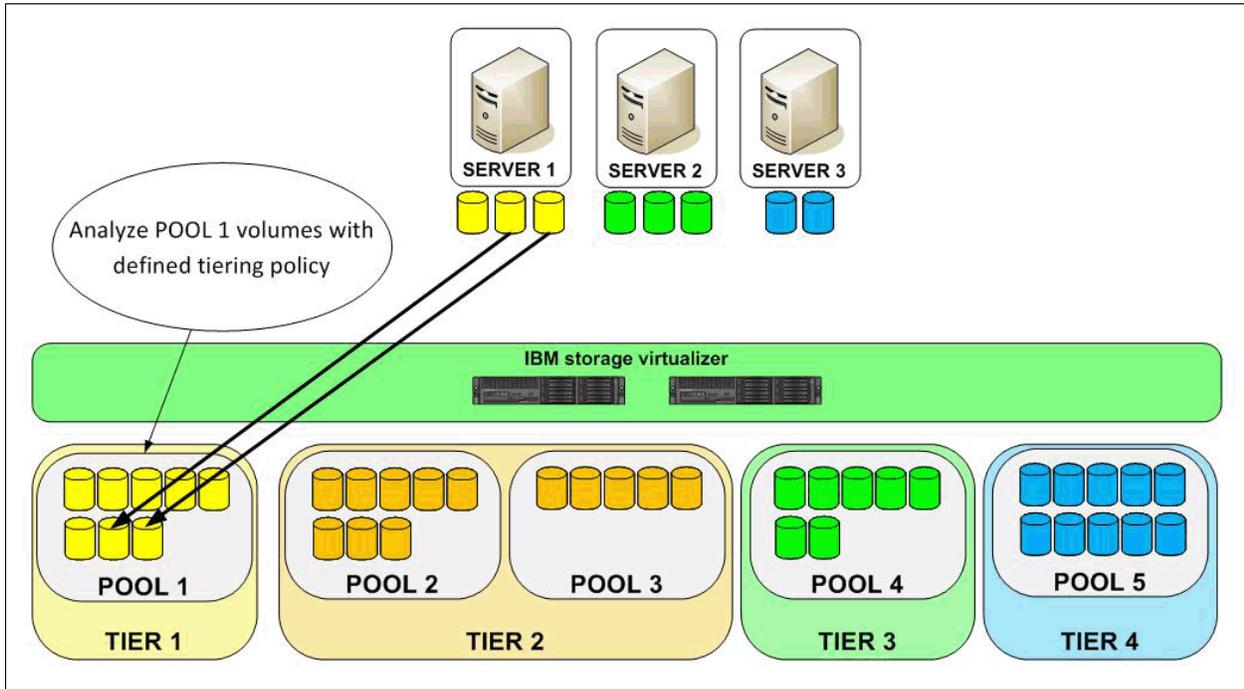


Figure 7-20 Scenario 3: Analyze Tiering analysis

After you review the recommendation, start or schedule the execution task (Figure 7-21), which in this scenario moves volumes from Tier 1 to Tier 3 and releases Tier 1 from additional performance. The VDisk copy function is used to move the volumes and the workload is not disrupted.

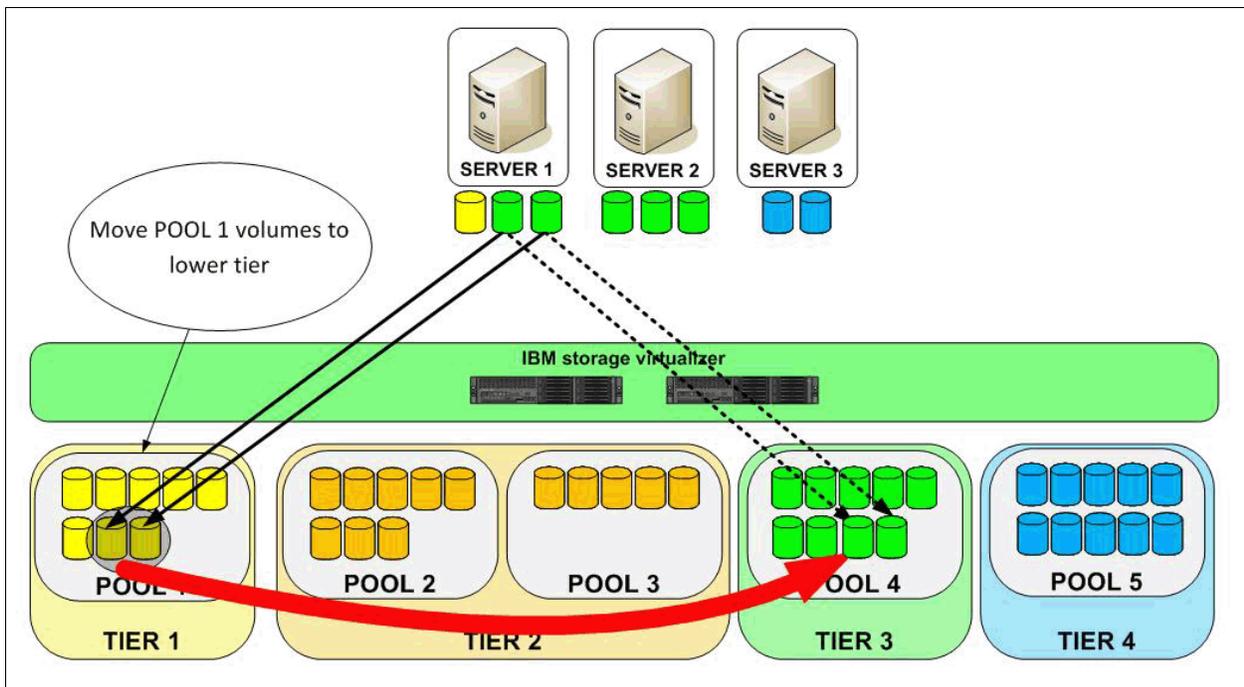


Figure 7-21 Scenario 3: Analyze Tiering, moving volumes to lower tier

After the execution task completes, volumes are moved to Tier 3 and the workload runs normally (Figure 7-22).

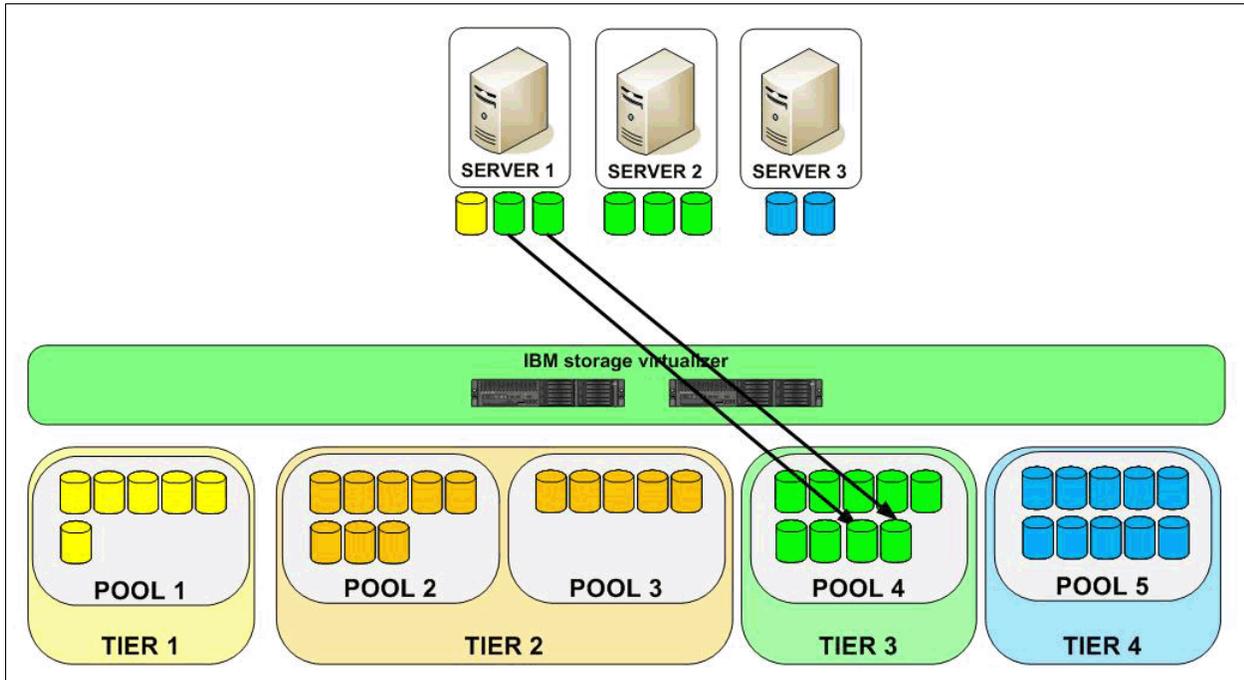


Figure 7-22 Scenario 3: Analyze Tiering done

7.4 Volume transformation

The volume transformation function in Tivoli Storage Productivity Center is used to convert volumes in storage pools to fully allocated volumes, compressed volumes, or thin-provisioned volumes. It can be also used to move volumes to other pools on the same storage system or to pools that are enabled for Easy Tier on the same storage system.

Note: Tivoli Storage Productivity Center uses VDisk copy to implement most of the transformations. This means that volume transformation is supported with only IBM SAN Volume Controller, IBM Storwize V7000, and Storwize IBM V7000 Unified.

The following volume transformation options can be used:

- Migrate pool

Migrate pool moves the selected volumes from a pool to those pools that you selected from the available pools. This option can be used if you want to move some volumes to a different pool, which is on another back-end storage system or on a pool that has slower disk drives. Also you can bring a new storage system and move all the volumes from an old storage system to the new system. In that way, you can remove the old storage system.

- Compression

Compression is used to convert your fully allocated volume to a compressed volume, or to transform a compressed volume to a fully allocated volume. This option provides immediate capacity savings in your storage environment.

IBM storage virtualizers are using the Random Access Compression Engine (RACE) technology, which compresses data that is dynamically written into the storage system. This compression occurs transparently, so Fibre Channel and iSCSI connected hosts are not aware of the compression. RACE is an inline compression technology, meaning that each host-write is compressed as it passes through the storage virtualizer software to the disks. This technology provides immediate capacity savings and it can also be used for primary storage workloads, such as virtual machines, databases, and active data set applications.

- ▶ Thin provisioning

Thin provisioning enables the storage to present the required capacity to the host while allocating only the actual used capacity in terms of space on the physical storage media. By using the thin provisioning function, you can convert fully allocated volumes to thin-provisioned volumes or thin-provisioned volumes to fully allocated volumes.

By transforming volumes to thin-provisioned volumes, you can better utilize your storage environment and provide some capacity savings. In some cases, you might want to transform thin-provisioned volumes to fully allocated volumes. This might be a case where you used some thin-provisioned volumes for test, and now you want them to use for production where all the volumes are fully allocated volumes.

- ▶ Easy Tier

By using the Easy Tier feature in the volume transformation function, you are moving selected volumes from non Easy Tier pool to Easy Tier pool to benefit from Easy Tier. Non Easy Tier pools are usually pools with high-performing or low-performing storage media; Easy Tier pools are with mixed storage media (high-performing and low-performing).

Easy Tier is a performance function that automatically migrates or removes extents from a volume to, or from, one MDisk storage tier to another MDisk storage tier. Easy Tier monitors the host I/O activity and latency on the extents of all volumes with the Easy Tier function turned on in a multitier storage pool over a 24-hour period (heatmap creation). Next, it creates an extent migration plan based on this activity and then dynamically moves high activity or hot extents to a higher disk tier within the storage pool. It also moves extents whose activity has dropped off or cooled from the high-tier MDisk back to a lower-tiered MDisk.

Multiple choices

The volume transformation function allows multiple choices. For example, you might want to implement compression or thin provisioning on a volume and move the volume in a different pool at the same time. The following options are possible:

- ▶ Migrate pool + thin provisioning
- ▶ Migrate pool + Easy Tier
- ▶ Migrate pool + thin provisioning + Easy Tier
- ▶ Migrate pool + compression + thin provisioning + Easy Tier
- ▶ Compression + thin provisioning

Multiple choices are also available. For example if you want to implement compression or thin provisioning on a volume and move the volume in a different pool at the same time, you select both options and create the task.

How volume transformation works

The volume transformation functions are based on the VDisk copy feature, which is supported only for volumes that are defined within storage virtualizers: SAN Volume Controller, Storwize V7000, and the Storwize V7000 Unified storage systems.

When you initiate the volume transformation function in Tivoli Storage Productivity Center, it will start VDisk copy task in storage virtualizer for a selected volume. The VDisk copy task will create a copy of the selected volume and start the synchronization process. The synchronization process updates the copy until it is fully synchronized. When the copy is fully synchronized, the storage virtualizer will split off a synchronized volume copy to a new volume and the workload will continue on the new transformed volume. The original primary volume is deleted after the transformation function is completed.

Transformation functions require temporary extra space to convert volumes to thin-provisioned or fully allocated volumes. Also when migrating pools, additional capacity is required in target pools.

Some volume transformation functions depend on other functions. So, for example, when you select Easy Tier, the Migrate Pool function is automatically selected.

Volume transformation restrictions

Restrictions apply when you implement volume transformation. The restrictions for converting or moving volumes are as follows:

- ▶ To move volumes, the destination pool must be on the same storage virtualizer. You cannot move a volume from a pool on one storage virtualizer to a pool on another storage virtualizer.
- ▶ To convert or move volumes, image mode volumes must be converted to managed mode volumes.
- ▶ To convert fully allocated volumes to compressed volumes, you must have the IBM Real-time Compression license.
- ▶ Only Tivoli Storage Productivity Center, administrators can implement the Transform Storage functions.

When to use volume transformation

You can use the volume transformation functions to change certain characteristics of selected volumes to improve performance or optimize the use of available storage. Volume transformation functions can also be used if you want to migrate data from one back-end storage to another in case you are replacing old back-end storage with a new one.

Volume transformation steps

To run the volume transformation functions and change characteristics of your volumes, complete the following steps:

1. Select one or more volumes from Tivoli Storage Productivity Center web GUI
2. For the selected volumes, select a Transform Storage option and select volume settings that you want to change. You may select more than one option.
3. Enter additional information for the selected Transform Storage options.
4. The Transform Storage function will create the task.
5. Start or schedule the transformation.

Details about the steps are described in 7.7, “Use case: Volume transformation” on page 219.

Note: You can find more details about volume transformation in *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204.

7.5 Use case: Balance Pools

You can use the *Balance Pools* function (wizard) to redistribute workloads across pools in same tier.

You may start the Balance Pools function from any list of pools. In this use case, we start the Balance Pools function from the Tivoli Storage Productivity Center navigation pane (Figure 7-23) by selecting **Advanced Analytics** → **Optimization**.



Figure 7-23 Tivoli Storage Productivity Center navigation pane

From the optimization pane, select **Optimize Pools** to see all your pools. We select only the pools that belong to one storage virtualizer (svc1prod), and we select the pools from Tier 3. The activity deviation percentage shows that the pools are not balanced (Figure 7-24).

