IBM Private, Public, and Hybrid Cloud Storage Solutions

What is a storage cloud?

Why would I want one?

How can I get one?
Note: Before using this information and the product it supports, read the information in “Notices” on page vii.

Second Edition (July 2014)

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Preface

This IBM® Redpaper™ publication takes you on a journey that surveys cloud computing to answer several fundamental questions about storage cloud technology. What are storage clouds? How can a storage cloud help solve my current and future data storage business requirements? What can IBM do to help me implement a storage cloud solution that addresses these needs?

We show how IBM storage clouds use the extensive cloud computing experience, services, proven technologies, and products of IBM to support a smart storage cloud solution designed for your storage optimization efforts. Clients face many common storage challenges and some have variations that make them unique. We describe various successful client storage cloud implementations and the options that are available to meet your current needs as well as position you to avoid storage issues in the future. IBM Cloud Services (IBM Cloud Managed Services and IBM SoftLayer) are highlighted as well as the contributions of IBM to OpenStack® cloud storage.

This paper is intended for anyone who wants to learn about storage clouds and how IBM addresses data storage challenges with smart storage cloud solutions. It is suitable for IBM clients, storage solution integrators, and IBM specialist sales representatives.

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Chapter 1. What is cloud computing

Before focusing specifically on storage clouds, it is useful to describe the larger IT landscape by developing a general understanding of cloud computing concepts. The trade press, journals, and marketing collateral have generated substantial content that is dedicated to the subject of cloud computing, but differ widely in exactly what constitutes an IT cloud. A helpful way to think is in general terms of ownership, that is public and private clouds, and categorizing the types of services that an IT cloud provides, which are described in some detail in this chapter. Finally, the IBM Cloud Computing Reference Architecture is described as a definition of the basic elements of any cloud service environment.
1.1 Cloud computing definition

The National Institute of Standards and Technology (NIST) provides the following definition\textsuperscript{1} for cloud computing:

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

Users interact with cloud computing environments with the services that the cloud environment provides. The following examples are of services that are provided by a cloud (cloud services):

- Virtual servers
- Database services
- Email applications
- Storage

A company can use cloud services that are provided by third parties, or the company can build its own cloud and provide services from the cloud to internal company users, to selected business partners or customers, or to the world at large.

For a service to be considered a “cloud service,” it needs to exhibit the following characteristics:

- Support self-service provisioning.
- Be accessible through the Internet or corporate intranet.
- Provide resources from a resource pool, without the user needing knowledge of the pool.
- Provide simple and fast resource elasticity, as users demand changes.
- Provide ability to monitor resources with a dashboard view on cloud health status.
- Support a metering capability, which enables a dynamic chargeback model.

To provide these characteristics, the infrastructure that enables the cloud services takes advantage of two key enablers:

- Virtualization
  Virtualization allows computing resources to be pooled and allocated on demand. It also enables pay-per-use billing to be implemented.

- Automation
  Automation allows for the elastic use of available resources, and for workloads to be moved to where resources are available. It also supports provisioning and deprovisioning of service instances to support scalability.

Although these enablers are not part of any formal cloud definition, they are proven to be indispensable in delivering the essential cloud service characteristics.

Many traditional IT services are provisioned with the characteristics of a cloud service. So how do you know that you are providing a cloud service, or when you are using a cloud service? You know that you are \textit{providing} a cloud service when your service exhibits the characteristics listed previously, and it is provisioned by using the virtualization and automation enablers.

As the user of any service, whether it is being provisioned as a cloud service might be immaterial. However, you are likely to be using a cloud service when the service you are using exhibits the characteristics listed previously. From a cloud user perspective, it is important that you are able to perform self-service activities that relate to the cloud service you are using, to quickly provision new service instances, and have resources elastically sized to meet your changing processing demands.

### 1.2 What is driving IT and businesses to cloud

Cloud computing has clearly moved beyond the hype and into the mainstream reality of today’s IT environments. What are the drivers for this rapid adoption and disruption in the traditional IT world? In the past couple of years, this question has been thoroughly studied and documented from numerous sources. One well known example is the December 2012, KPMG Consulting report, “The Cloud Service Providers Survey”, in which the following reasons shown in Figure 1-1 for cloud adoption were derived.

**Figure 1-1  Reasons to use cloud environments are business reasons**

As you can see, while cost savings are obviously important, what is even more noteworthy is the number of business-related, time-to-market, competitive advantage, business revenue-related aspects of the move to the cloud. In aggregate, these business reasons are at least as important, if not more so, than the cost reduction reasons. For more insight into the data behind what is driving cloud decisions, see the following website:

1.3 Introduction to cloud service models

When discussing cloud services (identified in 1.1, “Cloud computing definition” on page 2), a helpful approach is to organize service capabilities into groups. NIST formally describes a standard for grouping cloud services, referring to them as service models. These service models are sometimes referred to as delivery models, because they describe the services that are delivered by the cloud model. The following sections describe the NIST service models.

1.3.1 Infrastructure as a service (IaaS)

The IaaS model is the simplest for cloud service providers to provision. It may include the following elements:

- Processing
- Storage
- Network

Each of these elements is provisioned in an elastic fashion. As an IaaS user, you can deploy and run your chosen software, including operating systems and applications. You do not need to manage or control the underlying cloud infrastructure, but you have control over operating systems, storage, and deployed applications. You might also have limited control of select networking components (for example, host firewalls).

Examples of commercial implementations of IaaS include IBM SmartCloud® Enterprise and Enterprise+, IBM SmartCloud managed backup, Amazon Elastic Compute Cloud (EC2).

1.3.2 Platform as a service (PaaS)

The PaaS model includes services that build on IaaS services. They add value to the IaaS services by providing a platform in which the cloud users can provision their own applications, or conduct application development activities. The user does not need to manage the underlying cloud infrastructure (network, storage, operating systems), but may control configuration of the provisioned platform services. The following examples are of services that are provisioned in PaaS models:

- Middleware
- Application servers
- Database servers
- Portal servers
- Development runtime environments

Examples of commercial implementations of PaaS environments include IBM SmartCloud Application Services, Amazon Relational Database Service, and Microsoft Windows Azure.

1.3.3 Software as a service (SaaS)

The SaaS model provides software services that are complete applications that are ready to use. The cloud user simply connects to the application, which is running at a remote location; the user might not know where. The cloud service provider is responsible for managing the cloud infrastructure, the platform on which the application is running, and the application itself. This approach eliminates the need for the users to install and run the application on their own computers, thereby significantly reducing the need for maintenance and support.
SaaS is sometimes referred to as *applications as a service* because SaaS essentially provides applications as a service, rather than simply software in general. SaaS also includes content services (for example, video on demand) and higher value network services (for example VoIP) as typically encountered in communication service provider scenarios.

Examples of commercial implementations of SaaS environments include IBM Payment Systems, IBM SmartCloud for Social Business, PeopleSoft HR, Google Apps for Business.

### 1.3.4 Business process as a service (BPaaS)

Unlike the previously defined service models, NIST does not provide a definition for BPaaS. In recognition of the IT industry direction of provisioning business processes as a service from within a cloud environment, IBM developed a definition of the BPaaS model.

The BPaaS model combines software and workflow elements to deliver end-to-end business processes as a service. Many business processes have the potential to be delivered through this model: Both horizontal applications (such as payroll, technical support, billing) and vertical markets (such as healthcare and insurance). BPaaS allows businesses to pass on some of their day-to-day operating costs to service providers using a fee-for-service model, so that the businesses can focus on their core competencies.

Examples of commercial implementations of BPaaS include IBM Blueworks Live™, IBM Collaborative Care Solution for the healthcare market, and Google Adsense.

### 1.3.5 Cloud service model layering

Figure 1-2 illustrates how the service models described previously can be layered. It also contrasts the level of effort required of the service provider with that of the service user through the service model layers. As you travel *up* the service model layers, the service provider is responsible for providing more effort, as the level of functionality increases. By contrast, as you travel *down* the service layers, the service user must provide more effort in terms of environment customization. More information about service providers, service users, and other roles is in 1.5.2, “Cloud service roles” on page 10.

![Cloud service model layering](image)

Table 1-1 lists the functions that are provided by the cloud service provider and the cloud service user for each service model. For any given service model, the service provider also provides the functions listed in the service models below it, whereas the cloud user provides
the functions listed in the service models above it, if required, as indicated by the arrows shown in the table.

Table 1-1  Cloud service provider and service user responsibilities by service model

<table>
<thead>
<tr>
<th>Service model</th>
<th>Cloud service provider delivered functions</th>
<th>Cloud user delivered functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business process as a service</td>
<td>Business Process</td>
<td>Business Process configuration</td>
</tr>
<tr>
<td>Software as a service</td>
<td>Applications</td>
<td>Application configuration</td>
</tr>
<tr>
<td>Platform as a service</td>
<td>Languages Libraries Tools Middleware Application Servers Database Servers</td>
<td>Applications</td>
</tr>
<tr>
<td>Infrastructure as a service</td>
<td>Processing Storage Network</td>
<td>Languages Libraries Tools Middleware Application servers Database servers</td>
</tr>
</tbody>
</table>
1.4 Introduction to cloud delivery models

Cloud delivery models refer to how a cloud solution is used by an organization, where the data is located, and who operates the cloud solution. Cloud computing supports multiple delivery models that can deliver the capabilities needed in a cloud solution.

The cloud delivery models are as follows:
- Public cloud
- Private cloud
- Hybrid cloud
- Community cloud

These delivery models provide services in line with the service models described in 1.3, “Introduction to cloud service models” on page 4. Integrating them with existing IT systems and with other clouds is possible. Figure 1-3 illustrates these cloud delivery models, and identifies some of their characteristics in terms of roles, users, and accessibility.

<table>
<thead>
<tr>
<th>Host</th>
<th>Provider</th>
<th>Enterprise, 3rd Party</th>
<th>Enterprise, 3rd Party</th>
<th>Community, 3rd Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Provider</td>
<td>Enterprise</td>
<td>Enterprise</td>
<td>Community</td>
</tr>
<tr>
<td>Access</td>
<td>Internet</td>
<td>Intranet, VPN</td>
<td>Intranet, VPN</td>
<td>Intranet, VPN</td>
</tr>
<tr>
<td>Users</td>
<td>Public Individuals Organizations</td>
<td>Business Units</td>
<td>Business Units</td>
<td>Community Members</td>
</tr>
</tbody>
</table>

Figure 1-3 Cloud delivery models

1.4.1 Public clouds

A public cloud is one in which the cloud infrastructure is made available to the general public or a large industry group over the Internet. The infrastructure is not owned by the user, but by an organization providing cloud services. Services can be provided either at no cost, as a subscription, or under a pay-as-you-go model.

Examples of public clouds include IBM SmartCloud Enterprise, Amazon Elastic Compute Cloud (EC2), Google AppEngine, and Windows Azure Services Platform.

1.4.2 Private clouds

A private cloud refers to a cloud solution where the infrastructure is provisioned for the exclusive use of a single organization. The organization often acts as a cloud service provider to internal business units that obtain all the benefits of a cloud without having to provision their own infrastructure. By consolidating and centralizing services into a cloud, the organization benefits from centralized service management and economies of scale.

A private cloud provides an organization with some advantages over a public cloud. The organization gains greater control over the various resources that make up the cloud. In
addition, private clouds are ideal when the type of work being done is not practical for a public cloud because of network latency, security, or regulatory concerns.

A private cloud may be owned, managed, and operated by the organization, a third party, or a combination. The private cloud infrastructure is usually provisioned on the organization’s premises, but it may also be hosted in a data center that is owned by a third party.

1.4.3 Hybrid clouds

A hybrid cloud, as the name implies, is a combination of various cloud types (public, private, or community; see 1.4.4, “Community clouds” on page 8). Each cloud in the hybrid mix remains a unique entity, but is bound to the mix by technology that enables data and application portability.

The hybrid approach allows a business to take advantage of the scalability and cost-effectiveness of a public cloud without exposing applications and data beyond the corporate intranet. A well constructed hybrid cloud can service secure, mission-critical processes, such as receiving customer payments (a private cloud service), and also those that are secondary to the business, such as employee payroll processing (a public cloud service).

The major drawback to a hybrid cloud is the difficulty in effectively creating and governing such a solution. Services from various sources must be obtained and provisioned as though they originated from a single location, and interactions between private and public components make the implementation even more complicated.

1.4.4 Community clouds

A community cloud shares the cloud infrastructure across several organizations in support of a specific community that has common concerns (for example, mission, security requirements, policy, and compliance considerations). The primary goal of a community cloud is to have participating organizations realize the benefits of a public cloud, such as shared infrastructure costs and a pay-as-you-go billing structure, with the added level of privacy, security, and policy compliance usually associated with a private cloud.

The community cloud infrastructure may be provided on-premises or at a third party’s data center, and may be managed by the participating organizations or a third party.

1.5 The IBM Cloud Computing Reference Architecture

This section introduces the IBM Cloud Computing Reference Architecture (CCRA), and describes the cloud service roles defined within it.

1.5.1 Introduction to the CCRA

What is a reference architecture, and why is it important to have one? A reference architecture is a proven template solution for architecture within a given domain, in this case, the cloud computing domain. A reference architecture is important to have because it offers these benefits:

- Delivers best practices in a standardized, methodical way.
- Ensures consistency and quality across the development and delivery processes.
- Mitigates risk by taking an asset-based approach to solution development.
What is the CCRA? IBM defined a reference architecture for the cloud computing domain, and named it the IBM Cloud Computing Reference Architecture. It is an evolving architecture, which is based on real-world input from many cloud implementations around the globe, and was submitted to the Open Group Cloud Architecture Project.

The IBM CCRA is designed around a set of architectural principles that establish the framework within which architectural decisions are made. The architectural principles for the CCRA are as follows:

- Design for cloud-scale efficiencies.
- Support lean service management.
- Identify and use commonalities.
- Define and manage cloud services generically along their lifecycle.

As shown in Figure 1-4, the IBM CCRA defines basic elements of any cloud service environment. You can use it to identify the physical components of a cloud implementation such as network, storage, virtualization, and also the software components that are required to run and manage the cloud environment. In addition, it defines governance policies tailored for the environment or organization.

Further details about the IBM CCRA are at the following location:

The roles defined by the CCRA are described, at a high level, in 1.5.2, “Cloud service roles” on page 10.
1.5.2 Cloud service roles

As shown in Figure 1-4 on page 9, the IBM CCRA defines the following interrelated roles:

- Cloud Service Creator
- Cloud Service Provider
- Cloud Service Consumer

These roles are interrelated in that a Cloud Service Creator is responsible for creating a cloud service, which can be run by a Cloud Service Provider, and exposed to Cloud Service Consumers. Multiple roles may be fulfilled by the same organization or person.

Cloud Service Creator
The Cloud Service Creator is responsible for creating a cloud service. The creator may be an individual or an organization that designs, implements, and maintains runtime and management artifacts that are specific to a cloud service. Typically, Cloud Service Creators build their cloud services by using functionality that is exposed by a Cloud Service Provider.

Also typical is that the operations staff, who are responsible for operating a cloud service, are closely integrated with the development organization that develops the service (this integration is commonly referred to as DevOps). This close integration helps to achieve the delivery efficiency that is expected from cloud services because it allows a short feedback loop to implement changes in the cloud service.

Cloud Service Provider
The Cloud Service Provider has the responsibility of providing cloud services to Cloud Service Consumers. The provider sets up the cloud service, and manages the effective running of the service, which can include the following tasks (and others):

- Determine performance service levels and management strategies.
- Monitor performance of virtualization infrastructure and service level agreements (SLAs).
- Manage long-term capacity and performance trends.
- Analyze how to prevent costly service quality problems.
- Ensure alignment of business and operational support systems.
- Track performance against the provider business plan.