Name	Tier	Storage System	Status	Physical Allocation (%)	Capacity (SiB)	Shortfall (%)	Activity	Activity Deviation (%)	RAID
XIV_BERNARD	3	SVC1PROD	Online	33%	5,760.00	51%	0.01	-97	RAID 10
XIV_OTHER	3	SVC1PROD	Online	14%	3,840.00	0%	6.15	1540	RAID 10
XIV_VMWARE	2	SVC1PROD	Online	92%	11,326.50	32%	0.02	300	RAID 10
XIV_VMWARE_NEW	2	SVC1PROD	Online	88%	5,600.00	88%	0.03	500	RAID 10

Figure 7-24 Optimize Pools pane

Either select **Actions** → **Balance Pools** or right-click the selected pools and select **Balance Pools** (Figure 7-25 on page 201).

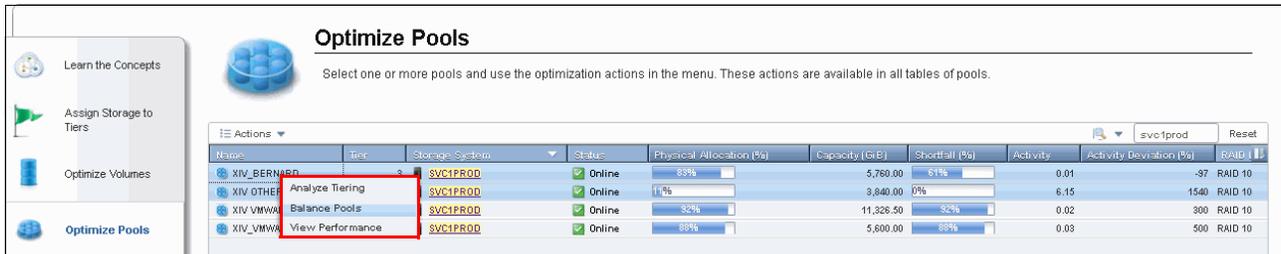


Figure 7-25 Optimize Pools pane: Balance Pools function

After Tivoli Storage Productivity Center checks prerequisites, the **Balance Pools** window opens, where you define a policy and specify parameters for the balance pools analysis. (Figure 7-26).

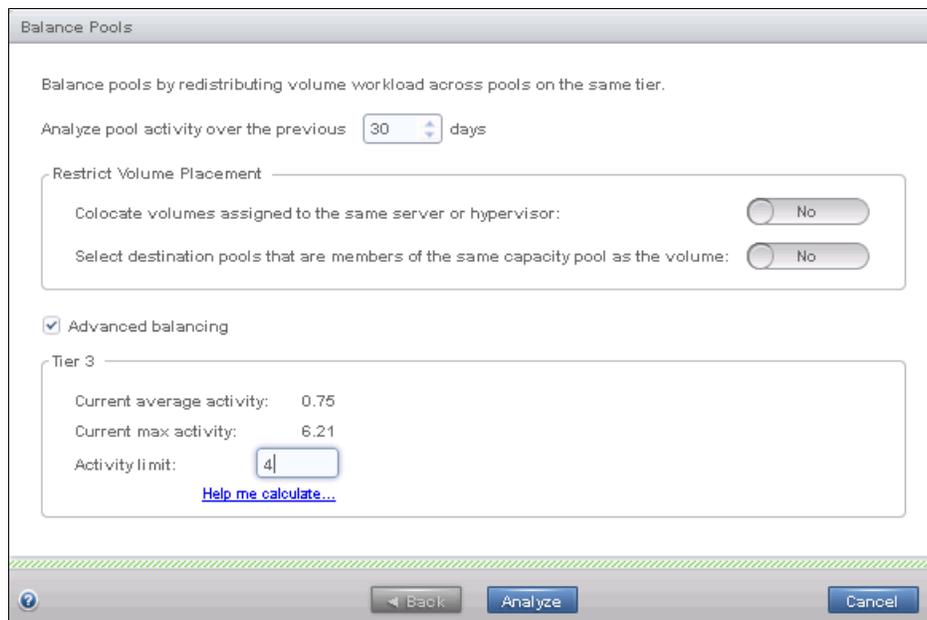


Figure 7-26 Balance Pools policy

In this use case we analyze performance data over the previous 30 days. Because we defined only one capacity pool for all pools of our storage virtualizer, we select **No** for the placement of optimized volumes in capacity pools. We also select **No** to collocate volumes because the volumes in selected pools are used only for test. By selecting **No** we do not restrict volumes that are assigned to the same server or hypervisor from being separated between the source and destination pool.

We also set the pool activity limit for the destination pools, which prevents adding volumes in the destination pools if their workload will exceed that limit.

Click **Analyze** to start the Balance Pools analysis for the selected pools and defined policy.

Note: During the analysis phase, Tivoli Storage Productivity Center looks at pools with an above average utilization and analyzes the volumes. If any pools fit the criteria, they should be moved to other pools in the same tier. The target pools must be able to accept the additional workload so that the balance can work; if all pools have a higher utilization than you specified in the Balance Pools wizard, Tivoli Storage Productivity Center will not be able to optimize anything.

Balance analysis successfully completed (Figure 7-27). The activity of the pools can be balanced.

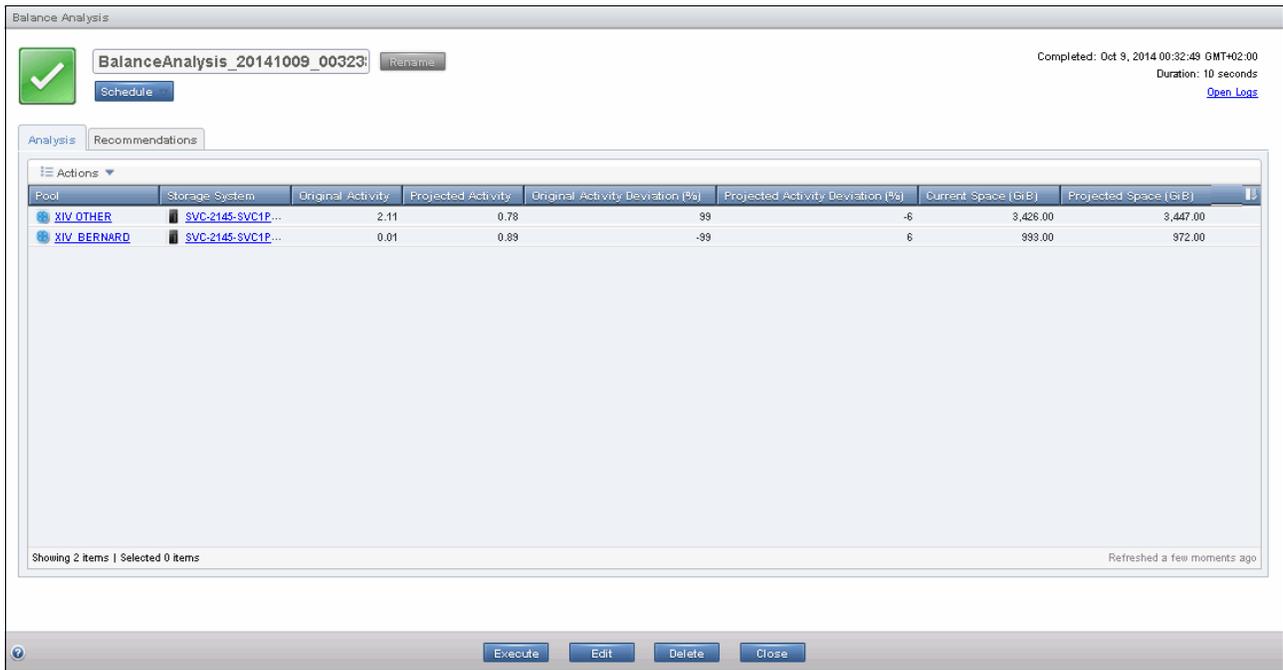


Figure 7-27 Balance Pools analysis

The Recommendation page (Figure 7-28) shows which volumes will be moved. In this case, the TPC_SVC1_0001 and TPC_SVC1_0002 volumes will be moved from the XIV_OTHER pool to the XIV_BERNARD pool.

Click the **Open Logs** link.

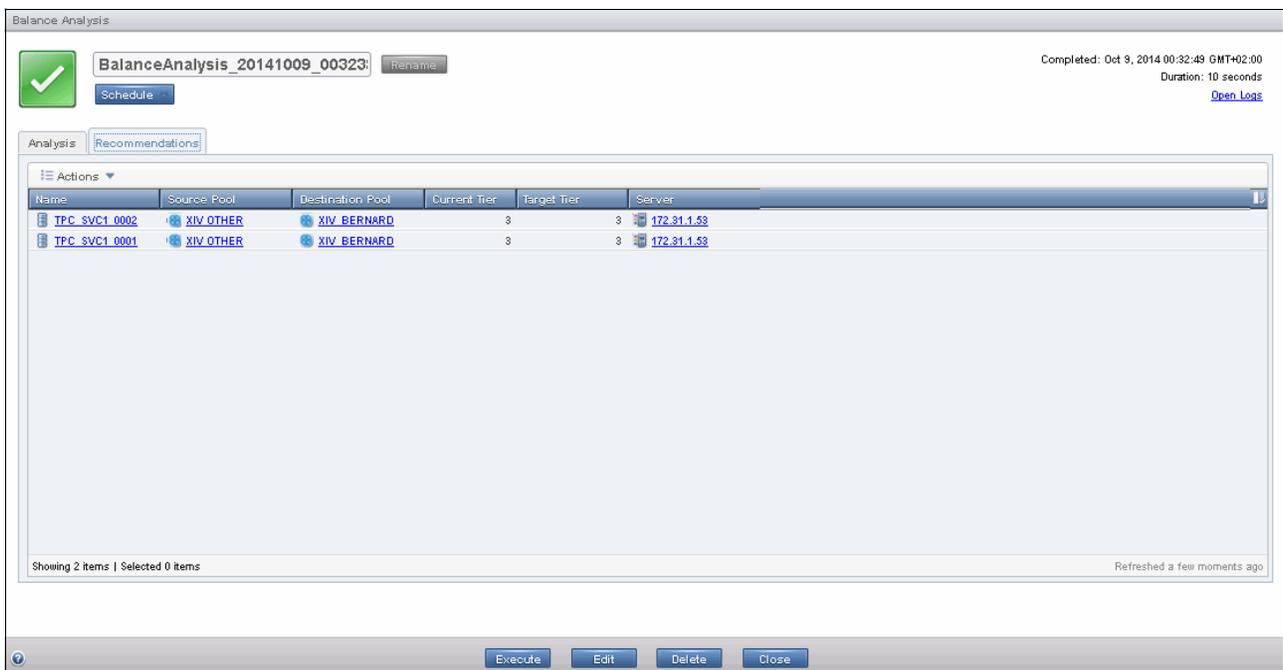


Figure 7-28 Balance Pools recommendations

The Logs pane opens, which shows the log of the Balance Pools analysis (Figure 7-29).

Logs

Task Type: Balance Analysis Task Name: BalanceAnalysis_20141009_003238546

Run 1: Oct 9, 2014 00:32:39 GMT+02:00 - Oct 9, 2014 00:32:49 GMT+02:00

Show all

Status	Date and Time	ID	Description
Information	Oct 9, 2014 00:32:39.951 GMT+02:00	HWN0240001	An optimization analysis task was started.
Information	Oct 9, 2014 00:32:39.998 GMT+02:00	HWN0240021	The option that was selected for mirrored volumes is: Do not optimize volumes with mirrored volumes.
Information	Oct 9, 2014 00:32:40.014 GMT+02:00	HWN0240471	The number of days for collecting performance data to analyze the volumes is set to 30.
Information	Oct 9, 2014 00:32:49.733 GMT+02:00	HWN0240151	The optimization analysis of the SVC-2145-SVC1PROD-IBM subsystem was started.
Information	Oct 9, 2014 00:32:49.733 GMT+02:00	HWN0240891	The option to colocate volumes that are assigned to the same server or hypervisor was not selected.
Information	Oct 9, 2014 00:32:49.733 GMT+02:00	HWN0240201	Started analysis to balance pools on tier 3.
Information	Oct 9, 2014 00:32:49.795 GMT+02:00	HWN0240701	The analysis to optimize subsystem SVC-2145-SVC1PROD-IBM was completed.
Information	Oct 9, 2014 00:32:49.795 GMT+02:00	HWN0240011	The analysis is completed.

Figure 7-29 Balance Pools analysis log

The volumes that will be moved to the new pool are mapped to the test Windows server IICTPCRT1-SEC (Figure 7-30). You see that the volumes are in the XIV_OTHER pool.

Volumes

4 Normal
0 Warning
0 Error

Volumes Volume Mappings Performance

Name	Pool	Storage System	Status	ID	Unique ID	Capacity	Hosts	Volume Number
TPC_SVC1_0001	XIV_OTHER	SVC1PROD	Online	164	600507880194007918.00000000000000d7	10.00		
TPC_SVC1_0002	XIV_OTHER	SVC1PROD	Online	165	600507880194007918.00000000000000d8	11.00		
TPC_SVC1_1000	XIV_OTHER	SVC1PROD	Online	166	600507880194007918.00000000000000d9	20.00		
TPC_SVC1_2000	XIV_OTHER	SVC1PROD	Online	167	600507880194007918.00000000000000da	21.00		

Showing 4 items | Selected 0 items Refreshed a few moments ago

Figure 7-30 Test server volumes

Figure 7-31 shows the Disk Management window on the Windows server where you see the same volumes.

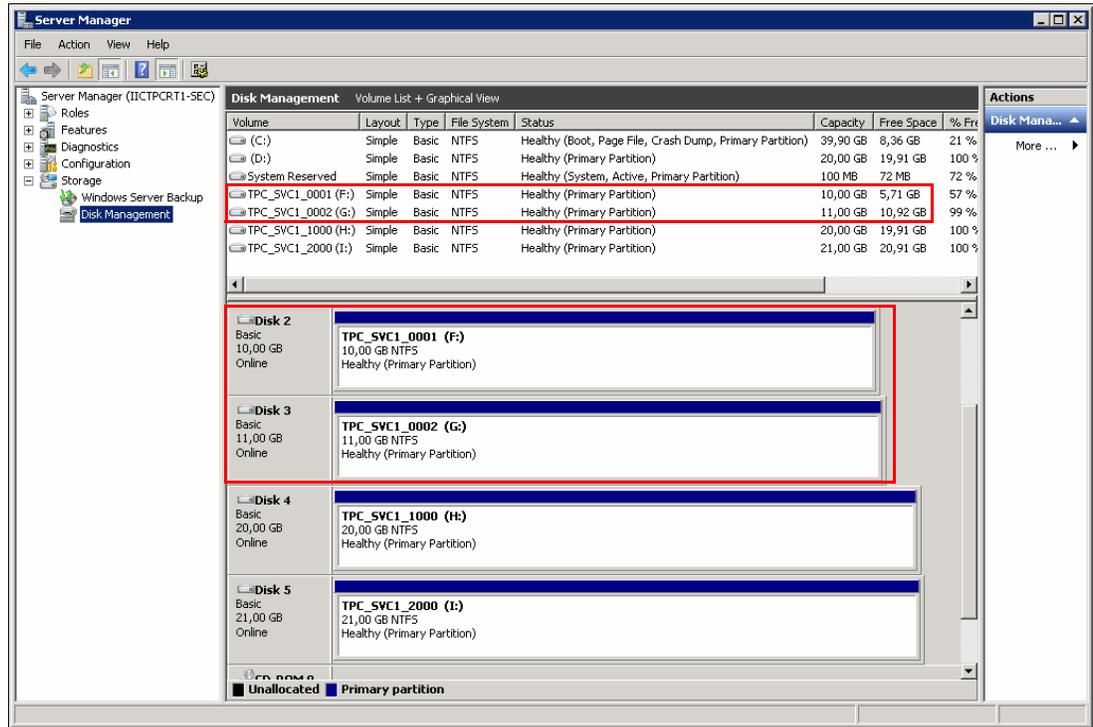


Figure 7-31 Disk Management of the test server

Figure 7-32 shows that we are running a workload on those volumes, by using an I/O meter tool.