A Cloud Service Provider might be a link within a chain of service providers and service consumers, with each provider adding some value to the service within the chain. In this case, each service provider needs to establish a partnership with their service provider to be able to guarantee service levels to their clients. This chain is illustrated in Figure 1-4 on page 9 by the shaded segment named “Existing and 3rd Party Services, Partner Ecosystems.”

Cloud Service Consumer
A Cloud Service Consumer is the user of a cloud service. The consumer might be an organization, a human being, or an IT system that requests, uses, and manages instances of a cloud service. Managing a service can include performing activities such as changing quotas for users, changing CPU capacity assigned to a virtual machine (VM), or increasing maximum number of seats for a web conference. The service consumer may be billed for all (or a subset) of its interactions with the cloud service and the provisioned service instances.

Within the Cloud Service Consumer role, more specific roles might exist. The consumer organization might require a technical role responsible for making service consumption work from a technical perspective. There might also be a business person on the consumer side who is responsible for the financial aspects of consuming the service. In simple public cloud scenarios, all of these consumer roles could be collapsed into a single person.
The Cloud Service Consumer browses the service offering catalog and triggers service instantiation and management from there. There might be cases where the interaction with the service delivery catalog is tightly embedded within the actual cloud service. In particular, these cases are common for SaaS and BPaaS cloud services where application-level virtualization is implemented.

### 1.6 Cloud enabled data center journey

Given the information presented so far in this chapter, what does the journey and industry best practices toward a true cloud-enabled infrastructure and a storage cloud look like? And, where is the storage cloud positioned within this overall cloud infrastructure?

IBM has published two Cloud Redpaper publications that answer these important questions in detail:

- **IBM SmartCloud: Building a Cloud Enabled Data Center**, REDP-4893
- **IBM SmartCloud: Becoming a Cloud Service Provider**, REDP-4912

We can summarize the cloud data center journey in Figure 1-5 extracted from the first of the preceding Redpaper publications.

![Figure 1-5](image-url)  
**Figure 1-5** The cloud-enabled data center journey

Figure 1-5 shows the best practices steps that every successful cloud deployment has followed.

However, note that what is *not* depicted in the preceding progression, are the specific *relationship patterns and workflows* that the successful cloud must implement. In the next section, we summarize those workflows so that you may exactly see what best practices and
organizational structure is required to provide true cloud services, and where the storage cloud is positioned within the overall cloud.

1.6.1 Cloud workflow macro patterns

The *IBM SmartCloud: Building a Cloud Enabled Data Center*, REDP-4893 shows us the overall cloud best practices macro-patterns and workflow of a cloud data center infrastructure. See Figure 1-6.

![Best practices cloud macro-pattern workflows](image)

Figure 1-6  Cloud best practices workflow macro-patterns

Figure 1-6 brings the cloud journey into focus, as it organizes the cloud journey shown in Figure 1-5 on page 11, into the necessary workflows and relationship macro-patterns that must exist in any successful cloud data center.

We take these macro-patterns and go down one more level to see the micro-patterns that make up each of these macro-patterns.

1.6.2 Cloud workflow micro patterns

Let us now zoom in (Figure 1-7 on page 13) to see the micro-patterns that make up each of the macro-patterns in the best practices cloud infrastructure.
Cloud micro-pattern workflows

Figure 1-7 Cloud best practices workflow micro-patterns

This view of cloud micro-patterns gives us the required level of granularity necessary to successfully understand, scope, plan, and implement a best practices cloud infrastructure.

Figure 1-7 gives us a checklist ability for cloud. We can see what functions must be implemented, where they must be implemented, in what order, and in relationship to what other functions. That is a powerful set of cloud implementation knowledge.

IBM provides a complete toolset, product portfolio, and offerings to implement each of the functions in the preceding cloud micro-pattern workflows. Specifics of those products are described in Chapter 3., “What enables a smart storage cloud” on page 37.

1.6.3 Cloud IT organizational structure

The previous figures point out an essential cloud implementation success factor.

In order to deliver true cloud services, a traditional IT organization is unfortunately almost certainly not organized like the best practices cloud workflows as shown in Figure 1-6 on page 12 and Figure 1-7. It is not surprising that a traditional IT organization finds it very difficult to deliver truly elastic modern cloud IT capabilities, as the traditional IT organization is almost certainly not organized along cloud best practices workflows.
Therefore, in order to be able to truly deliver elastic, scalable, automated cloud IT services, a necessary IT reorganization from the existing traditional structure is required; realigning instead along the workflows that make up the best practices cloud infrastructure.

The cloud best practices workflows therefore also give you an organization template for how your IT organization should and must be reorganized over time in order to deliver true cloud services.

1.7 Role of predefined IaaS offerings

We have seen that cloud IT best practices require different workflows and relationships among the functions of IT as compared to traditional IT, thus effectively requiring an IT reorganization like the cloud workflow in order to truly provide cloud IT services. These substantial required changes then create the following IT management and technical questions:

- How best to begin and accelerate the needed realignment of the IT organization?
- How best to redeploy existing skills and experienced personnel in this new cloud-oriented organization?
- What technologies and tools are available to address and implement the new, different cloud workflow and the newly required skillsets?

For almost any organization, the magnitude of effort required to construct internal custom-built answers to these questions from scratch, is daunting and often may not be feasible.

That is why the ready availability of proven, pre-built, pre-tested cloud workflow Infrastructure as a Service offerings can be so attractive and popular for organizations that need to change quickly to stay competitive. Proven, pre-built IaaS offerings already implement the cloud best practices workflow, and good IaaS offerings come with an ecosystem of proven experience and proven users. In this way, by adopting a proven IaaS solution, an IT organization can obtain and implement a reliable template and toolset for implementing true cloud capabilities within the IT organization.

1.7.1 Role of OpenStack cloud software in cloud computing

In just the past two years, one of the most popular and fastest growing of the generally available cloud IaaS offerings has become the open source OpenStack cloud software. Refer to Figure 1-8 on page 15.

OpenStack software was initially released into open source in 2010 by Rackspace Cloud and the US National Aeronautical and Space Administration (NASA). The OpenStack architecture goal is to provide an open source cloud operating system Infrastructure as a Service (IaaS) platform for creating and managing large groups of virtual private servers in a cloud computing environment. OpenStack cloud software is an open source IaaS cloud operating system, released under the terms of the Apache License.

OpenStack cloud software and offerings like it provide a means for traditional IT to quickly adopt newer cloud computing workflows and best practices.

By adopting and using offerings such as OpenStack cloud software, the IT organization is able to organize, develop skillsets, and deploy cloud computing around proven offerings that already implement industry cloud computing best practices.
The OpenStack cloud software has experienced rapid adoption in just the past two years, and has become largest, fastest growing open source IaaS offering. OpenStack community currently has more than 150 companies who have joined and actively contribute to OpenStack software and the OpenStack Foundation project, including IBM.

### 1.7.2 OpenStack architecture overview: An open source cloud IaaS platform

OpenStack architecture implements the complete collection of cloud infrastructure as a service workflow, which is shown in Figure 1-6 on page 12, and Figure 1-7 on page 13.

OpenStack architecture is modular and encompasses the major components required for a cloud infrastructure. The OpenStack architecture diagram, Figure 1-9 on page 16, shows the various OpenStack components, already implemented in a cloud best practices workflow.

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2 Sources: openstack.org and ohloh.net/p/openstack
OpenStack modular components include the following:

- Compute (Nova)
- Block Storage (Cinder)
- Object Storage (Swift)
- Virtual Machine boot image service (Glance)
- OpenStack Identity Management (Keystone)
- User Interface Dashboard (Horizon)

OpenStack IaaS solution provides a full cloud best practices solution for implementing cloud IT services. In addition, the most important aspect of OpenStack cloud software is its large and rapidly growing open source community of contributors worldwide. In a similar manner in which open source Linux has become a reliable, mission-critical capable technology for operating systems, over the longer term apparently OpenStack technology will play a similar role for cloud operating systems.

### 1.7.3 IBM participation in OpenStack Foundation

IBM believes that an open source approach to cloud is the most beneficial strategic means for clients to be able to enter and take advantage of the benefits of cloud computing. As such, IBM is investing in supporting the OpenStack Foundation as a platinum member. See Figure 1-10 on page 17.

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3 Source for this diagram is in the public domain, at: [http://docs.openstack.org/training-guides/content/module001-ch004-openstack-architecture.html](http://docs.openstack.org/training-guides/content/module001-ch004-openstack-architecture.html)
IBM views support of OpenStack cloud software as a strategic and key component of IBM participation in providing cloud computing capability.

1.8 Storage cloud components within overall cloud

Having now seen the overall cloud big picture, in the remainder of this paper we turn our attention to the storage-specific portions of the cloud journey. We focus on the role that storage plays in the cloud workflow, and storage cloud best practices.

We review what is a storage cloud, what are the storage features that enable a storage cloud, key technology aspects such as storage efficiency, automation and management, and security and data protection. We overview storage key enablers of a cloud Infrastructure as a Service, including a description of OpenStack storage components. We review specific IBM products that participate within the storage cloud workflow.

In the diagram that is shown in Figure 1-11 on page 18, we positioned some of the many key IBM storage products that are available to help you implement a true best practices cloud workflow.
Let us now begin the storage cloud portion of our journey.
Chapter 2. What is a storage cloud

Cloud data storage is a critical component in the cloud computing model; without cloud storage, there can be no cloud service. As stated in Chapter 1, “What is cloud computing” on page 1, a specific definition of what constitutes a storage cloud is not always clear in this emerging paradigm. The growing interest in cloud storage coincident with cloud computing is explained in terms of the challenges that traditional IT presents. In this chapter, we explore how these challenges can be addressed in the various storage cloud models that are aligned to cloud computing constructs (that is, public, private, and hybrid clouds). The following storage cloud topics are covered to help you continue your journey to storage cloud:

- Overview of storage cloud and storage types
- Traditional storage versus storage cloud
- Benefits and features of storage cloud
- Storage cloud service level classes
- Storage cloud delivery models
- Storage cloud journey use cases
2.1 Storage cloud overview

A storage cloud provides storage as a service to storage consumers. It may be delivered in any of the previously described cloud delivery models (public, private, hybrid, community). A storage cloud can be used to support a diverse range of storage needs, including mass data stores, file shares, backup, archive, and more. Implementations range from public user data stores to large private storage area networks (SAN) or network-attached storage (NAS), hosted in-house or at third-party managed facilities. The following examples are publicly available storage clouds:

- IBM SmartCloud offers various storage options, including archive, backup, and object storage.
- Skydrive from Microsoft allows the public to store and share nominated files on the Microsoft public storage cloud service.
- Email services, such as Hotmail, Gmail, and Yahoo, store user email and attachments in their respective storage clouds.
- Facebook and YouTube allow users to store and share photos and videos.

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

Figure 2-1 describes how various electronic or portable devices can access storage through the Internet without necessarily knowing the explicit details of the type or location of storage that is used underneath. Although the devices can access SAN or NAS storage, SAN or NAS storage can itself use storage cloud for backup or other purposes.
Storage usage differences within a storage cloud infrastructure

Within a cloud infrastructure, a useful distinction can be made between how storage capacity is used, similar to the difference that exists in traditional IT between system data (files, libraries, utilities, and so on), and application data and user files. This distinction becomes important for storage allocation in virtual server implementations.

Storage cloud

Storage cloud is the storage capacity service that is provided for client data and the primary focus of this paper. A storage cloud exhibits the characteristics that are essential to any cloud service (self-service provisioning, Internet and intranet accessibility, pooled resources, elastic, and metered). It is a cloud environment on which the offered services provide the ability to store and retrieve data on behalf of computing processes that are not part of the storage cloud service. A storage cloud can be used in combination with a compute cloud, a private compute facility, or as storage for a computing device. Storage in a storage cloud can be categorized as follows:

- Hosted storage
  This category is primary storage for block or file data that can be written and read on demand, and is provisioned as generally higher performance and availability storage.

- Reference storage
  This category is fixed content storage to which blocks or files are typically written to once, and read from many times. Examples of data typically residing on reference storage include multimedia, archival data, medical imaging, surveillance data, log files, and others.

Storage for cloud

Storage for cloud is a general name applied to the type of storage environment, implemented in cloud computing that is required 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 virtual machine creation process to support the operating system and runtime environment for the instance. It is not delivered by a storage cloud. However, it may be provisioned from the same storage infrastructure as a storage cloud. The types of storage provisioned for a cloud service can be categorized as follows:

- Ephemeral storage
  This storage is required only while a virtual machine is running. It is freed from use and made available to the storage pool when the virtual machine is shut down. Examples of this category of storage include boot volumes, page files, and other temporary data.

- Persistent storage
  This storage is required across virtual machine reboots. It is retained even when a virtual machine is shut down. It includes “gold” (master template) images, systems customization, and user data.
2.2 Traditional storage versus storage cloud

This section compares the various challenges of traditional and cloud storage, outlines the advantages of cloud storage, and explains key implementation considerations for potential storage cloud infrastructure deployments.

2.2.1 Challenges of traditional storage

Before exploring the advantages and benefits of storage cloud, we list several limitations of current IT infrastructure, which businesses deal with daily. This categorization is from a high level; challenges in one category can sometimes be applicable to other categories.

**Constrained business agility**

The time that is required to provision storage capacity for new projects or unexpectedly rapid growth affects an organization's ability to quickly react to changing business conditions. This situation can often negatively affect the ability to develop and deliver products and services within competitive time-to-market targets. The following constraints are examples:

- Time that is required to deploy new or upgraded business function
- Downtime that is required for data migration and technology refresh
- Unplanned storage capacity acquisitions
- Staffing limitations

Often substantial reserve capacity is required to support growth that requires planning and investment far in advance of the actual need to store data. The reason is because the infrastructure cannot easily scale up the needed additional capacity as a result of an inability to seamlessly add required storage resources. This key issue makes it more difficult to cope with rapidly changing business environments, adversely affecting the ability to make better decisions more rapidly and proactively optimize processes with more predictable outcomes.
Additional issues that can affect business agility are as follows:

- Inability to meet demand for data availability and not be able to access the correct data at the correct time to make better business decisions.
- Inability to support unplanned acquisitions and staffing limitations.

**Suboptimal utilization of IT resources**

The variation in workloads and the difficulty in determining future requirements typically results in IT storage capacity inefficiencies:

- Difficulty in predicting future capacity and service-level needs
- Peaks and valleys in resource requirements
- Over and under provisioning of IT resources

Extensive capacity planning effort is needed to plan for varying future storage capacity and service level requirements. Capacity is often underutilized as the storage infrastructure requires reserve capacity for unpredictable future growth requirements and therefore cannot be easily scaled up or down. Compounding these issues is the frequent inability to seamlessly provision additional storage capacity without impacting application uptime.

**Organizational constraints**

Another barrier to efficient use of resources can be traced to artificial resource acquisition, ownership, and operational practices:

- Project-oriented infrastructure funding
- Constrained operational budgets
- Difficulty implementing resource sharing
- No chargeback or showback mechanism as incentive for IT resource conservation

The limited ability to share data across the enterprise especially in the context of interdepartmental sharing can degrade overall use of IT resources including storage capacity. Parallel performance requirements in existing storage systems result in one node supporting one disk, leading to multiplication of nodes and servers.

**IT resource management**

Efficient IT support is based on cost-effective infrastructure and service-level management to address business needs:

- Rapid capacity growth
- Cost control
- Service-level monitoring and support (performance, availability, capacity, security, retention, and more)
- Architectural open standardization

The continued growth of resource management complexity in the storage infrastructure is often based on a lack of standardization and high levels of configuration customization. For example, adjusting storage performance through multiple RAID settings and manual tuning the distribution of I/O loads across various storage arrays consumes valuable staff resources.