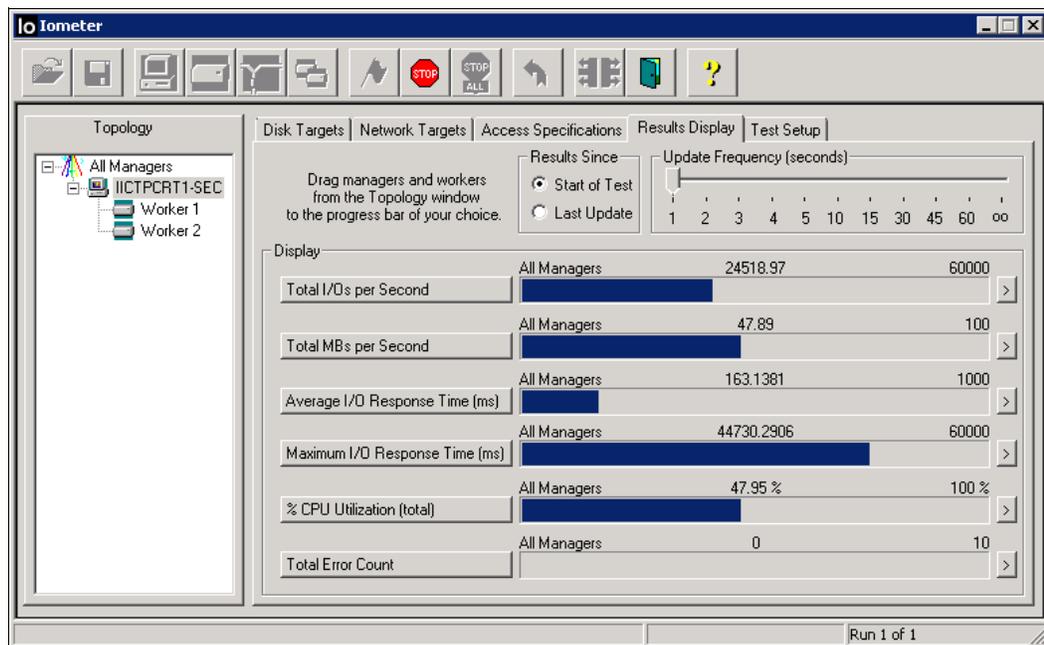


Figure 7-32 Workload on the test server

The same workload is shown in the storage virtualizer performance monitor (Figure 7-33). Because this workload is the only one running on this storage virtualizer, several IOPS are almost the same.

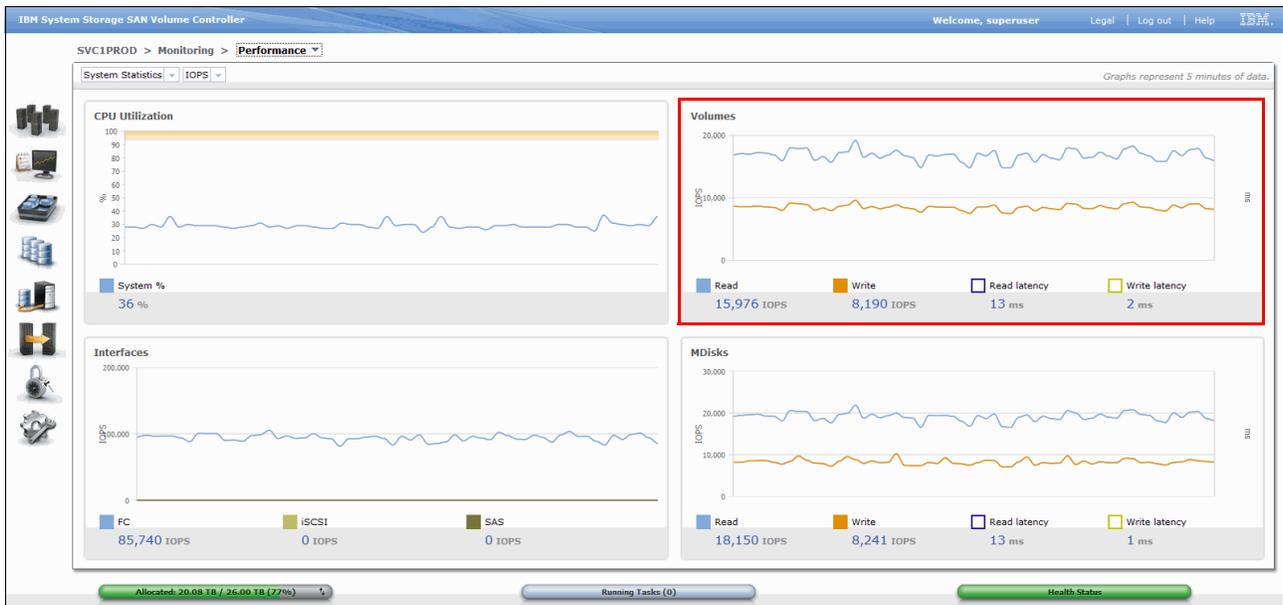


Figure 7-33 Workload on the test server shown in SAN Volume Controller GUI

After we review the recommendation (Figure 7-28 on page 202), we schedule the Balance Analysis task (Figure 7-34).

The screenshot shows a dialog box titled "Schedule BalanceAnalysis_20141009_003238545". It contains an "Execution:" field with a date dropdown set to "10/9/2014", a time dropdown set to "01:00", and a time zone dropdown set to "CEST". At the bottom of the dialog, there are "Save" and "Cancel" buttons.

Figure 7-34 Balance Analysis task schedule

Figure 7-35 shows all storage systems tasks and the Balance Pools task that we scheduled.

Storage Systems

10 Normal
0 Warning
1 Error

Block Storage Alerts Threshold Violations **Tasks** Performance

0 Failed 7 Warning 7 Successful 0 Running 1 Scheduled 0 Pending

Name	Type	Status	Related Task	Schedule	Last Run Time	Duration	Tickets
BalanceAnalysis_20141009_0032...	Analysis Execution	Scheduled	BalanceAnalysis_20141009_003218545	Run once on Oct 9, 2014 01:30:00 GMT+02:00	None	N/A	
BalanceAnalysis_20141009_0032...	Balance Analysis	Successful			Oct 9, 2014 00:32:49 GMT+0...	10 seconds	
BalanceAnalysis_20141009_0018...	Balance Analysis	Successful			Oct 9, 2014 00:18:34 GMT+0...	2 seconds	
BalanceAnalysis_20141008_2359...	Balance Analysis	Warning			Oct 9, 2014 00:00:02 GMT+0...	2 seconds	
TieringAnalysis_20141008_23320...	Tiering Analysis	Warning			Oct 8, 2014 23:32:09 GMT+0...	3 seconds	
TieringAnalysis_20141008_23223...	Tiering Analysis	Warning			Oct 8, 2014 23:22:38 GMT+0...	1 second	
BalanceAnalysis_20140927_0216...	Balance Analysis	Warning			Sep 27, 2014 02:16:55 GMT...	1 second	
BalanceAnalysis_20140927_0110...	Balance Analysis	Warning			Sep 27, 2014 01:10:40 GMT...	1 second	
BalanceAnalysis_20140927_0104...	Balance Analysis	Warning			Sep 27, 2014 01:04:40 GMT...	2 seconds	
Transforms_20140924_02261687...	Analysis Execution	Successful	Transforms_20140924_022616872		Sep 24, 2014 02:30:34 GMT...	3 minutes	
Transforms_20140924_022616872	Transform Plan	Successful			Sep 24, 2014 02:26:18 GMT...	1 second	
Transforms_20140924_022444325	Transform Plan	Successful			Sep 24, 2014 02:24:48 GMT...	2 seconds	
Transforms_20140924_022355950	Transform Plan	Successful			Sep 24, 2014 02:23:59 GMT...	3 seconds	

Showing 13 items | Selected 0 items

Refreshed a few moments ago

Figure 7-35 Storage Systems tasks status: scheduled

When the task starts, the status changes to Running (Figure 7-36).

Storage Systems

10 Normal
0 Warning
1 Error

Block Storage Alerts Threshold Violations **Tasks** Performance

0 Failed 7 Warning 7 Successful 1 Running 0 Pending

Name	Type	Status	Related Task	Schedule	Last Run Time	Duration	Tickets
BalanceAnalysis_20141009_0032...	Analysis Execution	Running	BalanceAnalysis_20141009_003218545		None	N/A	
BalanceAnalysis_20141009_0032...	Balance Analysis	Successful			Oct 9, 2014 00:32:49 GMT+0...	10 seconds	
BalanceAnalysis_20141009_0018...	Balance Analysis	Successful			Oct 9, 2014 00:18:34 GMT+0...	2 seconds	
BalanceAnalysis_20141008_2359...	Balance Analysis	Warning			Oct 9, 2014 00:00:02 GMT+0...	2 seconds	
TieringAnalysis_20141008_23320...	Tiering Analysis	Warning			Oct 8, 2014 23:32:09 GMT+0...	3 seconds	
TieringAnalysis_20141008_23223...	Tiering Analysis	Warning			Oct 8, 2014 23:22:38 GMT+0...	1 second	
BalanceAnalysis_20140927_0216...	Balance Analysis	Warning			Sep 27, 2014 02:16:55 GMT...	1 second	
BalanceAnalysis_20140927_0110...	Balance Analysis	Warning			Sep 27, 2014 01:10:40 GMT...	1 second	
BalanceAnalysis_20140927_0104...	Balance Analysis	Warning			Sep 27, 2014 01:04:40 GMT...	2 seconds	
Transforms_20140924_02261687...	Analysis Execution	Successful	Transforms_20140924_022616872		Sep 24, 2014 02:30:34 GMT...	3 minutes	
Transforms_20140924_022616872	Transform Plan	Successful			Sep 24, 2014 02:26:18 GMT...	1 second	
Transforms_20140924_022444325	Transform Plan	Successful			Sep 24, 2014 02:24:48 GMT...	2 seconds	
Transforms_20140924_022355950	Transform Plan	Successful			Sep 24, 2014 02:23:59 GMT...	3 seconds	

Showing 13 items | Selected 1 item

Refreshed a few moments ago

Figure 7-36 Storage Systems tasks status: running

Also when the task starts, the storage virtualizer moves the volumes to the new pool. It uses VDisk copy to move the volumes. The VDisk copy task creates a copy of selected volumes and starts the synchronization process.

Figure 7-37 shows a VDisk copy task in the SAN Volume Controller GUI; it shows that the new copies of selected volumes (Copy 1) are configured in a new pool.

Name	Status	Capacity	Storage Pool	UID
TPC_SVC1_0001	Online	10.00 GB	XIV OTHER	60050
Copy 0*	Online	10.00 GB	XIV OTHER	60050
Copy 1	Online	10.00 GB	XIV_BERNARD	60050
TPC_SVC1_0002	Online	11.00 GB	XIV OTHER	60050
Copy 0*	Online	11.00 GB	XIV OTHER	60050
Copy 1	Online	11.00 GB	XIV_BERNARD	60050
TPC_SVC1_0003	Online	12.00 GB	XIV OTHER	60050
TPC_SVC1_0004	Online	13.00 GB	XIV OTHER	60050
TPC_SVC1_0005	Online	14.00 GB	XIV OTHER	60050
TPC_SVC1_1000	Online	20.00 GB	XIV OTHER	60050
TPC_SVC1_2000	Online	21.00 GB	XIV OTHER	60050
TPC_SVC1_3000	Online	22.00 GB	XIV OTHER	60050
TPC_SVC1_4000	Online	23.00 GB	XIV OTHER	60050
TPC_SVC1_5000	Online	24.00 GB	XIV OTHER	60050
TPC_SVC1_FC1	Online	10.00 GB	XIV OTHER	60050
TPC_SVC1_FC10	Online	10.00 GB	XIV OTHER	60050
TPC_SVC1_FC2	Online	10.00 GB	XIV OTHER	60050
TPC_SVC1_FC3	Online	10.00 GB	XIV OTHER	60050

Figure 7-37 VDisk copy

The synchronization process updates the copy until it is fully synchronized. Figure 7-38 shows the synchronization progress in the SAN Volume Controller GUI.

Name	Progress	Time Remaining
TPC_SVC1_0002, copy 1	23%	2:02:13
TPC_SVC1_0001, copy 1	19%	2:02:07

Figure 7-38 Synchronization progress

When the copy is fully synchronized, the storage virtualizer will split off a synchronized volume copy to a new volume and workload will continue on the new volume. The original primary volume is deleted after the Balance Pools function completes. Figure 7-39 on page 208 shows the SAN Volume Controller GUI and only the new volumes in the new pool.

Name	Status	Capacity	Storage Pool	UID
TPC_SVC1_0001	Online	10.00 GB	XIV_BERNARD	60050
TPC_SVC1_0002	Online	11.00 GB	XIV_BERNARD	60050

Figure 7-39 Volume status in SAN Volume Controller GUI

The Storage Systems tasks pane (Figure 7-40) shows that the Balance Pools task successfully completed.

Name	Type	Status	Related Task	Schedule	Last Run Time	Duration	Tickets
BalanceAnalysis_20141009_0032...	Analysis Execution	Successful	BalanceAnalysis_20141009_003238546		Oct 9, 2014 01:12:34 GMT+0...	4 minutes	
BalanceAnalysis_20141009_0032...	Balance Analysis	Successful			Oct 9, 2014 00:32:49 GMT+0...	10 seconds	
BalanceAnalysis_20141009_0016...	Balance Analysis	Successful			Oct 9, 2014 00:16:34 GMT+0...	2 seconds	
BalanceAnalysis_20141008_2358...	Balance Analysis	Warning			Oct 9, 2014 00:00:02 GMT+0...	2 seconds	
TieringAnalysis_20141008_23320...	Tiering Analysis	Warning			Oct 8, 2014 23:32:09 GMT+0...	3 seconds	
TieringAnalysis_20141008_23223...	Tiering Analysis	Warning			Oct 8, 2014 23:22:38 GMT+0...	1 second	
BalanceAnalysis_20140927_0216...	Balance Analysis	Warning			Sep 27, 2014 02:16:55 GMT...	1 second	
BalanceAnalysis_20140927_0110...	Balance Analysis	Warning			Sep 27, 2014 01:10:40 GMT...	1 second	
BalanceAnalysis_20140927_0104...	Balance Analysis	Warning			Sep 27, 2014 01:04:40 GMT...	2 seconds	
Transforms_20140924_02261687...	Analysis Execution	Successful	Transforms_20140924_022616872		Sep 24, 2014 02:30:34 GMT...	3 minutes	
Transforms_20140924_022616872	Transform Plan	Successful			Sep 24, 2014 02:26:18 GMT...	1 second	
Transforms_20140924_022444325	Transform Plan	Successful			Sep 24, 2014 02:24:48 GMT...	2 seconds	
Transforms_20140924_022359590	Transform Plan	Successful			Sep 24, 2014 02:23:59 GMT...	3 seconds	

Figure 7-40 Successful completion of Storage Systems tasks

If you open the log, it shows all the steps that are done (Figure 7-41).

Logs

Task Type: Analysis Execution Task Name: BalanceAnalysis_20141009_003238545_1

Run 1: Oct 9, 2014 01:07:40 GMT+02:00 - Oct 9, 2014 01:12:34 GMT+02:00

Show all

Status	Date and Time	ID	Description
Information	Oct 9, 2014 01:07:44.228 GMT+02:00	HWN023004	The Optimization Automation request persisted recommendations to be processed.
Information	Oct 9, 2014 01:07:44.618 GMT+02:00	HWN023003	The Optimization Execution task retrieved 2 recommendations
Information	Oct 9, 2014 01:07:44.650 GMT+02:00	HWN023005	The Optimization Execution task updated the status of 2 recommendations.
Information	Oct 9, 2014 01:07:44.650 GMT+02:00	HWN023008	The Optimization Automation request begins processing 2 recommendations.
Information	Oct 9, 2014 01:07:45.556 GMT+02:00	HWN023015	Virtual disk TPC_SVC1_0002 will now be migrated from storage pool XIV_OTHER to storage pool XIV_BERNARD.
Information	Oct 9, 2014 01:07:55.556 GMT+02:00	HWN023015	Virtual disk TPC_SVC1_0001 will now be migrated from storage pool XIV_OTHER to storage pool XIV_BERNARD.
Information	Oct 9, 2014 01:08:24.322 GMT+02:00	HWN023016	Successfully added virtual disk copy to virtual disk TPC_SVC1_0001.
Information	Oct 9, 2014 01:08:25.181 GMT+02:00	HWN023016	Successfully added virtual disk copy to virtual disk TPC_SVC1_0002.
Information	Oct 9, 2014 01:08:44.884 GMT+02:00	HWN023017	Synchronization for virtual disk TPC_SVC1_0002 has completed 20% and requires about 78 seconds to complete.
Information	Oct 9, 2014 01:08:52.494 GMT+02:00	HWN023017	Synchronization for virtual disk TPC_SVC1_0001 has completed 18% and requires about 128 seconds to complete.
Information	Oct 9, 2014 01:09:01.775 GMT+02:00	HWN023017	Synchronization for virtual disk TPC_SVC1_0002 has completed 29% and requires about 89 seconds to complete.
Information	Oct 9, 2014 01:11:17.276 GMT+02:00	HWN023018	Synchronization for virtual disk TPC_SVC1_0002 has completed.
Information	Oct 9, 2014 01:11:54.698 GMT+02:00	HWN023018	Synchronization for virtual disk TPC_SVC1_0001 has completed.
Information	Oct 9, 2014 01:12:00.479 GMT+02:00	HWN023019	Successfully removed a virtual disk copy from virtual disk TPC_SVC1_0002.
Information	Oct 9, 2014 01:12:20.573 GMT+02:00	HWN023019	Successfully removed a virtual disk copy from virtual disk TPC_SVC1_0001.
Information	Oct 9, 2014 01:12:23.870 GMT+02:00	HWN023020	Successfully changed the synchronization rate of virtual disk TPC_SVC1_0002 to 50%.
Information	Oct 9, 2014 01:12:23.870 GMT+02:00	HWN023010	Virtual disk TPC_SVC1_0002 was successfully migrated from storage pool XIV_OTHER to storage pool XIV_BERNARD.
Information	Oct 9, 2014 01:12:33.901 GMT+02:00	HWN023020	Successfully changed the synchronization rate of virtual disk TPC_SVC1_0001 to 50%.
Information	Oct 9, 2014 01:12:33.901 GMT+02:00	HWN023010	Virtual disk TPC_SVC1_0001 was successfully migrated from storage pool XIV_OTHER to storage pool XIV_BERNARD.
Information	Oct 9, 2014 01:12:33.995 GMT+02:00	HWN023002	The Optimization Execution task has completed.

Figure 7-41 Balance Pools log

If you check the volumes for the Windows server, you see that they are now in the new pool XIV_BERNARD (Figure 7-42).

Name	Pool	Storage System	Status	Capacity	Hosts	Allocated Space (GiB)	Physical Allocation (%)	Shortfall (%)
TPC_SVC1_0001	XIV_BERNARD	SVC1PROD	Online	10.00		10.00	Fully Allocated	
TPC_SVC1_0002	XIV_BERNARD	SVC1PROD	Online	11.00	2	11.00	Fully Allocated	
TPC_SVC1_1000	XIV_OTHER	SVC1PROD	Online	20.00	2	20.00	Fully Allocated	
TPC_SVC1_2000	XIV_OTHER	SVC1PROD	Online	21.00	2	21.00	Fully Allocated	

Figure 7-42 Volumes status in Tivoli Storage Productivity Center web GUI

The most important objective of this use case is to show that the workload is now balanced across pools as shown in Figure 7-43 on page 210. Before we did the balancing, the XIV_BERNARD pool did not have any workload, and the XIV_OTHER pool was fully utilized. After we balanced the pools, you see that the workload is now running on both pools according to the defined policy.

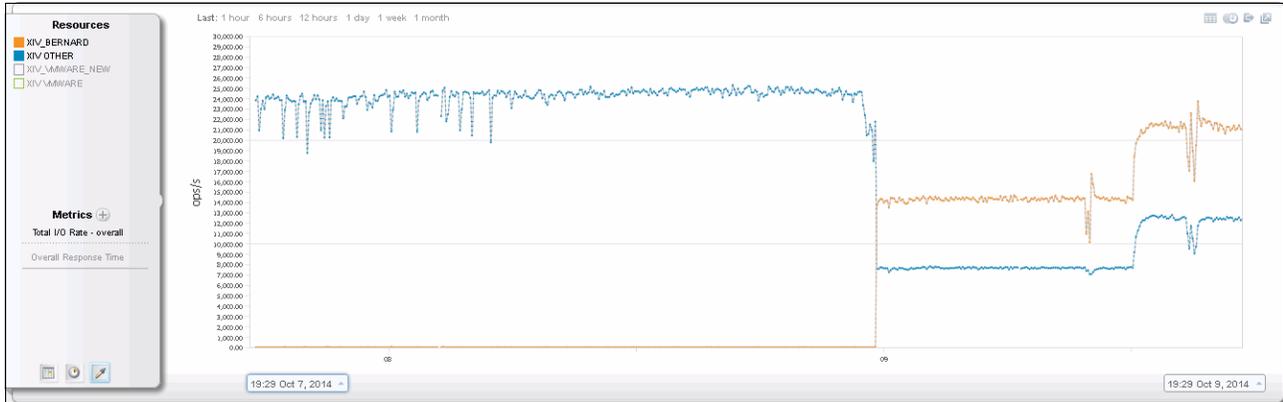


Figure 7-43 Pools performance

7.6 Use case: Analyze Tiering

This case shows how to use the Analyze Tiering function (wizard) at the volume level by setting minimum thresholds for I/O rate on each tier. The Analyze Tiering function is also possible at the pools, storage systems, hypervisors, and servers levels where the volumes are analyzed only for the selected resource.

Before starting this use case, we set the tier level of storage pools in our environment. We have four storage pools and we set three tiers. Figure 7-44 shows the tier levels of the pools in our use case.

Pools

4 Normal
 0 Warning
 0 Error

Pools Performance

Actions

Name	Tier	Status	Physical Allocation (%)	Capacity (GiB)	Shortfall (%)
XIV_BERNARD	1	Online	83%	5,760.00	62%
XIV_OTHER	2	Online	17%	3,840.00	0%
XIV_VMWARE	3	Online	92%	11,326.50	92%
XIV_VMWARE_NEW	3	Online	88%	5,600.00	88%

Figure 7-44 Tiering

When the tiers are defined, select the volumes that you want to analyze. We select four volumes of a test server from the volumes pane. The Analyze Tiering function is available from either the Actions menu or the context menu, as shown in Figure 7-45. Select **Analyze Tiering**.

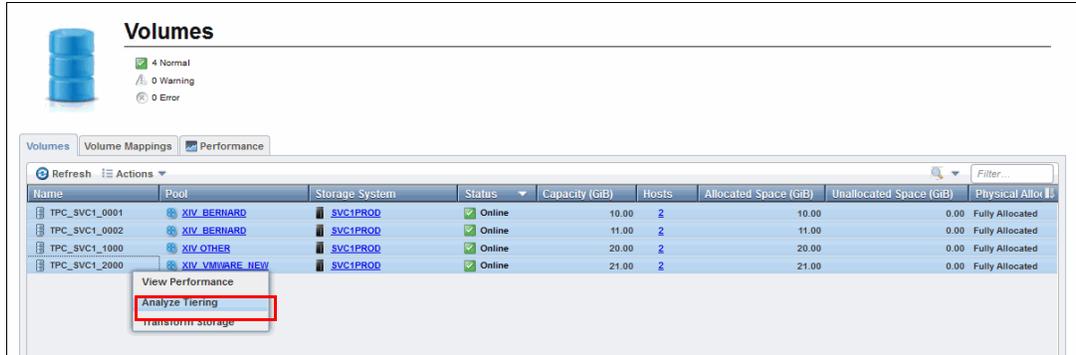


Figure 7-45 Analyze Tiering

Because we are running a workload on the selected volumes, you can see the performance monitor for all volumes (Figure 7-46).

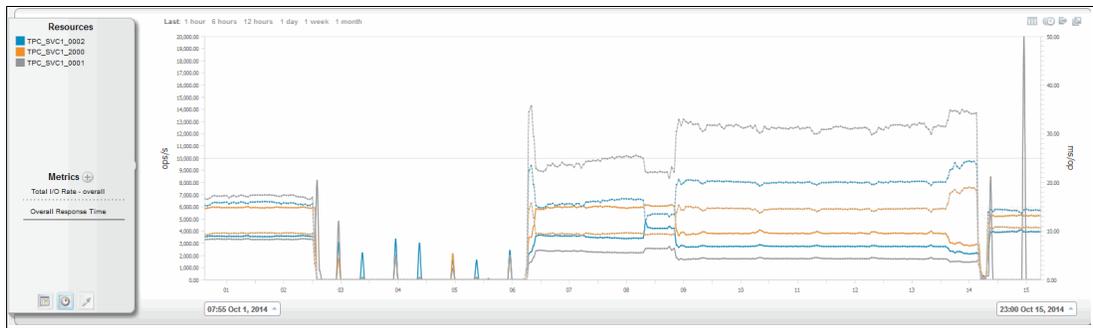


Figure 7-46 Volume performance

In this use case, we use I/O rate to perform Analyze Tiering of the volumes. The source storage pools that are related to the selected volumes are analyzed to determine whether they meet the workload requirements of the volumes. If the workload requirements of the volume in its current tier are not met, the volume is a candidate for relocation. Figure 7-47 shows I/O rates for the selected volumes that are used for Analyze Tiering.

Name	Storage System	Total I/O Rate - overall [ops/s]	Read I/O Rate - overall [ops/s]	Write I/O Rate - overall [ops/s]
TPC_SVC1_0001	SVC1PROD	7,698.31	5,228.36	2,469.95
TPC_SVC1_0002	SVC1PROD	5,204.91	3,551.82	1,653.08
TPC_SVC1_1000	SVC1PROD	3,772.76	2,568.93	1,203.83
TPC_SVC1_2000	SVC1PROD	3,575.12	2,434.44	1,140.69

Figure 7-47 Volumes I/O rate

After you select **Analyze Tiering**, target pools must be selected to optimize the placement of the volumes (Figure 7-48). We select all tiers because we want to optimize the placement across all tiers. Click **Next**.

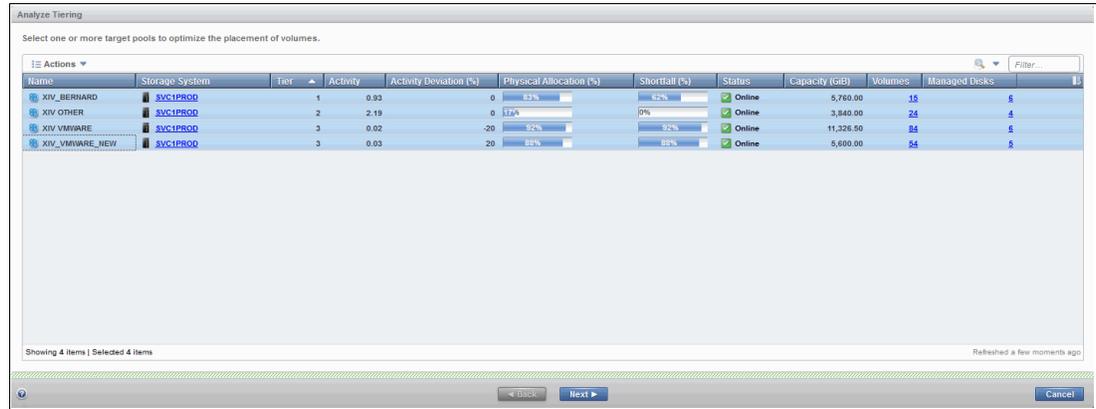


Figure 7-48 Target pools in Analyze Tiering

Figure 7-49 on page 213 shows Analyze Tiering definitions where you specify thresholds that are used in the analysis.

First, enter the number of days to use for analysis. By entering the number of days, you are manually updating the pane so the values for activity are updated. We use 15 days for this analysis.

If the volumes in the source pool that are assigned to the same hypervisor or server are assigned to different host connections, the collocation of the volumes is affected. In such cases, if volumes require optimization, the volumes that are assigned to the same host connection are kept together. In this case, we do not use collocation because it is not important for this test server.

You must decide if you want to use the default or the advanced options in Analyze Tiering. In this case, we are showing you the advanced options so we select **Show advanced options**. You can then set up volume thresholds for I/O rate, I/O density, and file usage. If you use the default options instead, you can set up the Activity limit only for tiers that are analyzed.

The default values for I/O density or I/O rate are not based on any analysis and you need to change those numbers based on your system requirements. If you do not know what threshold values to use, a better approach is to consider using the advanced option. The advanced option implies that you understand the workload of the tiers and that you need this flexibility.