Sometimes, the desire to avoid vendor lock-in because of proprietary protocols for data access also creates tremendous pressure on storage resource management. Other challenges are related to managing and meeting stringent SLA requirements and lack of enough in-house expertise to manage complex storage infrastructures. New service levels, adjusting existing SLAs to align IT disaster recovery, business resilience requirements, and high-availability solutions are also factors.
Duplicate data existing in the form of copies across organizational islands within the enterprise leads to higher costs for data storage and also backup infrastructure. Compounding all of this are ever-shrinking operational and project budgets, and lack of dynamic chargeback or showback models as incentives for IT resource conservation.

2.2.2 Advantages of a storage cloud

Storage cloud has redefined the way storage consumers can do business, especially those who have seasonal or unpredictable capacity requirements, and those requiring rapid deployment or contraction of storage capacity. Storage cloud can help them focus more on their core business and worry less about supporting a storage infrastructure for their data. Here are the advantages:

- Facilitates rapid capacity provisioning supporting business agility
- Improves storage utilization by avoiding unused capacity
- Supports storage consolidation and storage virtualization functionality
- Chargeback and showback accounting for usage as incentive to conserve resources

Storage cloud helps companies to become more flexible and agile, and supports their growth. Improvement in quality of service (QoS), by automating provisioning and management of underlying complex storage infrastructure, helps improve the overall efficiency of IT storage. Cloud features such as deduplication, compression, automatic tiering, and data migration capabilities are generally built-in options and also support the optimizing of storage costs by implementing tiered storage.

Often the growth in file-based systems is restricted to approximately a few terabytes (TB); this restriction can be easily overcome with storage cloud. Ubiquitous access to data over the Internet, intranet, or both, provides location-independent access and can provide a single management platform to manage hundreds of nodes, with data flowing from all the nodes to all the storage arrays.

Capital expenditure can be reduced with a cloud operational-based, pay-as-you-go model. Storage clouds can be tailored or services acquired to support key storage operations such as backup and recovery, remote site disaster recovery, archive, or development and test operations.

Figure 2-3 shows layers that provide unique benefits in the storage cloud.

---

Figure 2-3  Storage cloud characteristics
2.2.3 Implementation considerations for storage cloud

Storage cloud is still an emerging paradigm. Although it offers many advantages, you need to be aware of some of the challenges:

- Have a reliable and robust network infrastructure for remote data access. Because the storage is accessed over the Internet or intranet, a good network connection is essential. The reliability of network providers such as Internet service providers (ISPs) is an important factor because in some parts of the globe, the Internet is still catching up.
- Security is an important factor. Beyond user name and password, consider storage device-level encryption for sensitive data.
- Maintain security and control of data that is stored off-site, especially third-party locations.
- Ensure that regulatory compliance is preserved for various standards such as the Health Insurance Portability and Accountability Act (HIPAA) and the Sarbanes-Oxley Act (Sarbox or SOX).
- Beware of vendor lock-in because of proprietary protocols for access of data by separate storage cloud providers. Because standards are still evolving, the potential for inadvertent vendor lock-in should be part of a selection process.
- Know the overall reliability of the cloud storage provider. Are SLAs required and will providers offer adequate assurance of service delivery? Will the provider remain viable in the future?
- Multitenancy (isolation) is critical. Data needs to be protected from other clients, security threats, viruses, and so on, because data is stored on a common shared storage infrastructure.
- Difficulty in applying policies across many independent filers in an enterprise can cause operational problems.
- Determine whether the cloud storage provider can scale to your capacity and maintain required performance service levels. In some cases, under-performing and overtaxed storage can be upgraded with additional capacity, but often new capacity must be added seamlessly to the infrastructure.
- Be able to manage complexity of separate hardware from multiple vendors. Standardization can simplify management for heterogeneous storage devices. Storage virtualization across SAN arrays, such as SAN virtualization with SAN Volume Controller, or Global Namespace solutions, such as IBM Scale Out Network Attached Storage, can provide solutions to this issue.
2.3 Benefits and features of storage cloud

The overall benefits of storage cloud vary significantly based on the underlying storage infrastructure. Storage cloud can help businesses achieve more effective functionality at a lower cost while improving business agility and reducing project scheduling risk. Figure 2-4 identifies basic differences between the traditional IT model and a storage cloud model.

![Figure 2-4 Benefits of moving to storage cloud from traditional IT infrastructure](image)

Dynamic scaling and provisioning (elasticity)
One of the key advantages of storage cloud is dynamic scaling, also known as *elasticity*. Elasticity means that storage resources can be dynamically allocated (scaled up) or released (scaled down) based on business needs. Traditional IT storage infrastructure administration most often acquires capacity needed within the next year or two, which necessarily means this reserve capacity will be idle or under utilized for some period or time. A storage cloud can start small and grow incrementally with business requirements, or even shrink in size to lower costs if appropriate to capacity demands. For this key reason, storage cloud can support a company’s growth while reducing net capital investment in storage.

Faster deployment of storage resources
New enterprise storage resources can be provisioned and deployed in minutes compared to less optimized traditional IT, which typically takes more time, sometimes days or even months.

Reduction in TCO and better ROI
Enterprise storage virtualization and consolidation lower infrastructure total cost of ownership (TCO) significantly, with centralized storage capacity and management driving improved usage and efficiency, generally providing a significantly higher return on investment (ROI) through storage capacity cost avoidance. In addition, savings can be gained because of reduced floor space, energy required for cooling, labor costs, and also support and maintenance. This gain can be important where storage costs grow faster than revenues and directly affect profitability.

Reduce cost of managing storage
Virtualization helps in consolidating storage capacity and helps achieve much higher utilization, thereby significantly reducing the capital expenditure on storage and its management. Storage virtualization is explained further in 3.2.1, “Virtualization” on page 41.
Greener data centers
By consolidating geographically dispersed storage into fewer data centers, you achieve a smaller footprint in terms of rackspace. You can save on energy (electrical power) and charges for infrastructure space, which also improves TCO and ROI.

Dynamic, flexible chargeback model (pay-per-use)
By implementing storage cloud, an organization pays only for the amount of storage that is actually used rather than paying for an incremental spare capacity, which remains idle until needed. This model can provide an enterprise with enormous benefits financially. Savings can also be realized from hardware and software licensing for functionality such as replication and point-in-time copy.

Multiuser file sharing
By centralizing the storage infrastructure, all users can have parallel and simultaneous access to all the data across the enterprise rather than dealing with isolated islands of data. This also helps in collaboration and file sharing with higher data access rates.

Self-service user portal
A self-service user portal that is based on a service catalog empowers clients to automatically provision based on predefined templates. Manage IT infrastructure that is based on the users needs.

Integrated storage and service management
The storage cloud infrastructure usually includes integrated management software, which helps to manage the complete storage infrastructure from a single console, without having to buy proprietary management software from multiple vendors. This way saves time and helps reduce spending on various proprietary management software.

Improved efficiency of data management
Consolidation and standardization of storage resources facilitates less infrastructure complexity, which is intrinsically simpler to manage. Consistent policies and process with integrated management tools support geographically diverse infrastructure requirements that are driven by performance or availability considerations.

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 instead of worrying about the management of their IT infrastructure.
2.4 Storage classes for cloud

Enterprises with optimized storage infrastructures use storage tiers with characteristics that are aligned to business process operational requirements. These tiers support granular service levels for performance, resiliency, availability, security, retention, and so on, as defined for various workloads, which are outlined in Table 2-1.

Table 2-1  Typical storage service level requirements for various workloads

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▶ Planned uptime</td>
<td>Five 9s +</td>
<td>Four 9s +</td>
<td>Four 9s</td>
<td>Four 9s</td>
<td>Three 9s</td>
</tr>
<tr>
<td>▶ Redundant local disk</td>
<td>Double</td>
<td>Single, double</td>
<td>Single</td>
<td>Single</td>
<td>Single</td>
</tr>
<tr>
<td>▶ Remote replication</td>
<td>Yes</td>
<td>Yes</td>
<td>Possibly</td>
<td>Possibly</td>
<td>No</td>
</tr>
<tr>
<td>▶ Snapshot</td>
<td>Multiple</td>
<td>Multiple</td>
<td>Yes</td>
<td>Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▶ Sequential I/O latency</td>
<td>Best</td>
<td>Better</td>
<td>Best</td>
<td>Better</td>
<td>Better</td>
</tr>
<tr>
<td>▶ Random I/O latency</td>
<td>Best</td>
<td>Best</td>
<td>Good</td>
<td>Better</td>
<td>Good</td>
</tr>
<tr>
<td>▶ I/O throughput</td>
<td>Best</td>
<td>Best</td>
<td>Good</td>
<td>Better</td>
<td>Good</td>
</tr>
<tr>
<td>Recovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▶ RPO</td>
<td>5 minutes</td>
<td>4 hours</td>
<td>24 hours</td>
<td>4 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>▶ RTO</td>
<td>2 hours</td>
<td>4 hours</td>
<td>6 hours</td>
<td>4 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>▶ Disaster resources</td>
<td>Tier 1</td>
<td>Tier 2</td>
<td>Tier 2</td>
<td>Tier 2</td>
<td>Tier 3</td>
</tr>
<tr>
<td>Storage class</td>
<td>Enterprise</td>
<td>Enterprise, mid-range</td>
<td>Mid-range</td>
<td>Mid-range</td>
<td>Mid-range, low cost</td>
</tr>
</tbody>
</table>

Table 2-2 shows classes of storage and their characteristics.

Table 2-2  Types of storage and their features or requirements

<table>
<thead>
<tr>
<th>Types of data</th>
<th>Typical features or requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured, transactional, or both</td>
<td>▶ Storage to support runtime computations of a compute cloud, for example, database indexing, which are considered “tier one”&lt;br&gt;◀ Must be co-located with the computation&lt;br&gt;◀ Has the most stringent latency, I/O operations per second (IOPS) and data protection requirements&lt;br&gt;◀ Is the least sensitive to cost and is the smallest quantity of storage</td>
</tr>
<tr>
<td>File, unstructured, or both</td>
<td>▶ Storage that allows a customer to flexibly increase file storage capacity, for example: productivity, web content&lt;br&gt;◀ Must be relatively close to customer data center&lt;br&gt;◀ Has intermediate latency and IOPS requirement&lt;br&gt;◀ Has immediate sensitivity to cost</td>
</tr>
<tr>
<td>Fixed Content</td>
<td>▶ Contains objects that are written once and never modified but may be replaced, for example: records, images&lt;br&gt;◀ Can accept some latency in access to first byte and is not focused on IOPS&lt;br&gt;◀ Has high sensitivity to cost and is the largest quantity</td>
</tr>
</tbody>
</table>
2.5 Storage cloud delivery models

The cloud delivery model described in 1.3, “Introduction to cloud service models” on page 4 can be extended to include storage cloud as outlined in the following descriptions.

2.5.1 Public storage cloud

Data is stored on-premises with the cloud storage service provider and is accessed through network services. All the management tasks that are associated with storage, such as upgrading and replacing, are carried out by the storage service provider; you simply pay for the amount of storage space that is used. Typically, this storage capacity is somewhat inexpensive because of economies of scale. But with data stored in the public domain, security and multitenancy are major areas of concern, which need to be evaluated in accordance with business requirements. Storage resources can be scaled up or down to meet the user requirements. Also, in this model, the bulk of capital expenditures (CAPEX) to acquire storage capacity is shifted to operational expense, as the storage cloud service provider purchases the resources and therefore incurs the CAPEX.

2.5.2 Private storage cloud

The data is stored on-premises with the client or in client-dedicated facilities, and accessed over the client’s intranet. The management can be done either by the client or can be given (outsourced) to a service provider. Unlike the public model, data is comparatively secure behind enterprise firewalls. Because the storage space is not shared by other organizations, security and multitenancy concerns are the same as in traditional IT. In this model, the client can also save significantly with storage consolidation and virtualization.

2.5.3 Hybrid storage cloud

As the name implies, hybrid storage data is provisioned in a mixed private and public environment. For example, business-critical data (payroll processing, HR, finance) can be stored in a private cloud (to use the security and control over the data) and relatively less important data can be maintained in public cloud storage.

2.5.4 Community storage cloud

A community storage cloud limits access to a cloud infrastructure to organizations within a specific “community” that has common requirements and concerns (for example, mission, security requirements, policy, and compliance considerations). The participating organizations realize the benefits of a storage cloud, such as shared infrastructure costs and a pay-as-you-go billing structure, with added levels of privacy, security, and policy compliance usually only associated with a private cloud. The community cloud infrastructure may be delivered on premises or at a third party’s data center, and may be managed by the participating organizations or a third party.
### 2.6 The storage cloud journey

The journey to storage cloud starts at different places for different organizations. In this section, we describe an effective path to transition from a traditional IT infrastructure to a cloud-based storage infrastructure.

Figure 2-5 shows the typical journey from a traditional model to cloud-based model.

**Figure 2-5** The overall cloud journey from traditional IT to storage cloud

Storage cloud offers a path to IT optimization by implementing common key practices such as virtualization, standardization, and automation. An optimized storage infrastructure aligns IT resources to business requirements through managed service levels that are usually defined in a service catalog, which is supported within a storage cloud implementation. The journey takes the following path:

- **Traditional IT**
  
  Evaluate the current IT infrastructure (servers, storage, networking, and so on) and identify where servers and storage can be consolidated for better performance and utilization and operational efficiency.

- **Consolidate**
  
  Inventory the storage capacity by location, identifying opportunities to combine capacity, where feasible, to drive inherent economies of scale and usage improvement.
Chapter 2. What is a storage cloud

- Virtualize
  
  Virtualize storage capacity for better utilization and performance.

- Optimize
  
  Optimization aligns business requirements with cost-effective infrastructure through service-level management. Tiering, archiving, and space reclamation are key practices in achieving an optimized storage infrastructure.

- Automate
  
  Automate the storage administrative processes, such as the movement of data, by using policies across different storage tiers, thereby enabling faster access to the most frequently used data, and also ensuring that the correct data is stored at the correct place.

- Shared resources
  
  After consolidating and virtualizing the storage resources, the infrastructure is ready to be shared across the global enterprise.

- Cloud-ready
  
  Although all of these practices are not absolutely mandatory, they are all instrumental for deploying an optimized infrastructure within a storage cloud implementation for your enterprise. Consolidation of servers and storage with virtualization technologies improves utilization, while standardizing infrastructure and processes improves operational efficiency. Automation facilitates flexible delivery while enabling client self-service. Establishing common workloads on shared resources allows clients to provision new workloads in a dynamic fashion to achieve a true cloud-enabled environment.

**Solutions:** IBM offers a comprehensive set of solutions geared toward enabling a cloud infrastructure for our clients, from small and medium businesses to global enterprises. See Chapter 4., “What does IBM offer for storage cloud” on page 83 for a survey of industry-leading, enterprise-ready IBM storage offerings for cloud.

### 2.6.1 Use case: Distributed Computing Environment

From an IT management perspective, centralizing data is an often repeated mantra, because it results in reduced capital expenditure, management costs, and security risks. However, for many organizations, centralizing data storage, although a laudable goal, might not be achievable, perhaps because of technology limitations, or a business operational model. The use case presented here illustrates how an organization, operating in a Distributed Computing Environment, can benefit from the introduction and use of a storage cloud.
Environment description

Figure 2-6 illustrates a typical topology of an organization that is operating within a Distributed Computing Environment model.

The following examples are types of organizations that might operate within the distributed computing model:

- Financial institutions
- Government departments
- Retail organizations

The following sections describe the tiering structure shown in Figure 2-6, and some of the operational characteristics of an organization that is operating within the distributed computing model.

Data center tier
The organization has one or more data centers. The data centers host a high concentration of the corporate IT infrastructure and data. Where more than one data center exists, data replication is usually required between the data centers to meet business continuity and high availability requirements. A data center typically does not house any users, and may be operated in a “lights out” (remotely, automatically operated) fashion. Some data that is held within the data center (typically high-value transactional data) is accessed only over the organization’s wide area network (WAN). Other data held here might be more appropriately accessed at another tier to avoid WAN latency and contention issues. Backup data is typically held here also.