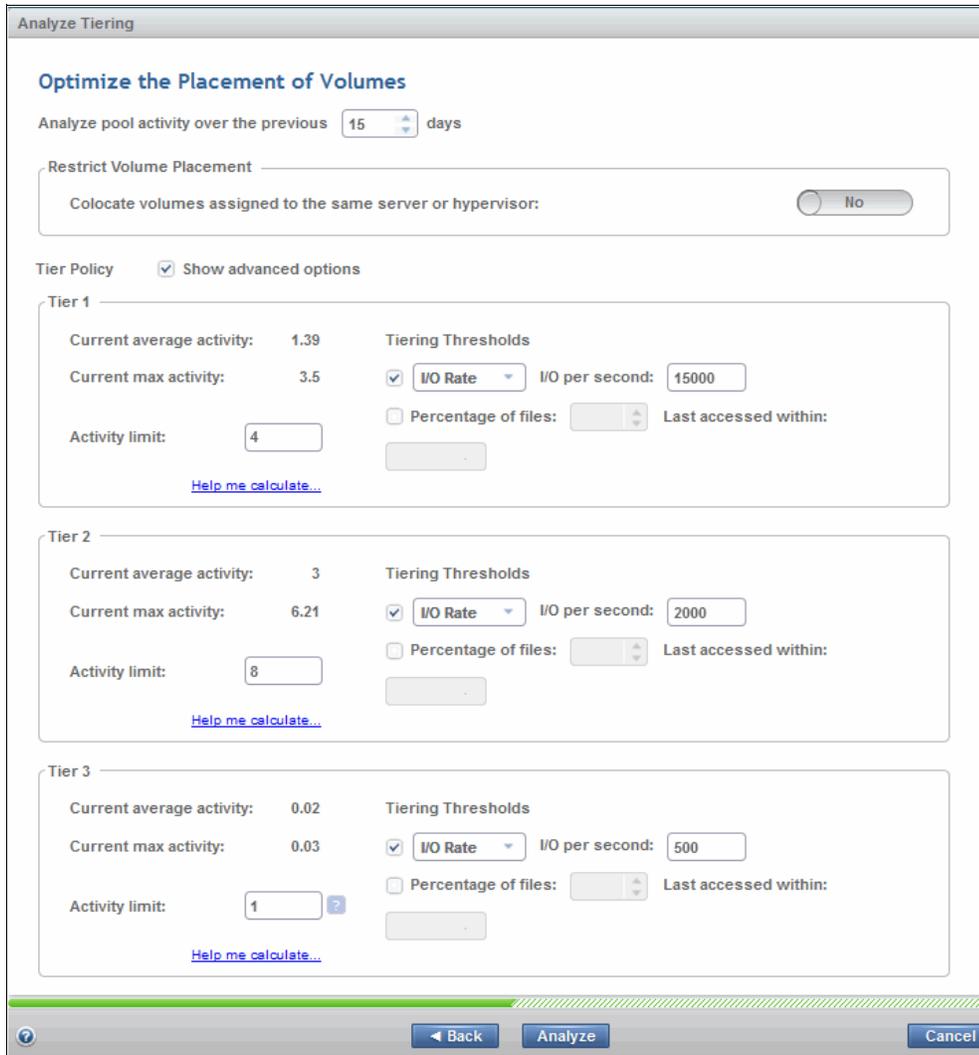


Figure 7-49 Analyze Tiering definition

In the definition, you set minimum thresholds for each tier of storage. In this case, we have volumes from three tiers that are analyzed, so thresholds must be set for all 3 tiers.

We specify minimum thresholds for I/O rate for each tier. You can also specify minimum thresholds for I/O density and file usage or you can combine minimum thresholds for I/O density and file usage, and for I/O rate and file usage. The workload of the volumes is evaluated to determine whether the volumes require re-tiering. In this case, we define the following I/O rates:

- ▶ Tier 1 = 15000 I/O per second
- ▶ Tier 2 = 2000 I/O per second
- ▶ Tier 3 = 500 I/O per second

By setting minimum I/O rate thresholds, volumes are evaluated. For example if the volume in Tier 2 has more than 15000 I/O per second, it is candidate to move up to Tier 1.

Note: When performing Analyze Tiering at the volume level, the pool activity values are used with the I/O rate that you set. In this example having an I/O rate higher than 15000 I/O per second will recommend a move only if the pool activity limit did not exceed it.

The activity limit must be set because it is used together with I/O rate to Analyze Tiering. You can calculate the activity limit by clicking the **Help me calculate** link. This value is set to the sum of the maximum read I/O rate and the write I/O rate operations that you want to specify as limits, divided by the average capacity of all of the pools on the same tier. In addition, the maximum write I/O rate is the highest value that a pool in the storage tier can accommodate in conjunction with the read I/O and vice versa. They must stay within desired performance bounds.

An example of calculating the activity limit is shown in Figure 7-50.

Tier 1

Calculate the Activity Limit

The activity limit is set to the sum of the maximum read I/O rate and write I/O rate operations that you want to specify as limits divided by the average capacity of all of the pools on the same tier.

Maximum write I/O rate:

Maximum read I/O rate:

Average pool capacity: 5760 GiB

Calculated activity limit: 4.34

Figure 7-50 Calculate Activity Limit

After you enter all the parameters in the tier definition for Analyze Tiering, click **Analyze** (see Figure 7-49 on page 213).

The completed analysis, with recommendations, is shown in Figure 7-51.

Tiering Analysis

Completed: Oct 16, 2014 23:25:28 GMT+02:00
Duration: 5 seconds
[Open Log](#)

TieringAnalysis_20141016_232519319

Analysis Recommendations

Name	Source Pool	Destination Pool	Current Tier	Target Tier	Server
TPC_SVC1_2000	XIV_VIMWARE_NEW	XIV_OTHER	3	2	172.31.1.83
TPC_SVC1_0001	XIV_BERNARD	XIV_OTHER	1	2	172.31.1.83
TPC_SVC1_0002	XIV_BERNARD	XIV_OTHER	1	2	172.31.1.83

Showing 3 items | Selected 0 items

Refreshed 15 minutes ago

Figure 7-51 Analyze Tiering recommendations

According to the analysis, three volumes will be moved to a new tier. Volumes TPC_SVC1_0001 and TPC_SVC1_0002 will be moved down from Tier 1 to Tier 2, and volume TPC_SVC1_2000 will be moved up from Tier 3 to Tier 2.

Figure 7-52 shows the complete log of the analysis.

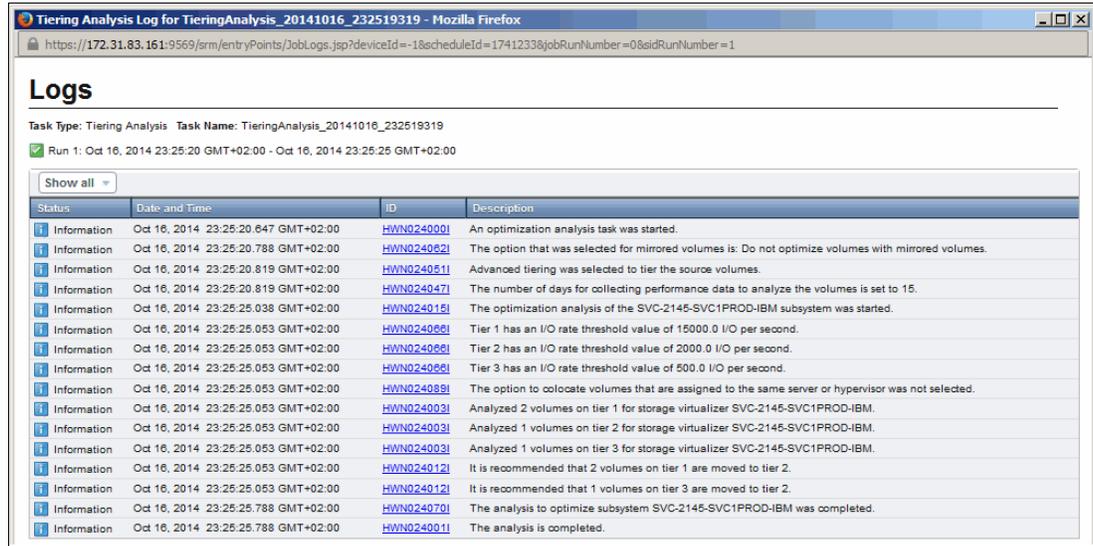


Figure 7-52 Analyze Tiering log

You can schedule the task or start it immediately. In this use case, we start it immediately. Figure 7-53 shows that task is running.

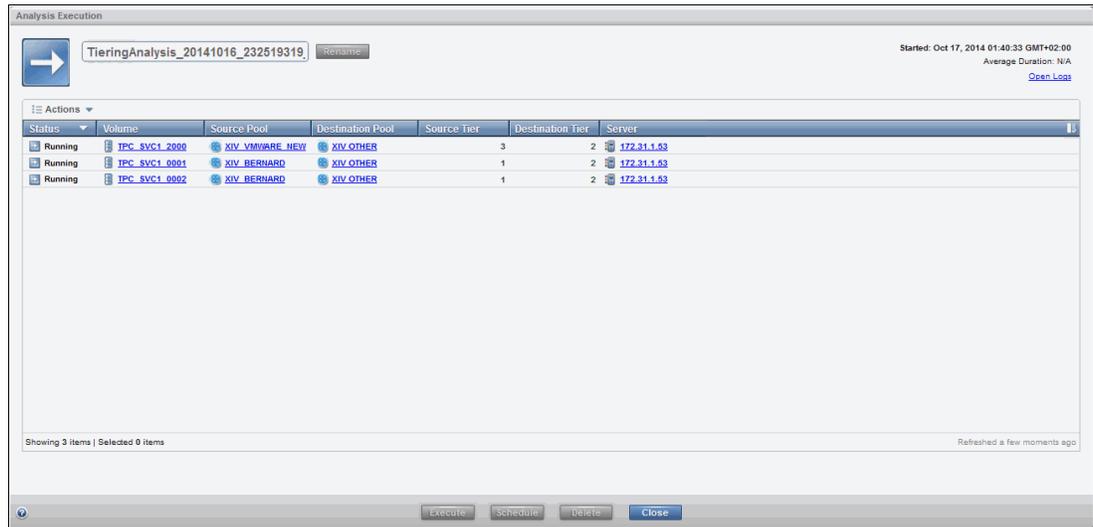


Figure 7-53 Analyze Tiering task running

When the task starts, storage virtualizer uses VDisk copy to move the volumes. The VDisk copy task creates a copy of the volumes that are moving to a new tier and starts the synchronization process.

Figure 7-54 shows the VDisk copy task in the SAN Volume Controller GUI. The new copies of the analyzed volumes are configured in a new pool, which is in different tier than the original pool.

Name	Status	Capacity	Storage Pool
TPC_SVC1_0001	Online	10.00 GB	XIV_BERNARD
Copy 0*	Online	10.00 GB	XIV_BERNARD
Copy 1	Online	10.00 GB	XIV_OTHER
TPC_SVC1_0002	Online	11.00 GB	XIV_BERNARD
Copy 0*	Online	11.00 GB	XIV_BERNARD
Copy 1	Online	11.00 GB	XIV_OTHER
TPC_SVC1_0003	Online	12.00 GB	XIV_OTHER
TPC_SVC1_0004	Online	13.00 GB	XIV_OTHER
TPC_SVC1_0005	Online	14.00 GB	XIV_BERNARD
TPC_SVC1_0006	Online	10.00 GB	XIV_OTHER
TPC_SVC1_0007	Online	15.00 GB	XIV_OTHER
TPC_SVC1_1000	Online	20.00 GB	XIV_OTHER
TPC_SVC1_2000	Online	21.00 GB	XIV_VMWARE_NEW
Copy 0	Online	21.00 GB	XIV_OTHER
Copy 1*	Online	21.00 GB	XIV_VMWARE_NEW
TPC_SVC1_3000	Online	22.00 GB	XIV_OTHER
TPC_SVC1_4000	Online	23.00 GB	XIV_OTHER
TPC_SVC1_5000	Online	24.00 GB	XIV_OTHER

Figure 7-54 SAN Volume Controller VDisk copy

The synchronization process updates the copy until it is fully synchronized. During the synchronization, the workload runs on the test server by using the IO meter tool (Figure 7-55) and in the SAN Volume Controller GUI (Figure 7-56).

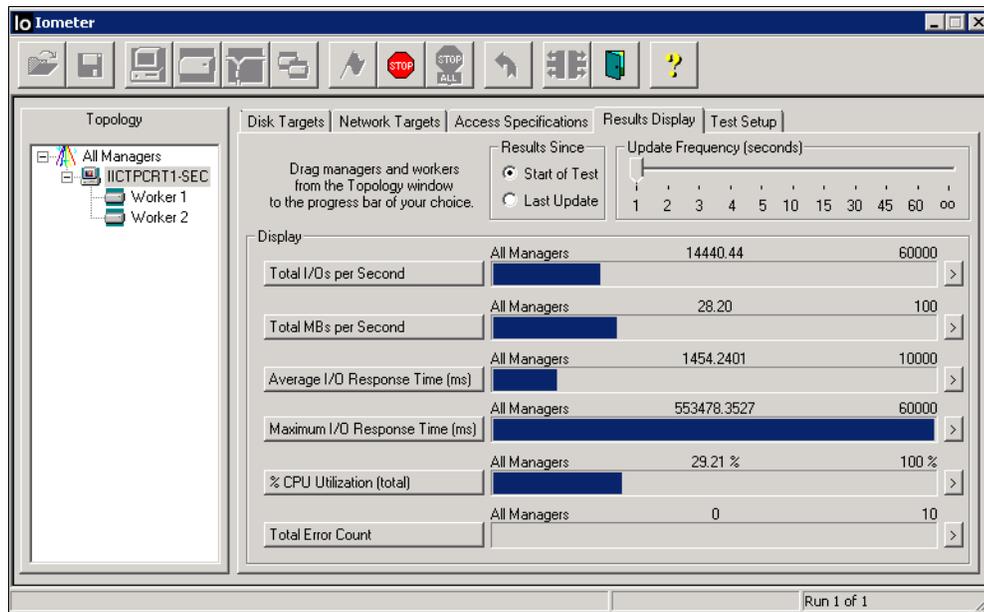


Figure 7-55 IO meter workload



Figure 7-56 SAN Volume Controller GUI: workload performance

When the copy is fully synchronized, the storage virtualizer splits off a synchronized volume copy to a new volume; the workload continues. The original volumes are deleted and the Analyze Tiering task is complete (Figure 7-57).

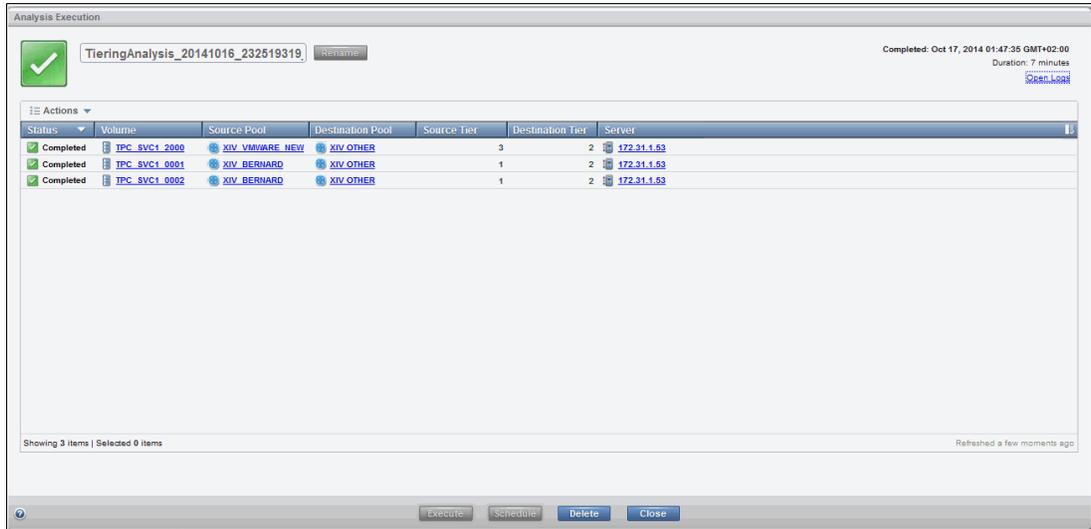


Figure 7-57 Analyze Tiering task is completed

Figure 7-58 shows the log of the Analyze Tiering task.