Regional office tier
Regional offices are large corporate offices that are hosting IT infrastructure in support of the personnel who are located at the office. A regional office might also provide services to branches within the region. A head office can act as a regional office in this tier. A regional office may be co-located with a data center, and therefore share the data center infrastructure. In some organizations, this tier might be small, or omitted entirely.
Read-only data held in this tier includes IT support data, such as standard operating environment images, client-side application packages, updates, and patches. Other read-only data can include corporate policy documents and other reference material. Although this type of data is often accessed through web technologies, where manipulation or printing is required, the data might be better placed locally to reduce the impact of WAN traffic.

Read/write data that is held in this tier includes a user's personal data, and data shared among co-workers within a team. Teams might be spread across regional offices within this tier.

Although most users who are operating within this tier are normally dedicated to a single regional office, users in management roles might roam across the regional offices.

**Branch office tier**
Branches often represent the public face of an organization. It is here that much of the transactional data is initiated. Branches can vary widely in terms of size and numbers of users. Some can be so small that the presence of significant local IT infrastructure cannot be cost-justified. In this case, the branch can be serviced out of the closest regional office, or directly from the data center. Data requirements for a branch are often identical to a regional office, including read-only and read/write data.

For some organizations, branch users are not dedicated to a single branch, but roam among branches within a region. Regional managers might also spend time at the branches for which they are responsible.

**Benefits of a storage cloud implementation**
For a Distributed Computing Environment, a storage cloud provides significant benefits for the accessibility, replication, and hierarchical storage management of data.

**Data accessibility**
One of the features of a storage cloud is its ability to consolidate multiple disparate data islands into a single data repository, accessible to anyone from anywhere throughout an organization (if security permits it). This single view of data is particularly helpful in a Distributed Computing Environment, where data islands are prevalent. Users and administrators can take advantage of this consolidated view to more easily access the data across the organization.

**Data replication**
Data replication is the key to enabling effective user roaming within and across the Distributed Computing Environment tiers. It can reduce WAN congestion and improve operational performance by having users access copies of data that are on their local area network (LAN), rather than across the WAN.

Branch staff can have their personal data replicated to branches within their region. Regional managers can have their personal data replicated to all of the branches within their region. Inter-region managers can have their personal data replicated to all regional offices. Teams that operate across regions can have their shared data replicated to their own regional office.

Each tier can have data replicated to its parent to facilitate high availability at the originating tier, and also to enhance the efficiency of the enterprise backup strategy. Corporate data can be replicated out to the branches for local manipulation, including printing.

IT infrastructure data can be replicated to all locations to facilitate IT-related tasks, such as workstation builds, software distribution, and patch management.
Although data replication is the key enabler for solving the data distribution dilemma, a smart storage cloud solution enhances the process by supporting automated management functions. These functions include features such as caching to reduce the amount of WAN traffic when accessing remote files, checking file “staleness” to ensure the current version of a file is always used, delta updates to minimize network traffic for updated files, and multiuser access management to eliminate update conflicts.

**Hierarchical storage management**

Data islands, as encountered within a Distributed Computing Environment, exacerbate the issue of organization data growth. As requirements for data storage grow, pressure is placed on each individual data island for capacity expansion. This pressure can be relieved by smart management of the data on each island. Because a storage cloud has a consolidated view of the storage environment across the enterprise, it is able to make intelligent decisions about whether data should be stored at a particular location based on metadata. Data that is infrequently used may be migrated to a central location. Inactive data can be archived, and retrieved on demand. These features allow for storage optimization, without the need for administrators to individually manage each storage repository.

### 2.6.2 Use case: Development and test environment

The software development lifecycle poses many challenges to a development organization. These challenges include enabling an agile development environment that supports the short time-to-market goals of the business, managing version control, meeting dynamically changing requirements, and keeping ahead of the competition.

**Business description and challenge**

Consider the example of a web development and hosting business unit within an IT services company. Such a unit is likely to experience peaks and troughs in demand, based on the business activity cycles of the clients they service. These demand-based fluctuations lead to bursts of intense activity, requiring access to large amounts of human and technology resources. At the completion of the development tasks, the resource requirements diminish significantly. Similarly, web hosting services add to the resource demand fluctuations as website traffic changes dynamically based on user-access patterns, driven by market forces, some of which are predictable, and some are not.

A traditional technology infrastructure presents the following challenges to an organization that is operating this type of business unit:

- Cost of provisioning and managing separate infrastructure for the differing business units
- Forecasting infrastructure requirements
- Provisioning adequate infrastructure for demand peaks

  Lead times for procuring and commissioning hardware are relatively lengthy, resulting in capacity that does not meet demand at critical project times, or resulting in the business being unable to compete for business opportunities.

- Wasting capital investment

  After hardware is provisioned, it might remain idle for lengthy periods of time, thereby wasting capital investment.

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1 These features are provided by the IBM Active Cloud Engine®. For further information, see “IBM Active Cloud Engine” on page 56.
Determining pricing models, based on apportionment of infrastructure resource utilization

Cost of upgrading

Infrastructure investment can leave the business behind in terms of current technology because the cost of upgrading diverse infrastructure can be prohibitive.

Figure 2-7 shows the current IT structure of Organization ABC’s currently isolated IT structures.

Figure 2-7 Various teams’ dedicated access makes sharing hardware resources difficult

Figure 2-8 shows how Organization ABC is now better prepared to adapt to changing demands.

Figure 2-8 Storage and compute resources can be scaled up or down to meet new demands

Benefits of a storage cloud implementation

A storage cloud can help the business units become more agile and dynamic to meet the fluctuating resource demands of their clients. Storage cloud also helps the larger organization to implement a pay-per-use model to accurately track and recover infrastructure costs across the business units.
Cost reduction
The business unit can provision storage to its clients at a significantly reduced cost because the infrastructure costs are shared across multiple customers and other business units, rather than paid solely by the client.

By consolidating its storage infrastructure, the organization is able to provide a single storage infrastructure over a broader client base. This way provides both economies of scale, and potential to even out the demand peaks and troughs.

Pooling of storage resources means that the organization can allocate storage from anywhere, where it is the most effective in meeting a client need.

Elasticity
Client resource demands can be met with agility because a storage cloud enables resources to be provisioned in an elastic fashion, dynamically as demands dictate.

Internal resource peak and trough demands for resources can also be met by provisioning a storage cloud. After activities, such as testing, are completed, the virtual machines and the attached storage that is associated with these activities can be released and added back to the virtual storage pool to be used later, or by other business units.

Rapid provisioning
A storage cloud allows for rapid provisioning of resources by providing a consolidated view of resources and automation of the overall storage provisioning process through a storage cloud portal.

Automation and self-provisioning also helps the temporary workforce, in terms of providing the test setup in minutes, rather than weeks. This feature means that personnel can be productive on startup, rather than being delayed by infrastructure provisioning workflows.

Standard deployment templates, which can be customized for differing environments, ensure that the provisioned environments are more stable and less error-prone, thereby improving the quality of deliverables.

Faster time to market
As a result of the reduction in time spent for manual provisioning processes, the business unit is able to focus on its core competencies, rather than being distracted by storage infrastructure administration. Less administrative complexity facilitates benefits like faster time to market for new products and services.
What enables a smart storage cloud

As outlined in the first two chapters, certain functions are vital to implementing a cloud architecture. Other capabilities enhance the overall infrastructure making it a smarter, more effective, and more efficient implementation, optimized to business requirements. This chapter describes the key features for storage cloud, storage virtualization, and automation, and also smart storage functionality including dynamic tiering, thin provisioning, compression, deduplication, and copy services.
3.1 Global collaboration for OpenStack storage components

As previously described in 1.7.2, “OpenStack architecture overview: An open source cloud IaaS platform” on page 15, OpenStack technology is a key enabler of cloud *infrastructure as a Service* (IaaS) capability. OpenStack architecture provides an overall cloud best practices workflow solution that is readily installable, and supported by a large ecosystem of worldwide developers in the OpenStack open source community.

Within the overall cloud workflow, there are specific OpenStack components that support storage. The following OpenStack components support storage:

- Cinder (block storage)
- Swift (object storage)

Figure 3-1 shows the OpenStack storage components, Cinder and Swift.

![OpenStack storage components](image)

**Figure 3-1** OpenStack storage components Cinder (block) and Swift (object)

We explore these two components in more detail below.

### 3.1.1 OpenStack block storage component (Cinder)

Cinder is the portion of OpenStack cloud software that is responsible for functions such as the following (not an all-inclusive list):

- Creating, modifying, deleting block storage LUNs
- Attaching these LUNs to server images created in the Nova component
- Performing block storage functions such as snapshots
- Provides support for backup and restore of volumes
OpenStack software contributors write storage drivers that allow specific storage systems to be supported, provisioned, and managed by Cinder.

IBM, a platinum member of the OpenStack Foundation, is an active contributor to OpenStack cloud software and to the Cinder component (as well as other components of the OpenStack architecture).

IBM has written and contributed OpenStack drivers for the following IBM block storage systems to be supported by Cinder in an OpenStack environment:

- IBM General Parallel File System (GPFS) (Havana release)
- IBM XIV® Storage System
- IBM Storwize® family (Storwize V7000 Unified support in Icehouse release)
- IBM System Storage DS8870

**Note:** For more information about the IBM storage drivers and functions that are supported in the various OpenStack releases, refer to the following wiki:

https://wiki.openstack.org/wiki/CinderSupportMatrix

The IBM OpenStack Cinder block storage contributions are shown in Figure 3-2.

With this OpenStack driver support contribution, the creation, provisioning, and management of block storage for server images is accomplished in a seamless fashion. When provisioning servers, the Nova component can talk directly to the Cinder component, requesting appropriate amounts of storage. The Cinder component is able to perform those requested operations on these storage systems, and return the results to Nova for attachment to the compute server images.
IBM has contributed to the development and maturity of OpenStack Cinder, beyond drivers, which enable IBM storage to work in an OpenStack cloud. The following are features contributed for OpenStack Havana and Icehouse releases.

**Volume migration**

IBM has driven support for migrating volumes from one storage system to another, a feature that was missing in the OpenStack environment. This feature allows administrators to move a volume from one system to another, supporting scenarios such as storage evacuation.

Moreover, it allows cloud administrators to define storage classes that abstract the type of storage (volume types) provided to users, and for users to manage the type of storage for their data by selecting a volume type or changing the volume type of a volume and triggering the migration of the volume to an appropriate storage system that supports the required functionality and features. For more information about the Storwize Family volume migration support, see Figure 4-2 on page 87.

**Mixing OpenStack and non-OpenStack volumes**

IBM has also driven a new feature available since Icehouse, allowing to mix OpenStack and non-OpenStack volumes. The OpenStack volume manager feature assumes control of an existing volume already allocated on the storage system, making the volume available to workloads running in an OpenStack cloud. In addition, the OpenStack volume manager can also unmanage a volume, releasing control over it, essentially making it no longer available to workloads running on the OpenStack cloud.

**Backup and restore enhancements**

IBM also enhanced the support of Cinder backup and restore, by introducing OpenStack support for electronic backup shipping between OpenStack clouds, so a backup of a volume could be restored in another cloud.

A cloud administrator can configure Cinder backup to support electronic backup shipping for its users.

### 3.1.2 OpenStack object storage component (Swift)

The OpenStack Swift (Object Store) component provides object storage and allows users to store or retrieve files in a blob mode. Object store is a great fit for data that does not change much: Backups, archives, video, audio, VM images, Internet-scale repositories of data. This is why it is so essential to cloud.

Following are some of the object storage capabilities:

- OpenStack cloud software provides redundant, scalable object storage by using clusters of standardized servers that are capable of storing petabytes of data.

- Object Storage is not a traditional file system, but rather a distributed storage system for static data such as virtual machine images, photo storage, email storage, backups, and archives. Having no central “brain” or master point of control provides greater scalability, redundancy, and durability.

- Objects and files are written to multiple disk drives spread throughout servers in the data center, with the OpenStack software responsible for ensuring data replication and integrity across the cluster.

- Storage clusters scale horizontally simply by adding new servers. If a server or hard disk drive fails, OpenStack software replicates its content from other active nodes to new locations in the cluster. Because OpenStack technology uses software logic to ensure
data replication and distribution across different devices, inexpensive commodity hard disk drives and servers can be used in lieu of more expensive equipment.

3.1.3 OpenStack architecture summary

OpenStack architecture is simply one implementation of a best practices cloud workflow. Regardless of the cloud operating system environment that is used, the following key summary points apply:

- Cloud operating systems provide the necessary technology workflow to provide truly elastic, pay per use cloud services
- OpenStack cloud software provides a vibrant open source cloud operating system that is growing quickly
- OpenStack storage components:
  - Cinder component provides support, provisioning, and control of block storage
  - Swift component provides support, provisioning, and control of object storage

The rapid growth, adoption, and open source nature of OpenStack cloud software, along with its well designed support of block and object storage, make it an attractive option for implementing a ready, proven cloud best practices workflow.

For more information about OpenStack technology, see the following site:
http://www.openstack.org

Regardless of whether you use OpenStack cloud software, other open source cloud operating systems, or a proprietary cloud implementation, the storage itself can offer many capabilities that optimize and improve the efficiency of the cloud operating environment. In the following sections, we explore these storage aspects that enable optimum cloud operation.

3.2 Storage efficiency

The insatiable desire for increased data storage space has led to significant innovations in storage efficiency. This section describes these innovations and the smart ways in which storage clouds are using them to provide users with a better return on their storage investment.

3.2.1 Virtualization

Storage virtualization refers to the abstraction of storage systems from applications and servers. It is a foundation for the implementation of other technologies, such as thin provisioning, tiering, and data protection, which are transparent to the server. It is one of the key enablers for storage cloud environments where several cloud services are typically sharing one common infrastructure. Storage virtualization abstracts storage from multiple sources into a single storage pool. It helps you to manage the rapid information growth by using your storage equipment and data center space more effectively. The increase in storage utilization reduces power costs and keeps the footprint of your storage hardware low.

IBM Storwize Family: SAN Volume Controller

The IBM SAN Volume Controller provides block-level aggregation and volume management for IBM and external storage systems in a storage area network (SAN). The SAN Volume Controller manages a number of logical volumes that are presented by back-end-storage
controllers as a single storage pool, and it creates virtual disks (VDisks) from that pool that is presented to servers attached to a SAN. One of the many advantages, from the server perspective, is that the storage environment is homogeneous.

Figure 3-3 shows how SAN Volume Controller virtualizes a storage environment with multiple storage systems.

![Figure 3-3: Storage virtualization with IBM SAN Volume Controller](image)

The SAN Volume Controller is deployed as a pair of nodes that form an I/O group, the I/O groups form a cluster, and there can be up to four pairs of nodes in a cluster. The SAN Volume Controller cluster sees the storage that is presented to a SAN by the back-end storage controller as a number of disks called managed disks (MDisks). MDisks can be provided by a SAN storage system or by the solid-state drives that are provided by the SAN Volume Controller nodes.

**IBM Storwize V7000 Unified**

To be able to serve logical volumes and files, the hardware and software to supply these services are integrated into one product. Viewed from a client perspective, one part of IBM Storwize V7000 Unified is a storage server and the other part is a file server, and therefore is referred to as “Unified.”

The Storwize V7000 Unified uses disk-level virtualization with storage-level virtualization. You can virtualize external storage systems and you can use the internal disks to provide logical volumes to servers in your SAN. IBM Storwize V7000 Unified consists of a set of drive and control enclosures. Control enclosures contain disk drives and two nodes that are referred to
as an I/O group, which is attached to the SAN fabric. Expansion enclosures contain drives and are attached to control enclosures. In addition to providing logical volumes, you can use Storwize V7000 Unified to implement file level storage virtualization, which refers to the provisioning of storage to operating systems and applications in your Internet Protocol (IP) network in the form of files and directories. Storwize V7000 Unified uses file access protocols and thus acts as a file server appliance. The file server subsystem of Storwize V7000 Unified consists of two file modules, which perform the functions that are provided by the proven, reliable IBM Scale Out Network Attached Storage Software. They use the VDisks provided by the virtualized subsystem to create file systems. IBM Storwize V7000 Unified provides various file access protocols such as Common Internet File System (CIFS), Network File System (NFS), File Transfer Protocol (FTP), and HTTPS so you can more easily access your data. Figure 3-4 shows an overview of the main components included in the file module software stack.

![Software stack on file modules](image)

You can also use Storwize V7000 Unified as a traditional block subsystem. Its internal drives are configured into RAID arrays and virtual disks that are created from those arrays. Storwize V7000 Unified supports hot-spare drives. In a disk failure, the system automatically replaces the failed member with a hot-spare drive and rebuilds the array to restore its redundancy. Every array has a set of goals that describes the location and performance of each array. A sequence of drive failures and hot-spare takeovers can leave an array unbalanced, that is, with members that do not match these goals. IBM Storwize V7000 Unified automatically rebalances such arrays when appropriate drives are available.

**IBM Scale Out Network Attached Storage**

Scale Out Network Attached Storage uses mature technology from IBM high performance computing and it is based on the proven, reliable IBM General Parallel File System (GPFS). Rather than having fragmented, isolated islands of information with underutilized storage resources (Figure 3-5 on page 44), the file-level virtualization and hardware-level abstraction of Scale Out Network Attached Storage allow you to effectively manage storage.
From the virtualization perspective, the Scale Out Network Attached Storage appliance consists of interface nodes, an integrated management node, and several storage pods. The interface node provides connectivity to your IP network for file services to external applications. The interface layer presents one single namespace for accessing your data through various file access protocols, such as CIFS, NFS, FTP, and HTTPS. This namespace remains constant, regardless of where the directory and folder are physically located. In this way, sharing files among servers becomes easier. It also facilitates the implementation of tiered storage at the file level, for best operational efficiency. The management node provides a management interface as your single entry point for the configuration.

Each storage pod consists of high-density disk-expansion units, keeping the storage footprint at a low level. They are connected to storage controllers that provide a set of RAID-protected logical volumes to a storage node. Each storage pod contains two storage nodes that are connected to both storage controllers. Storage nodes and interface nodes form a cluster. Files can be accessed through each of the interface nodes, which provide highly scalable capability for data access. Additional data access performance can be obtained by more interfaces nodes. Scale Out Network Attached Storage supports your current and future capacity needs. It provides extreme scalability to accommodate capacity growth up to over 20 petabytes (PB) by adding more storage pods.

### 3.2.2 Compression

The amount of data stored will continue to grow exponentially every year, which creates tremendous strain on the IT infrastructure, especially on storage systems. Additional storage systems can help to meet these storage growth requirements in the near-term. However, shrinking IT budgets are pressuring IT managers to increase the lifetime of existing storage systems. Additional storage systems lead to higher energy costs, and available floor space in data centers is often a considerable limitation. Compression provides an innovative approach, which is designed to overcome these challenges.

Online compression immediately reduces the physical storage across all storage tiers. It allows storage administrators to gain back free disk space in the existing storage system without the need to change any administrative processes or enforcing users to clean up or archive data. The benefits to the business are immediate because the capital expense of upgrading the storage environment is delayed. Compression also reduces the environmental requirements per unit of storage. After compression is applied to stored data, the required
power and cooling per unit of storage are reduced because more logical data is stored in the same physical space.

**IBM Storwize V7000 and SAN Volume Controller**

IBM Real-time Compression™ software embedded in IBM SAN Volume Controller and Storwize V7000 solution addresses all the requirements of primary storage data reduction, including performance, using a purpose-built technology called real-time compression.

SAN Volume Controller and Storwize V7000 is designed to improve storage efficiency by compressing data by as much as 80% through supported real-time compression for block storage. This process enables up to five times as much data to be stored in the same physical disk space. Unlike other approaches to compression, IBM Real-time Compression is used with active primary data such as production databases and email systems. This configuration dramatically expands the range of candidate data that can benefit from compression. As its name implies, IBM Real-time Compression operates as data is written to disk, avoiding the need to store decompressed data that is awaiting compression.

Implementing Real-time Compression in Storwize V7000 or SAN Volume Controller provides the following benefits:

- **Compression for active primary data:** IBM Real-time Compression can be used with active primary data. Therefore, it supports workloads that are not candidates for compression in other solutions. The solution supports online compression of existing data. It allows storage administrators to regain free disk space in an existing storage system without requiring administrators and users to clean up or archive data. This configuration significantly enhances the value of existing storage assets, and the benefits to the business are immediate. The capital expense of upgrading or expanding the storage system is delayed.

- **Compression for replicated/mirrored data:** Remote volume copies can be compressed in addition to the volumes at the primary storage tier. This process reduces storage requirements in Metro Mirror and Global Mirror destination volumes as well.

- **No changes to the existing environment are required:** IBM Real-time Compression is part of the storage system. It was designed with transparency in mind so that it can be implemented without changes to applications, hosts, networks, fabrics, or external storage systems. The solution is not apparent to hosts, so users and applications continue to work as-is. Compression occurs within the Storwize V7000 or SAN Volume Controller system itself.

- **Overall savings in operational expenses:** More data is stored in a rack space, so fewer storage expansion enclosures are required to store a data set. This reduced rack space has the following benefits:
  - **Reduced power and cooling requirements:** More data is stored in a system, therefore requiring less power and cooling per gigabyte or used capacity.
  - **Reduced software licensing for additional functions in the system:** More data that is stored per enclosure reduces the overall spending on licensing.

**Tip:** Implementing compression in SAN Volume Controller provides the same benefits to externally virtualized storage systems.

- **Disk space savings are immediate:** The space reduction occurs when the host writes the data. This process is unlike other compression solutions in which some or all of the reduction is realized only after a post-process compression batch job is run.
Using IBM Easy Tier® together with Real-time Compression delivers elevated performance at a lower cost.

**Note:** For more information about evaluating potential savings, refer to *IBM Real-time Compression Evaluation User Guide for IBM Storwize V7000 and SAN Volume Controller Version 7.2*, at the following location:

http://www-01.ibm.com/support/docview.wss?uid=ssg1S7003988&aid=1

**IBM Tivoli Storage Manager compression**

Tivoli Storage Manager, as an enterprise-wide storage management application, provides automated storage management services to workstations, personal computers, and file servers. It enables you to protect your organization’s data from failures and other errors. The software product consists of two basic functional components:

- **Tivoli Storage Manager server with IBM DB2® database engine**

  The Tivoli Storage Manager server provides backup, archive, and space management services to the Tivoli Storage Manager clients and manages the storage repository. The storage repository can be implemented in a hierarchy as storage pools using any combination of supported media and storage devices that are directly connected to the Tivoli Storage Manager server system or are accessible through a SAN.

- **Tivoli Storage Manager clients with common application programming interface (API)**

  Backup/archive data is sent to the Tivoli Storage Manager server using the Tivoli Storage Manager backup/archive clients and complementary products. These products work together with the Tivoli Storage Manager server base product to ensure that any stored data is managed as defined. The Tivoli Storage Manager backup/archive client, included with the server, provides the operational backup and archive functions.

With Tivoli Storage Manager, files can be compressed by the Tivoli Storage Manager clients before the data is sent to the Tivoli Storage Manager server. This way decreases the amount of data that is sent over networks and the space that is occupied by the data in the Tivoli Storage Manager storage pools.
3.2.3 Deduplication

Data *deduplication* is a key technology to dramatically reduce the amount of, and the cost associated with, storing large amounts of data by consolidating redundant copies of a file or file subset. Incoming or existing data is standardized into “chunks” that are then examined for redundancy. If duplicates are detected, pointers are shifted to reference a single copy of the chunk and the extraneous duplicates are then released.

**IBM ProtecTIER data deduplication**

As mentioned, business data is growing at an exponential rate and backup windows are typically shrinking. IBM ProtecTIER® data deduplication helps you to back up and recover data as fast as possible. The ProtecTIER application is available as part of a gateway-based solution and as an appliance with integrated storage. It emulates a tape library to the backup application including drives, cartridges, and robotics.

The cornerstone of ProtecTIER is IBM HyperFactor®, an IBM technology that deduplicates data inline as it is received from the backup application. HyperFactor is based on a series of algorithms that identify and filter out the elements of a data stream that were previously stored by ProtecTIER. This search is extremely quick by using a small and efficient memory-resident index. Over time, HyperFactor considerably increases the usable capacity of your physical backup storage. With ProtecTIER native replication, the data reduction value of HyperFactor is extended to bandwidth and storage savings for the disaster recovery operations.

**IBM Tivoli Storage Manager data deduplication**

Another software-based option for reducing data storage is the native storage pool deduplication that is provided by Tivoli Storage Manager, which offers deduplication of both backup and archive data. With Tivoli Storage Manager data deduplication, you can save storage space and reduce the overall amount of time that is required to retrieve data by letting you store more data on disk, rather than on tape.

Tivoli Storage Manager provides two types of data deduplication:

- **Server-side deduplication:**
  
  This type consists of two phases. In the first phase, duplicate data is identified. During the second phase, duplicate data is removed by certain server processes, such as reclamation of storage-pool volumes. The server-side deduplication can be configured either as inline or post-processing:

  - **Inline:** Incoming client backup data is immediately processed as it is being stored in the Tivoli Storage Manager storage hierarchy.
  - **Post-processing:** Data is stored in the Tivoli Storage Manager server storage hierarchy as non-deduplicated and in the original structure. Deduplication occurs internally as a scheduled task outside of the backup window.

- **Client-side deduplication:**
  
  This type identifies and removes redundant data before it is sent to the Tivoli Storage Manager server to reduce load on your IP network. As part of the client-side deduplication process, the Tivoli Storage Manager client creates extents, which are part of files. The Tivoli Storage Manager client works together with the Tivoli Storage Manager server to identify duplicate extents and it sends only the non-duplicate ones.
3.2.4 Thin provisioning

Traditional storage provisioning pre-allocates and dedicates physical storage space for use by applications or hosts. However, the total requested capacity is usually not required from the beginning when the assignment is made, but it needs to be physically available already. Furthermore, estimating the exact amount of required space for a new application, which can lead to over-provisioning, is sometimes difficult or even impossible. This results in wasted space, which is known as white space, and bad utilization of the physical storage. Figure 3-6 illustrates the advantages of thin provisioning in terms of storage allocation.

![Figure 3-6  Advantages of thin provisioning over regular storage provisioning](image)

Thin provisioning allows applications and servers to see logical volume sizes that are larger than the physical capacity actually dedicated to the volumes on the storage system. Physically, capacity is allocated for the volumes only as needed. This way allows a higher storage utilization, which in turn, leads to a reduction in the amount of storage that is needed, lowering the capital expenses. Furthermore, the usage of thin-provisioned storage postpones the need to invest in more storage. Thin provisioning also simplifies your capacity planning because you can manage a single pool of free storage. Multiple applications or users can allocate storage from the same free pool, thus avoiding situations in which several volumes are capacity constrained, yet others have capacity to spare. In this way, your storage environment becomes more agile.

**IBM XIV Storage System**

The IBM XIV Storage System (XIV) specifies thin provisioning at the storage pool level. XIV system volumes inherit the provisioning characteristics of the storage pool in which they are created. All volumes that are created in thin provisioning storage pools are thin provisioned volumes. All volumes that are created in regular storage pools are fully provisioned volumes.

For a thin-provisioned XIV system volume, a volume of the requested size is created without any physical allocation reserved. If the thin-provisioned volume is presented to a host server, the host server sees the full size of the volume created, even if no physical capacity was
allocated. Physical space is allocated (transparently to the host server) only when data is written to the thin-provisioned volume.

Besides the possibility to create thin-provisioned volumes, all XIV snapshots (point-in-time copy) are thin-provisioned regardless in which storage pool type they are created. After an XIV system snapshot is created, there is no physical capacity allocation. Again, the full logical size is presented to a host server, but physical capacity is allocated only as needed to preserve the snapshot.

**IBM SAN Volume Controller and IBM Storwize V7000 Unified**
SAN Volume Controller and Storwize V7000 Unified provide the same capabilities in terms of thin provisioning. Both devices manage a number of logical volumes that are presented by back-end storage controllers as one storage pool, and they allow the creation of thin-provisioned VDisks to optimize the physical capacity utilization of the storage pool. Any physical capacity that is not used by a thin-provisioned VDisk is immediately available for use by any other thin-provisioned VDisk of the same storage pool. Thin provisioning for VDisks is implemented in the virtualization layer. It does not rely or depend in any way on the functionality that is provided by the underlying storage systems. Therefore, SAN Volume Controller and Storwize V7000 Unified enable thin provisioning support for your storage environment regardless of the capabilities of your existing storage hardware. SAN Volume Controller and Storwize V7000 Unified also provide support for thin-provisioned IBM FlashCopy® volumes.
3.2.5 Automated tiering

In modern and complex application environments, the increasing and often unpredictable demands for storage capacity and performance lead to related issues in terms of planning and optimization of storage resources. Determining the amount of I/O activity on storage and when to move the data to the appropriate storage tier are usually complex. As a manual process, these corrective actions are expensive in terms of hardware resources and labor, and they are critical to the service availability.

Automated tiering refers to the automated migration of data between storage tiers based on real-time analysis of access patterns. The continuously ongoing process basically consists of multiple steps:

1. The workload on the storage is continuously monitored by the storage system.
2. After a certain period, the storage system evaluates the historical information to identify “hot spots,” which means data with a high I/O density.
3. The storage system creates a migration plan for moving this “hot spot” data to a higher tier storage, which provides the required performance.

Data whose I/O density has dropped off is moved back to a lower tier. Automated tiering helps you to more precisely plan and manage both storage costs and application performance.

IBM SAN Volume Controller and IBM Storwize V7000 Unified Easy Tier

IBM Easy Tier is a built-in, dynamic data relocation feature available on the SAN Volume Controller and the Storwize V7000 Unified. Easy Tier determines the appropriate storage tier for your data, based on access patterns, and then automatically and nondisruptively moves your data. The automatic data placement allows you to gain the benefits by using a higher performance storage tier at a much lower cost and without manual management.

Easy Tier provides automatic migration of frequently accessed data to high-performing flash memory, enhancing usage efficiencies.

Easy Tier is designed to help improve performance at a lower cost through more efficient use of flash memory. Easy Tier automatically identifies highly active data and moves only that data to flash memory, which targets use of flash memory to the data that benefits the most, helping deliver the maximum benefit even from small amounts of flash memory capacity.

You can enable Easy Tier on the storage pool and the disk level for any storage that is managed by the SAN Volume Controller and Storwize V7000 Unified. This storage can be either internal or external disk storage, or a combination of both.

If enabled, Easy Tier continuously monitors the I/O activity and latency of the extents on the volumes in a storage pool. At least once every 24 hours, it evaluates the historical activity and creates a migration plan that is based on this history. It dynamically moves high activity data to a higher tier disk within the storage pool. It also moves data, whose activity decreased, back to a lower-tier disk. Because the data relocation works at the extent level, it is often referred to as sub-LUN migration.
Figure 3-7 illustrates the dynamic data migration process. Although data migration is not possible within a single-tier storage pool, the Easy Tier statistical measurement function is available. The statistics help you to understand your workload characteristics and to estimate the potential performance benefits of using multtier storage pools with SSDs before any major hardware acquisition.