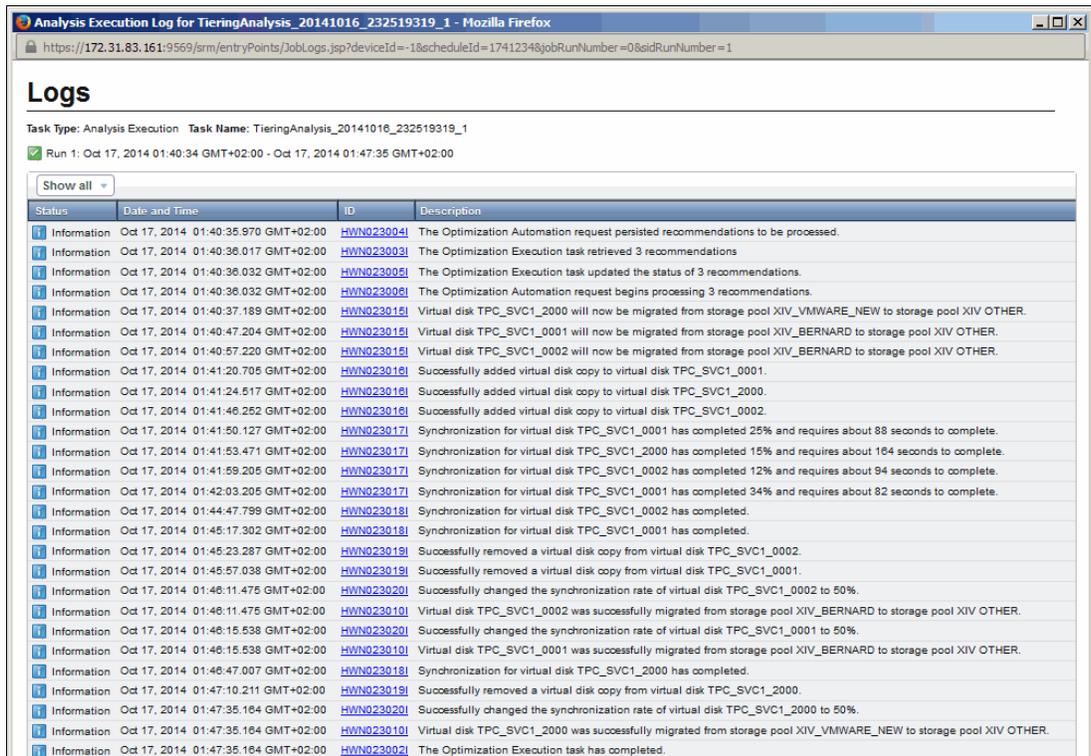


Figure 7-58 Analyze Tiering log

The optimized volumes are shown in Figure 7-59. You see that they are moved to a new pool in a new tier.

Name	Pool	Storage System	Status	Capacity (GiB)	Hosts	Allocated Space (GiB)	Unallocated Space (GiB)	Physical Allocation
TPC_SVC1_0001	XIV_OTHER	SVC1PROD	Online	10.00	2	10.00	0.00	Fully Allocated
TPC_SVC1_0002	XIV_OTHER	SVC1PROD	Online	11.00	2	11.00	0.00	Fully Allocated
TPC_SVC1_1000	XIV_OTHER	SVC1PROD	Online	20.00	2	20.00	0.00	Fully Allocated
TPC_SVC1_2000	XIV_OTHER	SVC1PROD	Online	21.00	2	21.00	0.00	Fully Allocated

Figure 7-59 Volumes after Analyze Tiering task is done

7.7 Use case: Volume transformation

You can use the volume transformation function to convert fully allocated volumes to thin-provisioned volumes in storage pools. Other volume transformation options (migrate pool, compression, Easy Tier) use the same wizard as shown in this use case.

Thin provisioning enables the storage systems to present the required capacity to the host while allocating only the actual used capacity in terms of space on the physical storage media. By using volume transformation to transform fully allocated volumes to thin-provisioned volumes, your storage environment is better used, and unused space is released. This use case shows how we transform a fully allocated volume of 10 GB to a thin-provisioned volume. We also run a workload that is using approximately 6 GB of data on that volume.

You can start the volume transformation function from any list of volumes. In this case, we start the volume transformation function from the Servers panel, and we use our test server ICTPCRT1-SEC (Figure 7-60). The server has four volumes that are fully allocated.

Name	Pool	Storage System	Status	Capacity (GiB)	Hosts	Allocated Space (GiB)	Unallocated Space (GiB)	Physical Allocation
TPC_SVC1_0001	XIV_BERNHARD	SVC1PROD	Online	10.00	2	10.00	0.00	Fully Allocated
TPC_SVC1_0002	XIV_BERNHARD	SVC1PROD	Online	11.00	2	11.00	0.00	Fully Allocated
TPC_SVC1_1000	XIV_OTHER	SVC1PROD	Online	20.00	2	20.00	0.00	Fully Allocated
TPC_SVC1_2000	XIV_OTHER	SVC1PROD	Online	21.00	2	21.00	0.00	Fully Allocated

Figure 7-60 Volumes pane

We want to transform volume TPC_SVC1_0001 to a thin-provisioned volume. To transform it, either select **Actions** → **Transform Storage** or right-click the volume and select the **Transform Storage** option (Figure 7-61).

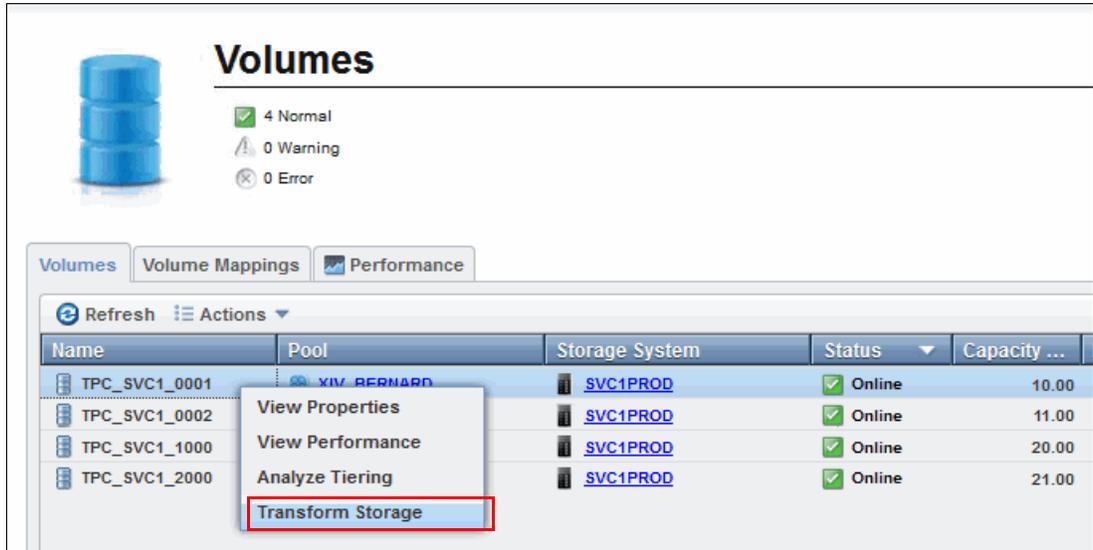


Figure 7-61 Transform Storage option

Because the pools where the volume is defined are in a capacity pool, we receive a warning message (Figure 7-62). Click **Next**.

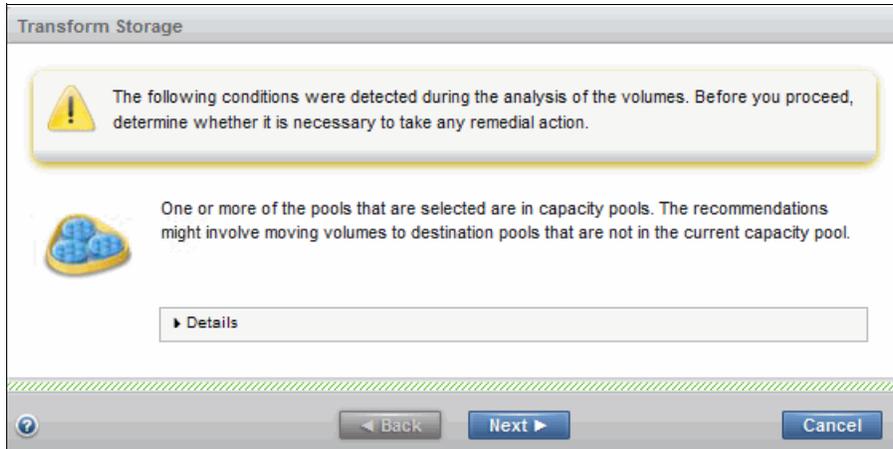


Figure 7-62 Transform Storage warning

In the next pane (Figure 7-63), select **Thin Provisioning** and set the option to **On**. Click **Next**.

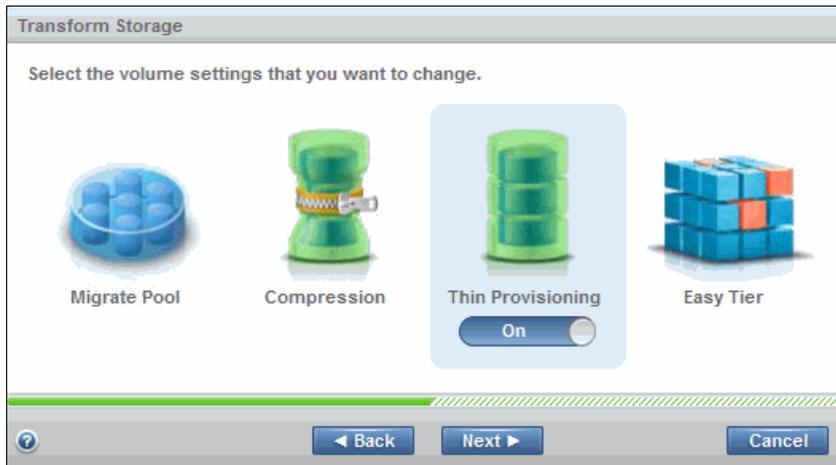


Figure 7-63 Thin Provisioning option

The Transform Storage pane opens (Figure 7-64). Enter the information in the empty fields, setting the values as required.

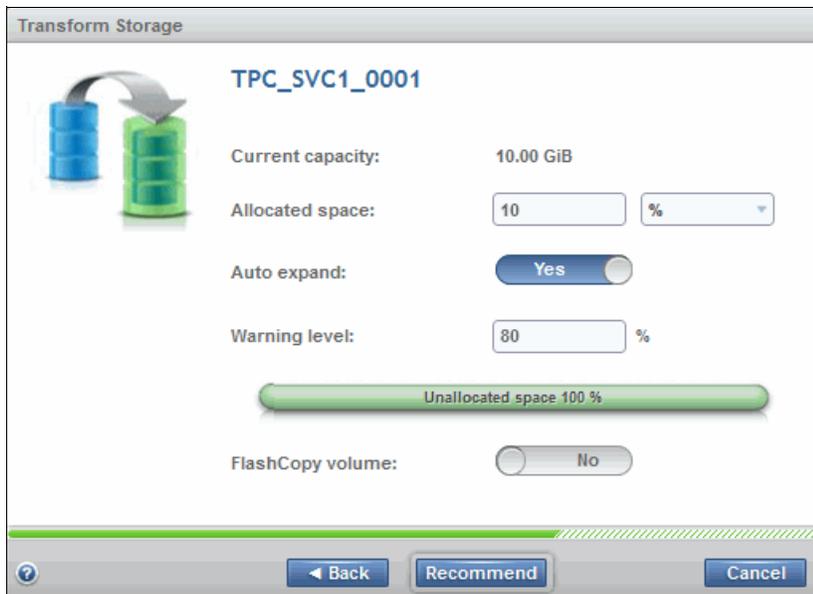


Figure 7-64 Thin provisioning details

If you want to transform more volumes, see the **Maximum volume capacity** field, which refers to the smallest volume size. This field helps you track how many volumes and the capacity you have used so far. You can then determine if you want to transform more volumes.

Figure 7-65 shows example of multiple volume selection for volume transformation.

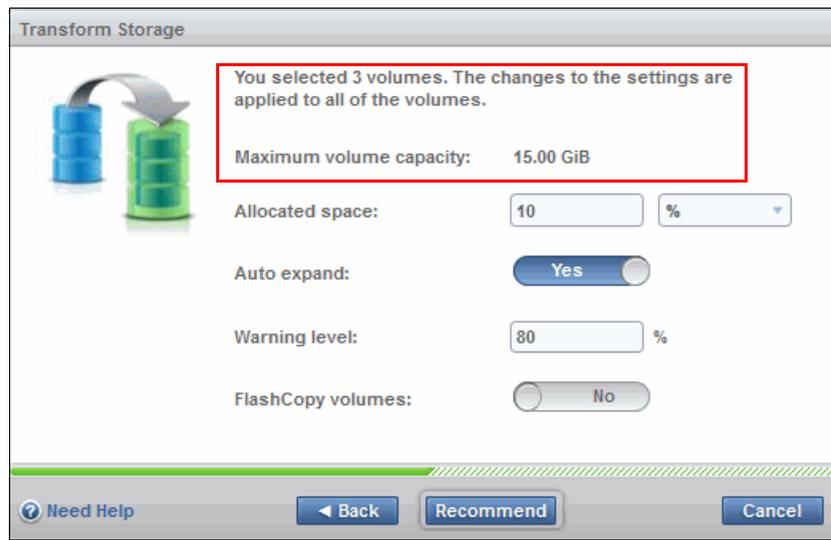


Figure 7-65 Multiple volume selection

You can change the default values for thin-provisioned volume according to your requirements and environment. In this case, we use default values.

The transform volume configuration fields for thin provisioning and their use are as follows:

► Allocated space

In this field, we enter the real capacity value. Use the drop-down menu to indicate percentage (%) or an absolute value (expressed in MiB, GiB, TiB).

- Percentage values: In this case the real capacity equals the indicated percentage value of the current capacity.
- Absolute values: As an example, an absolute value of 1 GiB is the real capacity for the selected volume.

► Auto expand

When this option is set to **Yes**, space is automatically added to the thin-provisioned volume when needed. The amount of space that is added is determined by the value that you enter in the **Allocated space** field.

If **Auto expand** is set to **No**, the thin-provisioned volume is taken offline when it runs out of available space.

► Warning level

A warning event is generated on the storage system when the percentage of used space exceeds the value that you specify. You can define a warning level either by specifying a value in this field, or by moving the warning level slider.

To be able to set a warning level, you must first set **Auto expand** to **Yes**.