![Easy Tier dynamic data migration](image)

**Figure 3-7  Easy Tier dynamic data migration**

### 3.3 Automation and management

As storage vendors seek to reduce the costs of configuring and managing their products, they are increasingly turning to automation to eliminate repetitive tasks, freeing up administrators for more productive activities. In storage clouds, vendors are introducing smarter automation, which performs analysis and makes process-based decisions that are aimed at avoiding operator intervention. This section describes smart cloud automation features, and the management capabilities that are made available to reduce the cost of managing storage environments.

#### 3.3.1 Cross-site data mobility

Clients are increasingly deploying virtualized servers by using IBM PowerVM®, VMware, and other technologies in high availability configurations, including multisite clustered implementations. Such configurations provide attractive options for high availability and load balancing.
IBM General Parallel File System

The IBM General Parallel File System (GPFS) is a high performance shared-disk file management solution that provides fast, reliable access to data from multiple nodes in a cluster environment. Applications can readily access files using standard file system interfaces, and the same file can be accessed concurrently from multiple nodes. GPFS is designed to provide high availability through advanced clustering technologies, dynamic file system management, and data replication. GPFS can continue to provide data access even when the cluster experiences storage or node malfunctions. GPFS scalability and performance are designed to meet the needs of data intensive applications such as engineering design, digital media, data mining, relational databases, financial analytics, seismic data processing, scientific research, and scalable file serving.

GPFS not only enables high-performance, file-based storage access, it also can help in optimizing data management. GPFS provides proven reliable access to a common set of file data using a single global namespace. This enables centralized visibility and administration features to help better manage storage costs, specifically:

- Online storage management and efficient use of available storage
- Scalable data access through tightly integrated information lifecycle tools capable of managing petabytes of data and billions of files
- Centralized administration
- Shared access to file systems from remote GPFS clusters
- Scalable, high-performance remote file data caching

**GPFS support in OpenStack Cinder Havana release**

OpenStack Cinder in the Havana release supports GPFS. This driver allows you to leverage GPFSs scalable, high performance data, and file management solution in your OpenStack cloud environment. When you deploy your OpenStack cloud environment with GPFS storage, all of your nodes are able to access image, block, object, and file data locally in the shared file system. Figure 3-8 shows a high-level view of the GPFS single name space in the OpenStack cloud environment.

![Figure 3-8 GPFS single name space in an OpenStack cloud environment](image)
The GPFS vision for cloud includes:

- GPFS as a single scale-out data plane for entire data center
- Unifies VM images, block devices, objects, and files
- Single name space no matter where data resides
- De-clustered parity: GPFS Native RAID (GNR)
- Data in best location, on the best tier (performance and cost), at the right time
- All in software

Figure 3-9 shows the volumes that are allocated for specific workloads using a GPFS cluster in an OpenStack environment.

![Using GPFS Storage in an OpenStack environment](image)

**Figure 3-9  Workload volume allocation using GPFS storage in an OpenStack environment**

**Note:** For more information about the GPFS block storage driver in the OpenStack Havana release, see YouTube:

[https://www.youtube.com/watch?v=q-0-VPsO8Kw](https://www.youtube.com/watch?v=q-0-VPsO8Kw)

**IBM SmartCloud Orchestrator**

IBM SmartCloud Orchestrator provides an open and extensible cloud management platform for managing heterogeneous hybrid environments. The software integrates provisioning, metering, usage, and accounting as well as monitoring and capacity management of cloud services.
IBM SmartCloud Orchestrator provides the following features and benefits:

- Standardization and automation of cloud services through a flexible orchestration engine and a self-service portal.
- Reusable workload patterns to enable dynamic cloud service delivery.
- Built on open standards, including OpenStack cloud software, for unparalleled interoperability.
- Leverage open technologies such as OpenStack cloud software to build an interoperable infrastructure foundation to provision workloads, provide multi-tenancy, and enable administration.
- Offer infrastructure and workload orchestration for VMware and Microsoft virtualization infrastructures, and adopts OpenStack technology.

IBM SmartCloud Orchestrator 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 help 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.
- Let you measure the cost of cloud services with metering and charge-back capabilities.

Dynamic cloud service delivery benefits from the following functions of reusable workload patterns:

- Enable rapid deployment and integration of cloud capabilities using reusable workload patterns for simple infrastructure services and complex multitier applications.
- Allow workload patterns to be created using templates, or from scratch. After a pattern is created, it can be reused to create multiple identical instances in the cloud.
- Can integrate with middleware components and infrastructure resources to help optimize components for a particular type of application workload.

**Monitoring and metering**

IBM SmartCloud Orchestrator Enterprise enables monitoring of workloads and instances through IBM SmartCloud Monitoring (SCM). This includes monitoring virtual environments. IBM SmartCloud Monitoring can also do capacity planning for right workload placement, which includes support for both VMware and PowerVM (SCM includes a 5-step planner for capacity planning).

Metering capability on a cloud enterprise can be enabled with IBM SmartCloud Cost Management (SCCM). IBM SmartCloud Cost Management can meter the cloud services that are based on allocation as well as utilization.
IBM SAN Volume Controller split-cluster configuration

A SAN Volume Controller cluster can be installed in a stretched configuration where a single SAN Volume Controller cluster supports storage and servers in two data centers. Normally, as mentioned previously, the SAN Volume Controller is deployed as a pair of nodes that form an I/O group; I/O groups form a cluster, with up to four I/O groups in a cluster. A pair of nodes from the same I/O group is physically located within the same rack, in the same room.

With the split-cluster configuration feature that is provided by SAN Volume Controller, you can split an I/O group between two physical locations, up to 300 km apart. In this configuration, the SAN Volume Controller enables a highly available stretched volume to be concurrently accessed by servers at both data centers. When combined with server data mobility functions, such as VMware vMotion, a SAN Volume Controller stretched cluster enables nondisruptive storage and virtual machine mobility between the two data centers, as shown in Figure 3-10.

SAN Volume Controller split-cluster configurations can be combined with SAN Volume Controller Metro Mirror or Global Mirror to support a third data center for applications that require both high availability and disaster recovery in a single solution.

![Figure 3-10 Cross-site data mobility with SAN Volume Controller split cluster](image)

### 3.3.2 WAN optimization across clouds

Information lifecycle management (ILM) is the process of managing file data from where it is placed when it is created, to where it moves in the storage hierarchy, as its value typically changes multiple times during its lifetime. Policy-driven automation and tiered storage management can help you to improve your ILM, especially for unstructured data that is growing exponentially. However, the increasing need for accessing data from any place at any time also requires a seamless integrated replication strategy, which allows ubiquitous access to your data across extended distances and, which not only is bandwidth-friendly but also allows high performance for applications at the same time.
IBM Active Cloud Engine

IBM Active Cloud Engine, the core of IBM Scale Out Network Attached Storage and IBM Storwize V7000 Unified, is a powerful policy-driven engine that is tightly coupled with the file system and designed for managing massive amounts of data over multiple sites. Active Cloud Engine is designed to manage files in an automated, scalable manner and creates the appearance of a single system despite separate physical and geographic locations. Active Cloud Engine helps you to have the correct files in the correct place at the correct time to give the users of that file the fastest possible access, and the same view of their data no matter where they are or how they connect. Furthermore, Active Cloud Engine automates the intelligent and active management of data, both in a data center and in a storage cloud environment, with a single integrated experience to manage more storage with less effort on a global scale.

Local capabilities of Active Cloud Engine

Active Cloud Engine enables you to manage your file data within your data center with ease, efficiency, and at scale. It provides the following capabilities:

▶ High-performance scan
▶ Optimized data placement
▶ Transparent data movement
▶ Hierarchical storage management (HSM) using Tivoli Storage Manager
▶ Automated deletion, back up, and replication

Figure 3-11 illustrates the seamless integration of the policy engine with the file system.

The figure shows the following information:

▶ File set: A file set is a logical sub tree of the file system namespace and provides a way to partition the namespace into smaller, more manageable units.
Policy engine: The policy engine evaluates policies that can be created through Active Cloud Engine. With policies, you can define where you want your data to be placed and how you want it to be moved through time and various locations.

Storage pools: Storage pools are logical groupings of physical storage with similar characteristics that allow the creation of storage tiers.

Active Cloud Engine supports two types of files policies:

- File placement policies:
  - They are used to automatically place newly created files in a specific storage pool.
  - Files in the same file set can reside in separate storage pools.

- File management policies:
  - Transparently move files to another internal or external storage pool.
  - Delete, back up, restore, and replicate.
  - Remote caching and intelligent prefetching of subsets of files.

The integrated storage pools, file sets, and user-defined policies provide the ability to do automated storage tiering and therefore more efficiently match the cost of your storage to the value of data. The policy engine is tightly and seamlessly integrated into the global file system. This integration allows for rapid assessment, evaluation of many criteria, and then taking the appropriate action. Some of the simplest actions you might want to do is to search for particular file names, or any other type of metadata search, either to compile lists or to take actions on that data. You can also use these actions to place data in a specific storage pool. For example, you might have certain SLAs that require a certain level of performance, which would put this data on fast disks or SSDs. In other cases, you might want to optimize your cost and put that data on slower performing disks, as an example.

With policies, you can also move data external to a system, by using HSM. You can use pools to identify files that have changed and that you need to back up or restore. You can use the policy engine to perform replication functions to identify quickly which files have changed but are not backed up. You can prefetch information. Policies can be run against clones or snapshots. These activities are all done automatically within the system itself. Active Cloud Engine provides a high level of intelligence within the storage system and helps you to optimize your storage costs.

Figure 3-12 on page 58 illustrates how Active Cloud Engine supports your information lifecycle management (ILM). A file placement policy defines the initial placement of the data on high performance serial-attached SCSI (SAS) drives. Another file management policy migrates the data based on its attributes after 30 days to a high capacity nearline SAS drive. Finally, when the data is 180 days old, a third management policy automatically performs the migration to Tivoli Storage Manager and then to disk or tape.
**Global capabilities of Active Cloud Engine**

The global management of Active Cloud Engine extends the capability from a single global name space within a data center to a truly distributed worldwide namespace to allow comprehensive file management and collaboration across multiple sites. It provides the following capabilities:

- File caching at remote sites
- File prefetching or “on-demand” pull
- Push updates to a central “home” site
- Virtualization of physically separated systems to a global single view
- Disconnected mode

The Active Cloud Engine consists of a client/server architecture, where the home cluster (“server”) provides the primary storage of data, and cache clusters ("clients") can read or write cache data that is exported to them. Active Cloud Engine also supports mesh deployments in which clusters work as both home and cache cluster. Figure 3-13 shows a company whose three data centers are geographically dispersed. The headquarters provides the primary storage of data (home cluster) and the two branch offices read the exported data, which is locally cached (cache cluster).
As stated in “IBM Scale Out Network Attached Storage” on page 43, the interface node provides connectivity to your IP network for file services to external applications and users. For cache clusters, these Scale Out Network Attached Storage interface nodes now take on a second “personality” that is called a gateway node. These gateway nodes act as NFS clients that access data from the home cluster over a WAN connection. Any interface node can function as a gateway node yet still function as interface nodes that are serving the users. Data requests are handled locally through these interface nodes if the requested data is already in the cache. If the data is not in the cache, the request is forwarded to the gateway nodes. The gateway nodes then bring the data over the WAN and store it in the local GPFS file system from where the interface nodes access it directly.

Figure 3-14 illustrates this process for “Fileset A”, which has been enabled for Active Cloud Engine. Active Cloud Engine performs whole-file caching, where data is brought into the cache even when the file is read partially. However, read requests are split among various gateway nodes for better performance, and the caching of data happens asynchronously.

![Figure 3-14](image)

Active Cloud Engine supports the following caching modes on the file set level:

- **Read**: The cache cluster can read data, but write-data changes are not allowed. This mode is useful for data broadcast, for latency and bandwidth reduction, and for localizing data to the local users.

- **Single writer**: One cache cluster is defined as the only writing location. The home cluster receives the writes, but does not change the data. The home cluster acts as a central repository so that multiple other cache clusters can read the data.

- **Local update**: Data is read or pushed from home and cached at the local cache cluster. Changes are allowed locally, but changes are not pushed back to home. This local update mode is similar to a sandbox or scratch pad environment.

Active Cloud Engine allows true collaboration worldwide through sharing, through efficient caching, and through virtualization.
3.3.3 Storage management

The continuously increasing demand for storage clearly leaves a large footprint of data that is stored, shared, archived, or replicated many times for various purposes. The storage infrastructure often consists of widely diverse hardware from various vendors, which are driven by evolving technologies and changing business strategies. New storage technologies, such as virtualization, thin provisioning, and tiering, help to provide more efficient use of the storage resources, however, they also introduce additional layers of complexity. The resulting storage environments are typically difficult to use, expensive to manage, difficult to oversee, and therefore prone to service interruptions and failures. The most severe issues usually are the following items:

- Controlling out-of-control storage growth
- Planning for capacity upgrades
- Minimizing performance bottlenecks
- Keeping SAN highly available
- Simplifying the management of multivendor storage devices
- Reducing storage-related costs

Centralized storage management gives you insights into storage utilization and allocation across your heterogeneous storage infrastructures. It provides a better understanding of storage performance and utilization patterns, enabling a better ILM of your application data. Furthermore, with centralized storage management, you can perform infrastructure management proactively rather than reactively. It leads to cost savings through improved operational efficiency and allows more intelligent business decisions, so you can respond faster to changing demands.

IBM Tivoli Storage Productivity Center

IBM Tivoli Storage Productivity Center is an integrated suite that provides comprehensive storage infrastructure management: From file systems and databases on servers, through the storage area network (SAN) fabric and network, to the destination storage systems. It can help you improve time-to-value ratio, and also reduce the complexity of managing your heterogeneous storage environment by centralizing, simplifying, automating, and optimizing storage tasks that are associated with storage systems, storage networks, replication services, and capacity management. Tivoli Storage Productivity Center is designed to improve your storage TCO and ROI by combining the assets, capacity, performance, and operational management that are traditionally offered by separate storage resource management, SAN management, and device management applications into a single platform.

Key features of Tivoli Storage Productivity Center are as follows:

- Centralized storage management
  Tivoli Storage Productivity Center offers centralized, integrated, role-based management capabilities to monitor and manage storage resources, and their metrics. Tivoli Storage Productivity Center automates the gathering of management information and reporting on capacity and storage assets. It helps you to manage your entire data center from one single user interface, which reduces the total administrator effort needed. Figure 3-15 on page 61 shows the Storage Systems panel of Tivoli Storage Productivity Center, which gives the storage administrator an overview of all storage systems that are managed by Tivoli Storage Productivity Center, their status, and capacity metrics. Similar panels are available, for servers, fabrics, switches, and hypervisors, for example.
Heterogeneous device support

Tivoli Storage Productivity Center provides a broad platform coverage of storage systems, servers, operating systems, and databases. It supports IBM and many other popular storage devices that are supported by Storage Management Initiative Specification (SMI-S). With this heterogeneous device support, you can reduce the number of storage management products that are needed to manage storage from separate vendors. It also helps you to prepare for virtualization of tiered storage by visualizing files and databases in the storage environment at capacity levels.

Performance monitoring

Tivoli Storage Productivity Center helps you to manage performance and connectivity from the host file system to the physical disk, including in-depth performance monitoring and analysis on SAN fabric performance. You can quickly identify bottlenecks in your SAN environment to maintain your service-level agreements.

Environment monitoring

Tivoli Storage Productivity Center discovers new storage resources and collects information about all storage resources within your SAN in its DB2 database to help you to stay environment-aware. The advanced change management features help you quickly identify changes that have occurred within your SAN topology. Tivoli Storage Productivity Center alerting capabilities speed the identification of failures by automatically alerting “out of line” conditions. You can also define and receive alerts for threshold levels on a wide range of performance parameters. Figure 3-16 on page 62 shows the details of a missing volume alert in Tivoli Storage Productivity Center.
Complete provisioning

Tivoli Storage Productivity Center offers wizard-based experience for full provisioning tasks, also including performance-based recommendations. It allows both the immediate or schedule-based execution of the provisioning tasks to give you a greater flexibility. In addition, Tivoli Storage Productivity Center provides a comprehensive, feature-rich command-line interface (CLI) to support script-based provisioning activities.

Enterprise reporting

Tivoli Storage Productivity Center collects a wide range of information from the storage environment that it is monitoring, which helps you to view and understand performance, capacity, utilization, and availability metrics for your entire infrastructure. All collected data is stored in a central DB2 repository database. Tivoli Storage Productivity Center uses the powerful capabilities of the IBM Cognos® reporting engine to provide standard and customized reports on demand or on a scheduled basis.

Based on Cognos, Tivoli Storage Productivity Center provides the most relevant reports, but you can easily define your own reports on the Tivoli Storage Productivity Center data and also integrate data from other sources. Figure 3-17 on page 63 shows a predefined Volume Space Report, created by the Cognos reporting engine. Historical views and reports for detailed trending help you to predict your future storage requirements. In virtualized SAN Volume Controller and Storwize V7000 Unified environments, storage tiering reports identify the hottest and coolest storage pools based on performance to assist you in retiering decisions.

In addition to the reporting capabilities provided by Cognos, Tivoli Storage Productivity Center allows you to directly access the data stored in the Tivoli Storage Productivity Center repository database in a read-only way through a set of database views. You can use these “Tivoli Storage Productivity Center reporting views” to create your own reports by using other database reporting tools or to include Tivoli Storage Productivity Center data into your own applications.
Most storage products support many of the functions described in this chapter and Tivoli Storage Productivity Center is a good example of a storage management product that has various storage management functions like management, provisioning, reporting, interfaces to other products. vSphere Web Client extension for Tivoli Storage Productivity Center is one of those features that fits into storage management, provisioning, and reporting areas.

vSphere Web Client extension for Tivoli Storage Productivity Center

With the vSphere Web Client extension for Tivoli Storage Productivity Center, virtual storage can be managed in a vSphere environment. The vSphere Web Client extension can be used to complete provisioning tasks and to view information about storage resources in the vSphere Web Client. Provisioning storage and storage reports are key aspects of the vSphere Web Client extension for Tivoli Storage Productivity Center:

Provisioning storage in the vSphere Web Client extension

The vSphere Web Client extension can provision storage capacity on storage systems that are monitored by Tivoli Storage Productivity Center. You can provision file and block storage and use the service classes and capacity pools created in Tivoli Storage Productivity Center. Additionally, data stores can be created on storage volumes.

Viewing storage reports in the vSphere Web Client extension

The vSphere Web Client extension can be used to view information about the storage systems that are monitored by Tivoli Storage Productivity Center. Following are some of the views:

- The mapping of your virtual storage resources to storage systems that are monitored by Tivoli Storage Productivity Center.
- The metrics for your storage systems.
- The information about the fabric that is connected to a storage adapter.

From the storage reports, you can click links to open the resources in the Tivoli Storage Productivity Center web-based GUI.
IBM SmartCloud Virtual Storage Center

IBM SmartCloud Virtual Storage Center (VSC) is both a storage virtualization platform and a storage management solution. It provides the following features:

- Analytics-based tiered storage optimization that automatically moves data to the most cost-effective tier.
- Software Defined Storage that is dynamic, service-oriented, and cost effective.
- Built in efficiency capabilities to prevent complex integration issues and reduce the need for purchasing add-ons.
- Near-instant backup and restore capabilities that protect data without impacting application performance.
- Simplified visual administration tools including an advanced GUI and a VMware vCenter plug-in.

Note: IBM SmartCloud Virtual Storage Center Entry V5.2 can be used with two or fewer SAN Volume Controller I/O groups, thereby consisting of up to four machine type 2145 hardware engines for up to 250 TB of managed capacity.

IBM SmartCloud Virtual Storage Center for Storwize Family V5.2 can be used with Storwize family hardware engines providing the data storage virtualization, such as a Storwize V7000 control enclosure, with no restrictions on the quantity of I/O groups.

All of the same functions in SmartCloud Virtual Storage Center V5.2 are available in the IBM SmartCloud Virtual Storage Center Entry V5.2 and IBM SmartCloud Virtual Storage Center for Storwize Family V5.2.

The following three components are included in the solution:

**IBM Tivoli Storage Productivity Center**

Storage resource management and SAN fabric management software, including advanced functions such as storage planners, change management tracking, best practices gauge, file system scanning, disk optimizer, and IBM Tiered Storage Optimizer.

**IBM System Storage SAN Volume Controller**

Storage virtualization software core components: Includes Easy Tier, Metro/Global Mirror, and thin provisioning.

**IBM Tivoli Storage FlashCopy Manager**

Snapshot management and recovery software: Includes support for IBM and NetApp application-aware snapshots.

IBM SmartCloud Virtual Storage Center is efficient by design, self-optimizing, and cloud agile.

**Efficient by design**

IBM SmartCloud Virtual Storage Center has built-in efficiency features that help users avoid the need to purchase add-ons or additional licenses, or to deal with complicated integration issues. The following advanced efficiency features are included:

- Storage virtualization
- Advanced, easy-to-use GUI
- Thin provisioning
- Efficient remote mirroring
Storage virtualization using VSC allows you to virtualize storage resources from multiple arrays and vendors. Pooling storage devices allows you to access capacity from any storage system, a significant advantage over the limitations inherent in traditional storage.

**Self-optimizing**
Self-optimizing storage adapts automatically to workload changes to optimize application performance, eliminating most manual tuning efforts. The IBM SmartCloud Virtual Storage Center includes the following self-optimizing features:

**IBM Storage Analytics Engine**
IBM SmartCloud Virtual Storage Center uses performance metrics and advanced analytics to make storage tier recommendations. It enables storage tiering decisions to be made based on actual usage patterns, rather than on predictions. Data migration is simple and does not disrupt users or applications. This technology can reduce the unit cost of storage by as much as 50%, which is based on deployment in a large IBM data center.

**IBM System Storage Easy Tier**
IBM SmartCloud Virtual Storage Center implements flash optimization with this premier technology for automated tiering of critical data. 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.

**Cloud agile**
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 turn your 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. The following features make this agility and adaptability possible:

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

**Self-service portal**
SmartCloud Virtual Storage Center can provide provisioning automation for self-service storage portals. This enables immediate responses to service requests while eliminating manual administration tasks.

**Pay-per-use invoicing**
SmartCloud Virtual Storage Center integrates with SmartCloud Cost Manager, which is an optional chargeable product, and other chargeback systems to enable flexible usage accounting for storage resources. VSC can become the single source for usage metrics across SAN storage systems, network-attached storage, and direct-attached storage.
3.3.4 Automated provisioning

Storage provisioning in SAN environments has long been done manually. Given a storage provisioning request with capacity requirements and expected workload for the storage, administrators attempt to determine the best storage system, storage pool, and optimized storage configuration parameters. This analysis can be extremely complex depending upon the type of storage and also workload characteristics. Automated provisioning helps the storage administrator to consider all important factors and performs all required configuration tasks across the SAN in an automated manner.

IBM SmartCloud Storage Access

Growing data storage demands coupled with shrinking or nearly flat IT budgets place extraordinary pressure on IT managers. Many organizations see cloud as a way to deliver storage services more effectively while saving both time and cost, since cloud environments can support new ways to make storage solutions more efficient and agile.

IBM offers SmartCloud Storage Access (SCSA), an easy-to-deploy, simple-to-use software solution that features a self-service portal for storage provisioning, monitoring, and reporting. It is designed to provide users with a self-service file-serving facility over the Internet. With a few clicks, users can create an account, provision storage, and start uploading files.

Following are the SCSA highlights for storage management:

- Quickly implement a private cloud storage service
- Provision storage capacity on demand
- Easily store and access files
- Offer simple reporting, monitoring, and chargeback services
- Improve overall IT efficiency and service quality
- Increase user and administrator productivity
- Deploy with selected IBM SAN and network-attached storage (NAS) storage infrastructures
- Enable third-party developers to integrate applications using top-level Representational State Transfer (REST) application programming interface (API)

Figure 3-18 on page 67 illustrates the SCSA deployment architecture.
The three words that matter the most to any enterprise are *reduce, reuse, and recycle*. These words hold true for an SCSA-based private cloud deployment because the enterprises can perform these functions:

- Reduce administrator overhead, operational costs, and provisioning turn-around time.
- Reuse existing infrastructure components like NTP Server, DNS, SMTP server, and storage systems.
- Recycle unused or under utilized storage space and hence ensure optimal consumption.

The deployment architecture has SCSA working with IBM Tivoli Storage Productivity Center, which is the storage manager to provision and de-provision storage resources that are called *Network Drives*. IBM Tivoli Storage Productivity Center plays a major role in understanding the resource request from SCSA and actualizing the resource provisioning. A network drive that a user requests may be a file space or a block storage drive. The basic difference between file and the block storage is the medium of access along with the protocol. Typically file storage can be accessed over Ethernet network through network sharing protocols like NFS or CIFS. Block storage access requires Fibre Channel resources like a Fibre Channel network and supported Fibre Channel access mediums on the access end points.

In a typical IT enterprise, block storage serves space requests for physical or virtual servers. File storage can be consumed across server class machines as well as workstations through commonly available Ethernet channels.
SCSA acts as a user or administrator interface to storage resource requests and also as a policy management system. In other words, by deploying an SCSA-based private storage cloud, an IT enterprise can look to get away from the independent resource request tools, following complex security processes for provisioning, and legacy methods of metering. SCSA can bring a reduction of administrator overhead resulting in faster turn-around time to achieve rapid provisioning.

**Tape tier in the cloud:** IBM Systems and Technology Group (STG) Lab Services developed a customized adapter for SCSA that is able to support other storage, such as General Parallel File System (GPFS). IBM Linear Tape File System™ Enterprise Edition (LTFS EE) is based on GPFS and provides hierarchical storage management, so the adapter lets SCSA and LTFS EE work together, with SCSA focusing on storage provisioning and LTFS EE focusing on data migration to tapes for long-term retention.

Combining the SCSA ease of use for storage cloud management and the seamless integration of LTFS with GPFS for a low-cost, scalable storage tier, increases the storage cloud value by adding a tape tier to address business requirements for data archival.

Refer to *Adding an IBM LTFS EE Tape Tier to an IBM SCSA Managed Storage Cloud* at the following website:


**IBM Tivoli Storage Productivity Center**

Tivoli Storage Productivity Center offers the SAN Planner that assists the storage administrator in end-to-end planning that involves fabrics, hosts, storage controllers, storage pools, volumes, paths, ports, zones, zone sets, storage resource groups (SRGs), and replication. The SAN Planner utilizes collected current and historical performance data and also accurate analytical models for subsystem devices to identify the best configuration for new storage. Three SAN configuration planners are specifically designed to assist with recommending storage configuration changes based on new workloads being added, taking into consideration the current workloads, available capacity, best practices, and accurate device models:

- **Volume Planner**
  
  The Volume Planner helps administrators plan for the provisioning of system storage that is based on capacity, compression, SSD use, storage controller type, number of volumes, volume size, performance requirements, RAID level, performance utilization, and capacity utilization. It supports virtualization and also thin provisioning.
  
  Volume planning can be done with replication planning, or replication can be extended for existing storage volumes.

- **Zone Planner**
  
  The Zone Planner enables the administrator to plan for zoning and LUN masking configuration based on the following information: Host ports, storage controller ports, zones, zone sets, switches, user zoning input, user LUN masking input, existing LUN masking or mapping. The Zone Planner uses best practices in providing its recommendations.

- **Path Planner**
  
  The Path Planner enables system administrators to plan and implement storage provisioning for hosts and storage systems with multipath support in fabrics managed by Tivoli Storage Productivity Center. The Path Planner selects paths using a combination of best practices and port-level performance data.
These planners can be started either separately or together in an integrated manner. After you have the SAN Planner’s recommendation, also called planner output, you can review the plan and then choose to execute it, in which case the planner will create a job to make the changes in the environment that is based on the plan output. Alternatively, you can vary the input provided to the SAN Planner to get multiple possible solutions.

**IBM Tivoli Service Automation Manager**

IBM Tivoli Service Automation Manager manages the cloud services lifecycle and delivers request-driven provisioning of virtual machines for cloud environments. As Figure 3-19 on page 69 shows, Tivoli Service Automation Manager takes advantage of the integration of various components:

- The Web 2.0 User Interface (UI) provides cloud service consumers with on-demand self-service access to the service catalog set up by their cloud service provider.
- IBM Tivoli Service Request Manager® implements the service catalog and the approval workflows related to service request management.
- IBM Tivoli Provisioning Manager provides the automation engine that is needed to implement provisioning, management, and deprovisioning of cloud resources, including hardware servers, networks, operating systems, middleware, and application-level software.
- *Tivoli’s process automation engine* provides the underlying platform for process management.
- The administration UI, available as part of Tivoli’s process automation engine platform, provides the tools for the administration and configuration of all components.

As highlighted in Figure 3-19, Tivoli Service Automation Manager supports several server virtualization technologies. It also provides a reservation feature that allows cloud server consumers to schedule the usage of needed resources so that they cannot be requested by others.
Tivoli Service Automation Manager and Extension for Network-Attached Storage

With the Extension for Network-Attached Storage, Tivoli Service Automation Manager uses the storage management capabilities of Tivoli Storage Productivity Center (see “IBM Tivoli Storage Productivity Center” on page 60) to provide service offerings to provision and manage the entire lifecycle (storage as a service, or SaaS) of storage from filers such as Scale Out Network Attached Storage. The service provider uses Tivoli Storage Productivity Center to define the set of storage service classes and levels to be offered, and the physical storage systems environment.

Those storage systems can be logically grouped in “Cloud Capacity Pools” in Tivoli Storage Productivity Center (Figure 3-20), which are listed as “Storage Pools” in Tivoli Service Automation Manager.

![Edit Storage Resource Group](image)

Figure 3-20  A Cloud Capacity Pool in Tivoli Storage Productivity Center, containing two SONAS filers

When cloud service consumers request a storage service in Tivoli Service Automation Manager, they can choose between all available service classes and can select the Storage Pools to be used for the storage allocation. The provisioned storage is organized in Storage Projects, which are independent from the lifecycle of provisioned virtual machines (VMs) within Server Projects.
Chapter 3. What enables a smart storage cloud

3.3.5 Service management

The ability to provide services within a dynamically changing and highly competitive environment is becoming more critical than before because of multiple factors:

- The growing demand for quick and easy access to IT services
- The need to be more responsive to change requests and provide better availability of services
- The need to maximize the use of current IT investments

A cloud service delivery platform offers the promise of multiple benefits, including improved service delivery, greater efficiency, and reduced overall IT costs.

IBM Service Delivery Manager

The IBM Service Delivery Manager is a pre-integrated software stack, deployed as a set of virtual images that automate IT service deployment and provide resource monitoring and cost management in a cloud. The preintegrated and preconfigured software solution provides a service delivery platform for cloud environments built on proven reliable software components such as IBM Tivoli Service Automation Manager, IBM Tivoli Usage and Accounting Manager, IBM Tivoli Monitoring, IBM Tivoli Service Automation, IBM Systems Director, and VMControl. The virtual images can be easily deployed on your existing hardware environment achieving both rapid time to value and strong return on investment.
IBM Service Delivery Manager is a cloud management platform that enables the data center to accelerate the creation of service platforms for a wide spectrum of workload types with a high degree of integration, flexibility, and resource optimization with these core service management capabilities:

- A self-service portal interface for in-advance computing reservations of virtualized environments, including storage, and networking resources
- Automated provisioning and de-provisioning of resources
- Real-time monitoring of physical and virtual cloud resources
- Integrated usage and accounting chargeback capabilities that can help system administrators to help, track, and optimize system usage
- Built-in high availability of the cloud management platform
- Prepackaged automation templates and workflows for most common resource types
- Can leverage existing hardware for the cloud infrastructure

3.4 Security and data protection

Organizations today demand that their data is protected from corruption and loss, whether by accident or intent. This section highlights the security and data protection mechanisms available within storage clouds, and their relevance to providing the data integrity, which businesses have come to expect.