► FlashCopy volumes

If the volume you are transforming is a source or a target FlashCopy volume, select **Yes**. In the field that opens, specify a grain size, which must match the grain size that is specified in FlashCopy relationship.

Click **Recommend**. Tivoli Storage Productivity Center then prepares the transformation plan.

When it completes the Transform Plan pane opens (Figure 7-66).

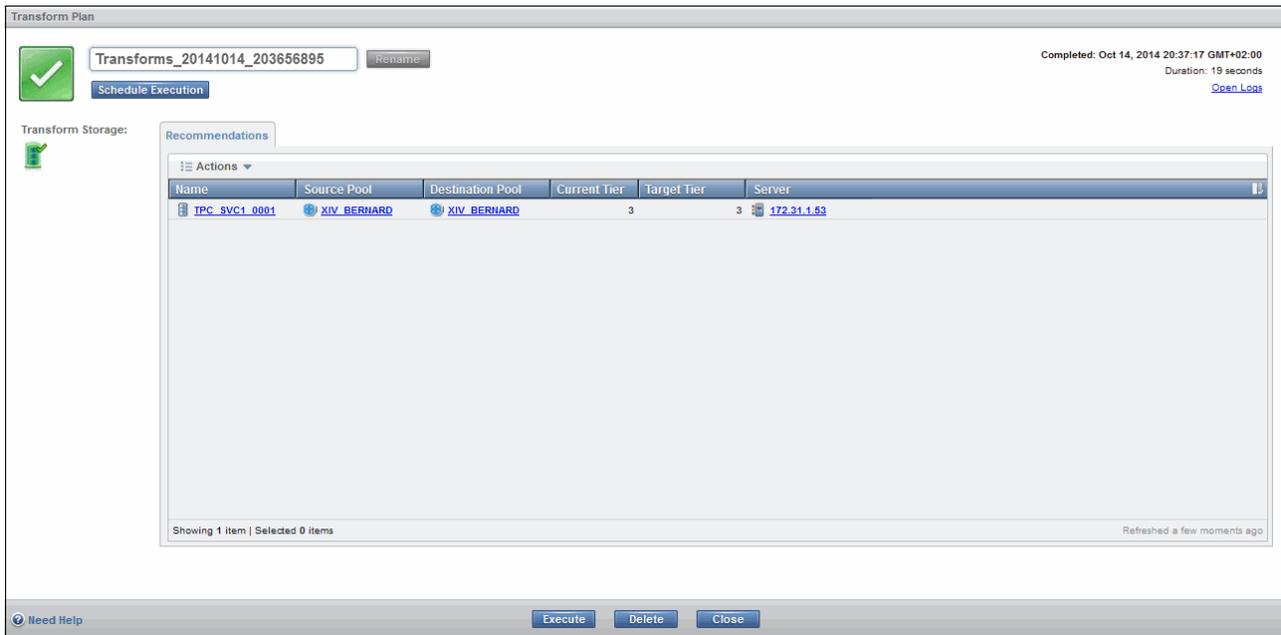


Figure 7-66 Transform Plan

You can schedule the transform plan or you can start it immediately. In this case, we start it immediately.

Also in this case, we run a workload on the volume that will be transformed (Figure 7-67). By running the workload, we show that this task is not disruptive to your server.

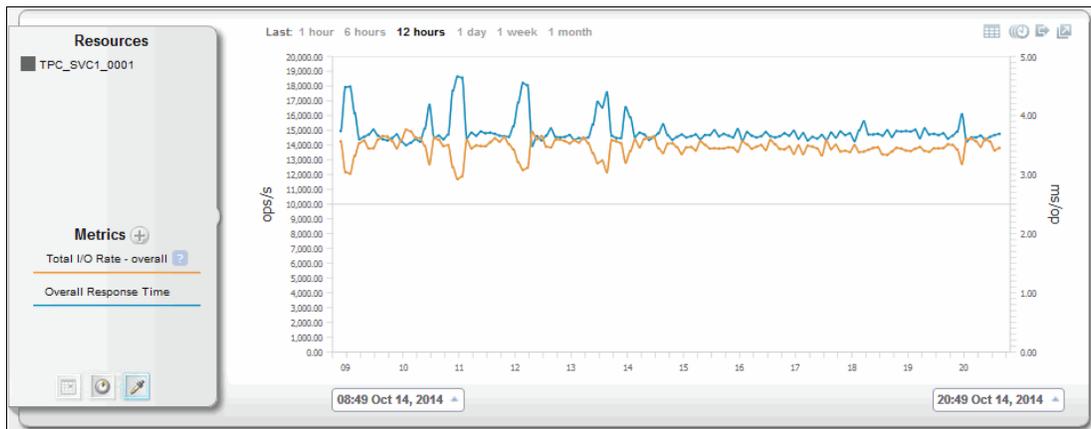


Figure 7-67 Volume performance monitor

When the task starts, the status changes to Running (Figure 7-68).



Figure 7-68 Transform volumes task is running

Also when the task starts, the storage virtualizer uses VDisk copy to transform the volume. The VDisk copy task creates thin-provisioned copy of a selected fully allocated volume and starts the synchronization process.

Figure 7-69 shows the VDisk copy task in the SAN Volume Controller GUI and shows that the new copy of the selected volume is configured.

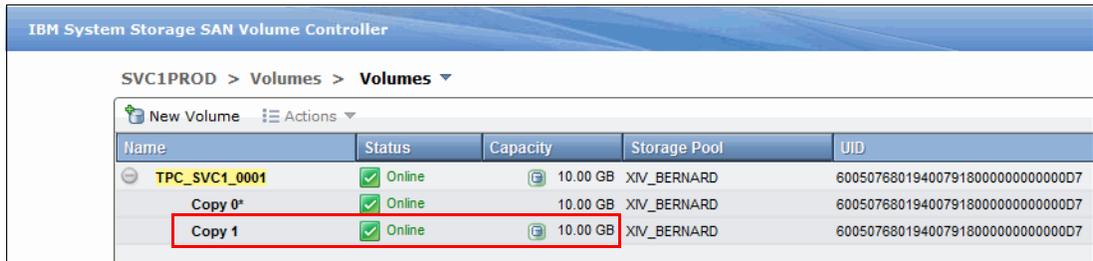


Figure 7-69 VDisk copy

The synchronization process updates the copy until it is fully synchronized. When the copy is fully synchronized, the storage virtualizer splits off a synchronized volume copy to a new thin-provisioned volume and workload will continue on the new thin provisioned volume. The original fully allocated volume will be deleted after the transform volumes function is done.

Figure 7-70 shows the new thin-provisioned volume.

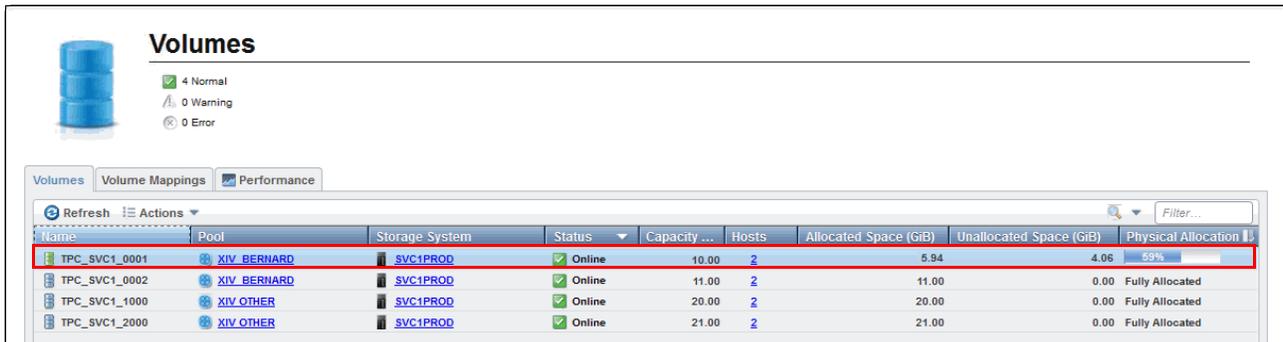


Figure 7-70 Thin-provisioned volume

The physical allocation on the thin-provisioned volume is 59%, which means that the allocated capacity is only 5.94 GB. By transforming a fully allocated volume of 10 GB to a thin-provisioned volume, 4.06 GB is released.

The complete log of the volume transformation function is shown in Figure 7-71.

Analysis Execution Log for Transforms_20141014_231833243_1 - Mozilla Firefox
https://172.31.83.161:9569/srm/entryPoints/JobLogs.jsp?deviceId=-1&scheduleId=1741210&jobRunNumber=0&sidRunNumber=1

Logs

Task Type: Analysis Execution Task Name: Transforms_20141014_231833243_1
Run 1: Oct 14, 2014 23:20:05 GMT+02:00 - In Progress

Show all

Status	Date and Time	ID	Description
Information	Oct 14, 2014 23:20:05.338 GMT+02:00	HWN023004	The Optimization Automation request persisted recommendations to be processed.
Information	Oct 14, 2014 23:20:05.353 GMT+02:00	HWN023003	The Optimization Execution task retrieved 1 recommendations
Information	Oct 14, 2014 23:20:05.369 GMT+02:00	HWN023005	The Optimization Execution task updated the status of 1 recommendations.
Information	Oct 14, 2014 23:20:05.369 GMT+02:00	HWN023008	The Optimization Automation request begins processing 1 recommendations.
Information	Oct 14, 2014 23:20:05.447 GMT+02:00	HWN023015	Virtual disk TPC_SVC1_0002 will now be migrated from storage pool XIV_BERNARD to storage pool XIV_BERNARD.
Information	Oct 14, 2014 23:20:33.322 GMT+02:00	HWN023016	Successfully added virtual disk copy to virtual disk TPC_SVC1_0002.
Information	Oct 14, 2014 23:20:41.416 GMT+02:00	HWN023017	Synchronization for virtual disk TPC_SVC1_0002 has completed 3% and requires about 261 seconds to complete.
Information	Oct 14, 2014 23:20:48.541 GMT+02:00	HWN023017	Synchronization for virtual disk TPC_SVC1_0002 has completed 6% and requires about 238 seconds to complete.
Information	Oct 14, 2014 23:24:54.140 GMT+02:00	HWN023018	Synchronization for virtual disk TPC_SVC1_0002 has completed.

Figure 7-71 Volume transformation log



A

Tivoli Storage FlashCopy Manager and DB2 scripts

The appendix describes the Tivoli Storage FlashCopy Manager and DB2 scripts *pre-freeze* and *post-thaw*. The scripts also document the steps to create customer scripts before running a backup. These scripts are written for a Windows and VMware environment. They will reside in the virtual machine where our customer application is running.

Modifying scripts: These scripts are examples only and must be modified for your environment.

A.1 Scripts

The *freeze script* puts the DB2 database into a suspend write mode before VMware takes a snapshot of the virtual machine. This script passes the suspend write operation to the main executing script. The name of the script is `freeze.cmd` and it is in the `C:\Windows` directory.

The last script that is called is the *thaw script*. This script calls the main execute script and passes it the resume write command, which takes the database out of a suspend mode and resumes normal operations. This script is in the `C:\Windows` directory.

Note: These scripts are examples only and will need to be modified for each user environment.

Example A-1 shows the DB2 pre-freeze (*freeze*) and post-thaw (*thaw*) scripts, and also an example of the wrapper script needed to call the main script. The main script, also shown, is called by the freeze and thaw scripts.

Example A-1 DB2 pre-freeze and post-thaw

The script below is a **wrapper script** that calls the main scripts depending on the operation, freeze or thaw. The name of the script is `vcb.bat` and is located in the following directory "`C:\Program Files\VMware\VMware Tools\backupScripts.d`"

Wrapper script:

```
echo off
if "%1" == "freeze" goto doFreeze
goto doThaw
:doFreeze
call c:\windows\freeze.cmd
goto EOF
:doThaw
call c:\windows\thaw.cmd
:EOF
```

Freeze script:

The script below is the **freeze script**, this script puts the DB2 database into suspend write mode prior to VMware taking a snapshot of the virtual machine. This script passes the suspend write operation to the main executing script. The name of the script is `freeze.cmd` and is located in the `C:\Windows` directory you can enable logging and set the log directory in this script

```
@echo off
@setlocal

@rem *****
@rem db2_preconpoint.cmd
@rem
@rem Description: Pre consistency point script for DB2 backup.
@rem
@rem Functionality:
@rem - Connects to the local database to back up.
@rem - Calls a SQL script that suspends write operations for the database to be backed up.
@rem - Terminates database connection.
@rem
@rem Authorization:
@rem You must run the script as an user id with sysadm, sysctrl, or sysmaint authority.
@rem
@rem Exit with Return Code:
```

```

@rem 0, if execution is successful.
@rem other, if error encountered.
@rem
@rem *****
@rem version 0.6
@rem last modification 20080806
set SCRIPT_LEVEL=20080806
@rem author
@rem *****

@rem *****
@rem !!! ADJUST THE FOLLOWING VARIABLES IF YOU WISH TO USE OTHER THAN THE DEFAULT VALUES
!!!
@rem doLogging - Flag to create a trace log; possible values: TRUE, FALSE
@rem logDir - Trace log directory
set doLogging=TRUE
set logDir=G:\logs
@rem !!! END OF SETTING VARIABLES !!!
@rem !!! DO NOT MODIFY BELOW THIS LINE OF CODE !!!
@rem *****

@rem Create the log dir if there is not yet.
dir "%logDir%" 1>NUL 2>&1
set /A RC=%errorlevel%
if "%RC%" equ "0" goto isLogDir
mkdir "%logDir%"
set /A RC=%errorlevel%
if "%RC%" equ "0" goto isLogDir
@echo Error: Cannot create the log directory "%logDir%"
goto byebye2

:isLogDir
set /A RC=0
if /i "%doLogging%" NEQ "true" goto noTrace

@rem traceLogPrefix - prefix for the log file name
set traceLogPrefix=%~n0_
@rem traceLogExtension - log file extension
set traceLogExtension=log

@rem Set the file name of the trace log to contain the current date and time.
goto parsDate
:datePrsd
goto parsTime
:timePrsd
set
traceLog="%logDir%\%traceLogPrefix%_year%_month%_day%_hh%_min%_ss%_ds%.%traceLogExtension%"
goto commence
:noTrace
set traceLog=NUL
:commence
@echo %date% %time% Running %~0 ...>%traceLog%
@echo %date% %time% Script level %SCRIPT_LEVEL% >>%traceLog%

@rem Delete db2.err file if there is any.
set db2err=%logDir%\db2.err
if not exist "%db2err%" goto runCLP
@echo %date% %time% del /F /Q /A:H "%db2err%" 1>>%traceLog%
del /F /Q /A:H "%db2err%" 1>>%traceLog% 2>&1

```

```

:runCLP
@rem Run the DB2 CLP command.
set CWD=%~dp0
set execSQL="%CWD%db2_executeSQL.cmd"
@echo %date% %time% call db2cmd -w -c -i "" "%execSQL%" SUSPEND "" "%traceLog%"
1>>%traceLog%
call db2cmd -w -c -i "" "%execSQL%" SUSPEND "" "%traceLog%"
set /A RC=%errorlevel%
@echo %date% %time% executeSQL.cmd exited with RC=%RC% 1>>%traceLog%
goto byebye

@rem *****
@rem Parse generic system date to get the numerical values of current month, day, and
year.
@rem Set variables _month, _day, _year
@rem *****
:parsDate
set $tok=1-3
for /f "tokens=1 delims=./-," %u in ('date /t') do set $d1=%u
if "%$d1:~0,1%" GTR "9" set $tok=2-4
for /f "tokens=%$tok delims=./-," %u in ('date /t') do (
for /f "skip=1 tokens=2-4 delims=./-,()." %x in ('echo.^|date') do (
set %%x=%u
set %%y=%v
set %%z=%w

    set _month=%u
    set _day=%v
    set _year=%w

set $d1=
set $tok=))
goto datePrsd

@rem *****
@rem Parse generic system time to get the numerical values of current hour, minute,
second, and second division.
@rem Set variables _hh, _min, _ss, _ds with the time elements as 2 digit values (24 hr
clock.)
@rem *****
:parTime
for /f "tokens=5-8 delims=.:," %a in ('echo.^|time') do (
    set _hh=%a
    set _min=%b
    set _ss=%c
    set _ds=%d
)
if %_hh% LSS 10 set _hh=0%_hh%
goto timePrsd

:byebye
@echo %date% %time% Exit %~0 >>%traceLog%
@echo %date% %time% RC=%RC% >>%traceLog%
:byebye2
@endlocal& exit /B %RC%

```

Main script:

The script below is the main executing script. This is called by the freeze and thaw scripts and passes either the suspend write or resume write depending on the operation. The

name of it is **db2_executeSQL.cmd** and is located in **C:\Windows**. In this script you need to define the following parameters:

- ▶ dbuser
- ▶ dbpass
- ▶ dbinst
- ▶ dbname

```
@echo off
@setlocal
```

```
@rem *****
@rem executeSQL.cmd
@rem
@rem Script used by TSM FastBack for backing up DB2.
@rem It suspends and resumes write I/O for a database.
@rem It also can restart the database with write resume option.
@rem
@rem Usage:  executeSQL.cmd <operation> <trace-log>
@rem
@rem All parameters are required:
@rem operation - Operation to be run against a database
@rem             Possible values (case insensitive) are:
@rem             SUSPEND, to temporarily suspend database write I/O
@rem             RESUME, to resume write I/O for the database
@rem             RESTART, to restart the database with WRITE RESUME
@rem trace-log - Absolute path of the trace log
@rem
@rem IMPORTANT: You also need to set variables for db user, db password, db name, db
instance.
@rem
@rem Exit codes:
@rem 0, if execution is successful
@rem -1, if there are missing parameter(s).
@rem -99, if an attempt to connect to the database returned an error message,
@rem      indicating that the database must be restarted.
@rem other value, if other error types encountered.
@rem *****
@rem
@rem *****
@rem version 0.5
@rem last modification 20080717
@rem author
@rem *****

@rem *****
@rem !!! ADJUST THE FOLLOWING VARIABLES IF YOU WISH TO USE OTHER THAN THE DEFAULT VALUES
!!!
@rem dbuser - User ID having with sysadm, sysctrl, or sysmaint authority.
@rem dbpass - Password of that user ID
@rem dbinst - DB2 instance name that runs the database
@rem dbname - Database alias to back up
set dbuser=db2admin
set dbpass=Object00
set dbinst=DB2
set dbname=TPCDB
@rem !!! END OF SETTING VARIABLES !!!
@rem !!! DO NOT MODIFY BELOW THIS LINE OF CODE !!!
@rem *****

if not "%~2" equ "." goto SETENV
```

```

@echo Error: Missing parameter(s).
@echo Usage:  executeSQL.cmd ^<operation^> ^<trace-log^>
set /A RC=-1
goto byebye

:SETENV
set operation=%1
set log=%2

@rem Check for empty variables
if "%dbuser%" EQU "" set emptyVar=dbuser
if "%dbpass%" EQU "" set emptyVar=dbpass
if "%dbinst%" EQU "" set emptyVar=dbinst
if "%dbname%" EQU "" set emptyVar=dbname
if defined emptyVar goto invalid

@echo %date% %time% Running %^0...>>%log%
@echo dbuser      : %dbuser% >>%log%
@echo dbpass      : ***** >>%log%
@echo dbinst      : %dbinst% >>%log%
@echo dbname      : %dbname% >>%log%
@echo operation   : %operation% >>%log%
@echo log         : %log% >>%log%
@rem *****
@rem ERROR_CONNECTION is the return code in case of connection hanging.
set /A ERROR_CONNECTION=-99
set CLP_FLAGS=-es -ov

@echo %date% %time% set DB2INSTANCE=%dbinst% >>%log%
set DB2INSTANCE=%dbinst%

if /i "%operation%" equ "RESTART" goto restart

@rem *****
@rem Create a file called db2.err in %logDir% directory.
@rem Write %ERROR_CONNECTION% in it.
@rem This should prevent the situation in which the subsequent CONNECT command
@rem hangs for any reason when attempting to resume the database.
@rem The script is expected to get cancelled by TSM FastBack as a result of time-out
@rem period expires.
@rem Subsequently this assumes that post sbapshot script will restart the database.
if /i "%operation%" neq "RESUME" goto connect
set /A RC=%ERROR_CONNECTION%
set BAILOUT=FALSE
goto noteRC
@rem *****

:connect
set /A RC=0
set BAILOUT=TRUE
@echo %date% %time% Connecting to %dbname% database... 1>>%log%
db2 %CLP_FLAGS% CONNECT TO %dbname% USER %dbuser% USING %dbpass% 1>>%log% 2>&1
set /A RC=%errorlevel%
@echo.>>%log%
if "%RC%" equ "0" goto connOK
    @echo %date% %time% Error: Connection to %dbname% database failed RC=%RC%.>>%log%
    @rem ADM6024C The database cannot be restarted because table spaces cannot be brought
    ONLINE
    @rem          as a result of an outstanding WRITE SUSPEND.

```

```

@rem          To restart the database specify WRITE RESUME on the RESTART DATABASE
command.
::findstr /r "ADM6024C" %log%
::if %errorlevel% equ 0 set /A RC=%ERROR_CONNECTION%
if /i "%operation%" equ "RESUME" set /A RC=%ERROR_CONNECTION%
goto noteRC
:connOK
@echo %date% %time% Successfully connected to %dbname% database.>>%log%

@rem Now run the DB2 command.
if /i "%operation%" equ "SUSPEND" @echo %date% %time% Temporarily suspend writing to
database... 1>>%log%
if /i "%operation%" equ "RESUME" @echo %date% %time% Resume writing to database... 1>>%log%
db2 %CLP_FLAGS% SET WRITE %operation% FOR DATABASE 1>>%log% 2>&1
set /A RC=%errorlevel%
@echo.>>%log%
if "%RC%" neq "0" @echo %date% %time% Error: Command execution failed RC=%RC% 1>>%log%
goto terminat

:restart
@echo %date% %time% Restart %dbname% database... 1>>%log%
db2 %CLP_FLAGS% RESTART DATABASE %dbname% USER %dbuser% USING %dbpass% WRITE RESUME
1>>%log% 2>&1
set /A RC=%errorlevel%
@echo.>>%log%
if "%RC%" neq "0" @echo %date% %time% Error: Restart %dbname% database failed RC=%RC%
1>>%log%
goto terminat

:terminat
@echo %date% %time% Terminate the CLP's back-end process... 1>>%log%
db2 %CLP_FLAGS% TERMINATE 1>>%log% 2>&1
set /A RC2=%errorlevel%
@echo.>>%log%
if "%RC2%" neq "0" @echo %date% %time% Error: Failed to terminate the CLP's back-end
process RC=%RC2% 1>>%log%
if "%RC%" equ "0" set /A RC=%RC2%
set BAILOUT=TRUE
if /i "%operation%" equ "RESTART" goto byebye
goto noteRC

:noteRC
@rem Write RC to db2.err file
set CWD=%~dp2
set db2err=%CWD%db2.err
if not exist "%db2err%" goto writeRC
@echo %date% %time% del /F /Q /A:H "%db2err%" 1>>%log%
del /F /Q /A:H "%db2err%" 1>>%log% 2>&1
:writeRC
@echo %RC% 1>"%db2err%"
@echo %date% %time% type "%db2err%">>%log%
type "%db2err%" 1>>%log%
@echo %date% %time% attrib +H "%db2err%" 1>>%log%
attrib +H "%db2err%" 1>>%log% 2>&1
if /i "%BAILOUT%" equ "TRUE" goto byebye
@rem for pre snapshot script
goto connect

:invalid
@echo %date% %time% Error: Variable %emptyVar% cannot be set to empty value.>>%log%

```

```

set /A RC=-1
goto byebye

:byebye
@endlocal& exit /B %RC%

```

Thaw script:

The last script that is called is the **thaw** script. It calls the main execute script and passes it the resume write command which take the database out of suspend mode and resumes normal operations. This script is located in the **C:\Windows** directory and is called once the vmware snapshot creation has completed.

```

@echo off
@setlocal

@rem *****
@rem db2_presnapshot.cmd
@rem
@rem Description: Pre snapshot script for DB2 backup.
@rem
@rem Functionality:
@rem - Connects to the local database to back up.
@rem - Calls a SQL script that resumes write operations for the database.
@rem - Terminates database connection.
@rem
@rem Authorization:
@rem You must run the script as an user id with sysadm, sysctrl, or sysmaint authority.
@rem
@rem Exit with Return Code:
@rem 0, if execution is successful.
@rem other value, if error encountered.
@rem
@rem *****
@rem version 0.6
@rem last modification 20080806
set SCRIPT_LEVEL=20080806
@rem author
@rem *****

@rem *****
@rem !!! ADJUST THE FOLLOWING VARIABLES IF YOU WISH TO USE OTHER THAN THE DEFAULT VALUES
!!!
@rem doLogging - Flag to create a trace log; possible values: TRUE, FALSE
@rem logDir - Trace log directory
set doLogging=TRUE
set logDir=G:\logs
@rem !!! END OF SETTING VARIABLES !!!
@rem !!! DO NOT MODIFY BELOW THIS LINE OF CODE !!!
@rem *****

@rem Create the log dir if there is not yet.
dir "%logDir%" 1>NUL 2>&1
set /A RC=%errorlevel%
if "%RC%" equ "0" goto isLogDir
mkdir "%logDir%"
set /A RC=%errorlevel%
if "%RC%" equ "0" goto isLogDir
@echo Error: Cannot create the log directory "%logDir%"
goto byebye2

```

```

:isLogDir
set /A RC=0
set /A ERROR_CONNECTION=-99
if /i "%doLogging%" NEQ "true" goto noTrace

@rem  traceLogPrefix  - prefix for the log file name
set traceLogPrefix=%~n0_
@rem  traceLogExtension - log file extension
set traceLogExtension=log

@rem  Set the file name of the trace log to contain date and time
goto parsDate
:datePrsd
goto parsTime
:timePrsd
set
traceLog="%logDir%\%traceLogPrefix%_year%_month%_day%_hh%_min%_ss%_ds%.%traceLogExtension%"
goto commence
:noTrace
set traceLog=NUL
:commence
@echo %date% %time% Running %~0 ...>>%traceLog%
@echo %date% %time% Script level %SCRIPT_LEVEL% >>%traceLog%

@rem  Run the DB2 CLP command.
set CWD=%~dp0
set execSQL="%CWD%db2_executeSQL.cmd"
@echo %date% %time% call db2cmd -w -c -i "" "%execSQL%" RESUME "" "%traceLog%"
1>>%traceLog%
call db2cmd -w -c -i "" "%execSQL%" RESUME "" "%traceLog%"
set /A RC=%errorlevel%
@echo %date% %time% executeSQL.cmd exited with RC=%RC% 1>>%traceLog%
goto byebye

@rem *****
@rem  Parse generic system date to get the numerical values of current month, day, and
year.
@rem  Set variables _month, _day, _year
@rem *****
:parsDate
set $tok=1-3
for /f "tokens=1 delims=./-," %u in ('date /t') do set $d1=%u
if "%$d1:~0,1%" GTR "9" set $tok=2-4
for /f "tokens=%$tok delims=./-," %u in ('date /t') do (
for /f "skip=1 tokens=2-4 delims=./-,()." %x in ('echo.^|date') do (
set %%x=%u
set %%y=%v
set %%z=%w

set _month=%%u
set _day=%v
set _year=%w

set $d1=
set $tok=))
goto datePrsd

@rem *****

```

```

@rem Parse generic system time to get the numerical values of current hour, minute,
second, and second division.
@rem Set variables _hh, _min, _ss, _ds with the time elements as 2 digit values (24 hr
clock.)
@rem *****
:parTime
for /f "tokens=5-8 delims=.:," %a in ('echo:^|time') do (
    set _hh=%a
    set _min=%b
    set _ss=%c
    set _ds=%d
)
if %_hh% LSS 10 set _hh=0%_hh%
goto timePrsd

:byebye
@echo %date% %time% Exit %~0 >>%traceLog%
@echo %date% %time% RC=%RC% >>%traceLog%
:byebye2
@endlocal& exit /B %RC%

```

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Some publications referenced in this list might be available in softcopy only.

- ▶ *IBM SAN and SVC Stretched Cluster and VMware Solution Implementation*, SG24-8072
- ▶ *IBM SAN Volume Controller Enhanced Stretched Cluster with VMware*, SG24-8211
- ▶ *IBM Tivoli Storage Productivity Center: Beyond the Basics*, SG24-8236
- ▶ *IBM Tivoli Storage Productivity Center V5.2 Release Guide*, SG24-8204
- ▶ *Implementing the IBM Storwize V7000 Gen2*, SG24-8244
- ▶ *Implementing the IBM System Storage SAN Volume Controller V7.4*, SG24-7933
- ▶ *Optimize your investments with IBM Tivoli Storage Productivity Center and IBM SmartCloud Virtual Storage Center*, TIPS1210

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as further information sources:

- ▶ *IBM Tivoli Storage Productivity Center, Version 5.2.4 User's Guide*, SC27-4060
- ▶ *IBM Tivoli Storage Productivity Center, Version 5.2.4, Administrator's Guide*, SC27-4859

Online resources

These websites are also relevant as further information sources:

- ▶ IBM SmartCloud Virtual Storage Center Wiki
<http://ibm.co/H0Ckqb>
- ▶ Tivoli Storage Productivity Center welcome page (at the IBM Knowledge Center):
<http://www.ibm.com/support/knowledgecenter/SSNE44/welcome?lang=en>
- ▶ IBM SmartCloud Virtual Storage Center Storage Analytics Engine, Version 5.2.4, Quick Start Guide
http://www.ibm.com/support/knowledgecenter/api/content/nl/en-us/SSNE44_5.2.4/com.ibm.tpc_v524.doc/qstrtvsc.pdf

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- ▶ Introductory concepts
- ▶ VSC components and available integrations
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- ▶ Storage virtualization component of VSC
- ▶ Application aware data protection component of VSC
- ▶ VSC storage provisioning
- ▶ VSC storage optimization

This book is primarily for storage administrators, users who are responsible for maintaining IT and business infrastructures, and anyone who wants to learn more about IBM SmartCloud Virtual Storage Center.

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