3.4.1 Backup and disaster recovery

Despite rapid data growth, data protection and retention systems are expected to maintain service levels and data governance policies. Data has become integral to business decision-making and basic operations, from production to sales and customer management. Data protection and retention are core capabilities for their role in risk mitigation and for the amount of data involved.

The storage environment offers three functions that improve efficiency and effectiveness of data protection and retention:

- Backup and recovery
  Provides cost-effective and efficient backup and restore capabilities, improving the performance, reliability, and recovery of data in respect to SLAs. Backups protect current data and they are unlikely to be accessed unless data is lost.

- Archiving
  Retains data that has long-term data retention requirements, either for compliance or business purpose, by providing secure and cost effective solutions with automated process for retention policies and data migration to different storage media.

- Continuous data availability
  Ensures uninterrupted access to data for critical business systems, reducing the risk of downtime providing capability to fail over transparently and as instantaneously as possible to an active copy of the data. The total mirroring strategy needs to be automated to ensure automated failover and then an appropriate automated fail-back.

Optimizing all of these areas helps an organization deliver better services with reduced application downtime. Data protection and retention, archiving, and continuous data availability can improve business agility by ensuring that applications have the correct data
when needed, while inactive data is stored in the correct places for the correct length of time. This way means that the data protection functions must be application aware.

**IBM Tivoli Storage Manager**

The IBM Tivoli Storage Manager is a family of products that helps the management and control of the “information explosion” by delivering a single point of control and administration for storage management needs by providing a wide range of data protection, recovery management, movement, retention, reporting, and monitoring capabilities using policy-based automation.

Tivoli Storage Manager enables data protection from failures and other errors by storing backup, archive, space management, and “bare-metal” restore data and also compliance and disaster-recovery data in a hierarchy of auxiliary storage. Tivoli Storage Manager can help protect computers that run various operating systems, on various hardware platforms and connected together through the Internet, wide area networks (WANs), local area networks (LANs), or storage area networks (SANs). It uses web-based management, intelligent data move-and-store techniques, and comprehensive policy-based automation that are working together to help increase data protection and potentially decrease time and administration costs.

The progressive incremental methodology used by Tivoli Storage Manager backs up only new or changed versions of files, thereby greatly reducing data redundancy, network bandwidth, and storage pool consumption as compared to traditional methodologies.

**Products:** See the updated list of available products of the Tivoli Storage Manager Suite: http://www.ibm.com/software/tivoli/products/storage-mgr

Table 3-1 lists the main features, advantages, and benefits offered by the Tivoli Storage Manager family.

<table>
<thead>
<tr>
<th>Features</th>
<th>Advantages</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backup and recovery management</td>
<td>Intelligent backups and restores utilizing a progressive incremental backup and restore strategy, where only new and used files are backed up</td>
<td>Centralized protection based on smart-move and smart-store technology leading to faster backups and restores with less network and storage resources needed</td>
</tr>
<tr>
<td>Hierarchical storage management</td>
<td>Policy-based management of file backup and archiving</td>
<td>Ability to automate critical processes relating to the media on which data is stored while reducing storage media and administrative costs associated with managing data</td>
</tr>
<tr>
<td>Archive management</td>
<td>Managed archives</td>
<td>Ability to easily protect and manage documents that need to be kept for a certain period</td>
</tr>
<tr>
<td>Advanced data reduction</td>
<td>Combines incremental backup, source and target data deduplication, compression, and tape management to provide data reduction</td>
<td>Reduces the costs of data storage, environmental requirements, and administration</td>
</tr>
</tbody>
</table>
Tivoli Storage Manager in an OpenStack environment

Tivoli Storage Manager can protect data that is hosted in an OpenStack environment and it can use the OpenStack (Swift) environment as a repository for backup and archive objects. Figure 3-22 shows a Tivoli Storage Manager agent deployed within a VM guest.

Figure 3-22  Tivoli Storage Manager protecting data hosted in an OpenStack environment

Figure 3-23 on page 75 illustrates Tivoli Storage Manager using the OpenStack (Swift) environment as the repository for its backup and archive objects. Implementing Tivoli Storage Manager using OpenStack Swift as the repository requires the use of cloud gateways that support Swift.
IBM Tivoli Storage FlashCopy Manager

IBM Tivoli Storage FlashCopy Manager is a package that fully integrates with IBM System Storage products. Tivoli Storage FlashCopy Manager uses storage snapshot capabilities to provide high speed, low impact application integrated backup and restore functionality for the supported application and storage environments. IBM Tivoli Storage FlashCopy Manager includes all the function needed to execute application-aware snapshot protection. Automated policy-based management of multiple snapshot backup versions together provide a data protection solution that enables the most stringent database recovery time requirements.

Because a snapshot operation typically takes much less time than the time for a tape backup, the window during which the application must be aware of a backup can be reduced. This snapshot operation facilitates more frequent backups and increases the flexibility of backup scheduling. Furthermore, application availability is significantly improved because of the reduction of the load on the production servers.

Tivoli Storage FlashCopy Manager uses the incremental FlashCopy backup capabilities of the IBM System Storage DS8000®, IBM System Storage SAN Volume Controller, and IBM Storwize V7000 Unified to provide application-consistent protection of critical data, enabling faster, more reliable recoveries. Tivoli Storage FlashCopy Manager works with any of the
storage devices that can be virtualized under SAN Volume Controller and will automatically detect snapshot deletions that are done outside of Tivoli Storage FlashCopy Manager.

When used with IBM XIV Storage System, FlashCopy Manager similarly uses XIV's highly efficient, auto-provisioned snapshots.

The snapshots that are captured by Tivoli Storage FlashCopy Manager can be retained as backups on local disk. Through optional integration with Tivoli Storage Manager, you can use the full range of advanced data protection and data reduction capabilities, such as data deduplication, progressive incremental backup, hierarchical storage management, and centrally managed policy-based administration.

**IBM Tivoli Storage Productivity Center for Replication**

Storage replication management, especially in the instance where thousands of volumes of data must be replicated across multiple sites, can be a complex task. In large storage environment replication, technology is varied, providing multiple options for how and when to replicate data.

IBM Tivoli Storage Productivity Center for Replication helps to manage the storage advanced copy services (synchronous and asynchronous replication, snapshot, and FlashCopy) and establishes replication management through one single interface.

It simplifies the management of advanced copy services:

- Automates administration and configuration of these services with wizard-based session and copy set definitions.
- Provides simple operational control of copy services tasks, including starting, suspending, and resuming.
- Offers tools for monitoring and managing copy sessions.

It helps to manage data availability and resiliency and sustain business continuity:

- Reduces application outages that are caused by backups and other data copy activities.
- Preserves an up-to-date copy of the primary location data at a remote site.
- Maintains data currency at a remote site within a few seconds of the data to be written at the local site, regardless of distance.
- Gives users access to critical information during both planned and unplanned local outages.

### 3.4.2 Multitenancy

The term *multitenancy* refers to an architecture that is typically used in cloud environments. Instead of providing each cloud service consumer (tenant) a separate, dedicated infrastructure (single-tenancy architecture), all consumers share one common environment. Shared layers must behave as though they were set up in a dedicated fashion in terms of customization, isolation, and so on.

A cloud environment has two primary technology stacks were multitenancy is relevant:

- The management environment (cloud management stack)
- The managed environment (infrastructure, platform, or application that is provided as a service)
Depending on the service model, the level and degree of shared infrastructure varies as illustrated in Figure 3-24. For infrastructure as a service (IaaS), typically hypervisors are installed on the managed hardware infrastructure; for platform as a service (PaaS), there is a multitenancy-enabled middleware platform; and for software as a service (SaaS), the multitenancy-enabled software application is divided into virtual partitions.

Multitenancy in cloud service models implies a need for policy-driven enforcement, segmentation, isolation, service levels, and chargeback billing models, because multiple service consumers are using a shared infrastructure. Service consumers can be either distinct organizations in a public cloud service or separate business units in a private cloud service. All cloud service consumers want to ensure that, although from a physical perspective they are sharing the same infrastructure, from a logical perspective they are isolated without risk to sensitive data or their workloads.

Multitenancy offers several main benefits:

- Can quickly scale to additional tenants.
- Is cost-effective because the infrastructure is shared by all tenants.
- Has less overhead than a virtualized or mediated approach.
- Requires less storage.

**IBM Tivoli Service Automation Manager**

Tivoli Service Automation Manager (see “IBM Tivoli Service Automation Manager” on page 69) allows service providers to create cloud environments that can be used by multiple customers (multitenancy). Its main strength is data segregation: Teams of users are assigned to a customer and, although a single cloud can support multiple customers, each user sees only the objects that are associated with the customer that he or she is assigned to. In this way, resources can be used more efficiently. Customers can share the same set of servers, storage, and network resources, or be assigned to different physical resources.

Furthermore, the cloud service provider can assign quotas to each cloud service consumer to define limits on the usage of specific resource pools. These limits define the amount of resources that can be requested by an individual cloud service consumer, such as the
amount of storage, memory, physical CPU, and disk. If service requests are submitted that involve modification of resources or reservation time, the framework checks whether the quotas in the requested pool allow for request processing.

Multitenancy, as provided by Tivoli Service Automation Manager, does not only make sense for cloud service providers that are addressing external customers, but it can be also used by enterprises to effectively model different groups of internal customers and lines of businesses.

**IBM Scale Out Network Attached Storage and IBM Storwize V7000 Unified**

Scale Out Network Attached Storage and Storwize V7000 Unified provide several features that can be used to support scenarios where multiple tenants, such as separate departments, can share the large amount of file type storage:

- **Security**
  - Authentication: Scale Out Network Attached Storage and Storwize V7000 Unified connect to a single, trusted authentication source that can be either Active Directory or Lightweight Directory Access Protocol (LDAP). A “proxy” concept can be used to connect to multiple Active Directory servers without the need to create a forest. This allows different tenants such as different departments to use their own, isolated user directories. Figure 3-25 on page 79 illustrates the proxy configuration with multiple Active Directory servers.
  - Authorization: The access control lists (ACLs) that are used to store common permission attributes for NFS and CIFS are the baseline for consistent mappings across all platforms.
  - Audit logging: Scale Out Network Attached Storage and Storwize V7000 Unified support audit logging for all CLI and GUI commands.

- **Separation of data**
  - Hardware separation: Physical storage is organized in storage pools that allow a separation on the hardware level.
  - Logical separation: From a flexibility perspective, logical separations are far superior from physical separation. Dynamic allocation from a common physical hardware pool to logical entities allows quota-based over-provisioning, and also small step-expansion.
Utilization and chargeback

- Accounting: Scale Out Network Attached Storage and Storwize V7000 Unified allow reporting on these levels: user, group, share (if created as file set), and file system.
- SLA restrictions: Dedicating physical components to individual users can be used for mitigation. For example, assigning a limited number of physical ports to certain servers will throttle the bandwidth that becomes available to those servers. Creating dedicated file systems and file sets on dedicated storage pools can restrict the disk performance that is available.

3.4.3 Antivirus

NAS systems are designed to serve many users connecting to them using various file-based protocols, such as NFS or CIFS. The integrity of data that is created or accessed by using these protocols is potentially vulnerable to threats that might exist in an enterprise network environment, such as viruses, worms, Trojan horses, and other forms of malware. Computer viruses mostly target Microsoft operating systems. However, computers running other operating systems can be directly or indirectly affected by viruses. An antivirus solution, which works directly with your NAS system, helps you to effectively protect your data against those threats.

IBM Scale Out Network Attached Storage and IBM Storwize V7000 Unified

Both IBM Scale Out Network Attached Storage and IBM Storwize V7000 Unified systems include an AVB connector, which communicates with independent software vendor (ISV) scan engines by using Internet Content Adaptation Protocol (ICAP). The following two virus scanning modes are supported by Scale Out Network Attached Storage and Storwize V7000 Unified:

- On-access scan

  With the on-access scan, files are scanned immediately when they are either accessed or created. This method has the benefit of ensuring that the files are scanned with the latest
virus signature before they are being accessed. If scanning discovers malware, the file is
quarantined and repaired. The clean file is then sent to the Scale Out Network Attached
Storage and Storwize V7000 Unified where it replaces the infected file in storage before
access is granted to users. Only the repaired file is passed to the requesting user. The
on-access scan is more effective at detecting viruses before they are able to compromise
data. This method does not generate heavy network traffic between Scale Out Network
Attached Storage and Storwize V7000 Unified and the antivirus scan engines. The
antivirus connector caches antivirus scan attributes and time stamps for each file to be
used later in determining whether the file must be scanned or rescanned. If no new virus
signatures are released since the file was previously scanned, the system does not scan
again, enhancing performance. When new antivirus definitions are received and updated,
each file is rescanned before it is made available to the user requesting access.
On-access scan is available for customers that use the CIFS protocol for accessing their
data.

- **Bulk scan**

  The bulk scan allows you to scan a specified set of files, file sets, or file systems at once.
  You can run a bulk scan either directly or at a user-defined schedule. Bulk scans can
  complement on-access scans and they are available regardless of which network access
  protocols are used to access the data.

Figure 3-26 shows the high-level stages of the file scanning process.

![File on-access scanning and infection repair](image)

### 3.4.4 Encryption

The primary security controls for restricting access to sensitive information that is stored on
user devices are encryption and authentication. Encryption can be applied granularly, such as
to an individual file containing sensitive information, or broadly, such as encrypting all stored
data. The appropriate encryption solution for a particular situation depends primarily on the
type of storage, the amount of information that needs to be protected, the environments
where the storage will be located, and the threats that need to be mitigated.
Encryption is a technique that is used to encode data with an encryption key in such a way that the information content of the data can be decoded only with knowledge of a decryption key. Data that is encrypted is referred to as ciphertext. Data that is not encrypted is referred to as plaintext or cleartext. With an appropriately derived encryption key and an appropriate encryption algorithm, guessing the decryption key is prohibitively difficult. Data that is encrypted into ciphertext is considered securely secret from anyone who does not have possession of the decryption key.

Organizations need to consider the security of backups of stored information. Some organizations permit users to back up their local files to a centralized system. Other organizations recommend that their users do local backups. In this case, organizations should ensure that the backups are secured. Securing can be done with similar controls, such as encrypting the backups, or with various types of controls, such as storing backup tapes in a physically secured room.

**DS8000 disk encryption**

Self-encrypting drives protect and secure enterprise information from external and internal threats. The DS8000 (DS8700, DS8800, DS8870) disk system supports data encryption with the IBM Full Disk Encryption (FDE) drives. All disks in the DS8000 must be FDE drives; no intermix is allowed.

If a drive gets lost or stolen, storage encryption renders data inaccessible. IBM Full Disk Encryption also provides a simpler and more cost-effective method to remove sensitive data from systems that are being retired or repurposed through a cryptographic erasure. Full Disk Encryption drives are standard on every DS8870 system.

These disks have encryption hardware, and can perform symmetric encryption and decryption of data at full disk speed with no impact on performance. Self-encrypting drives and standards-based key manager provide advanced protection of data at rest.

The disk encryption hardware is used with Security Key Lifecycle Manager (formally Tivoli Key Lifecycle Manager). Security Key Lifecycle Manager uses a wrapped key method to deliver keys to encrypting storage devices. The IBM DS8000 implements this wrapped key method to secure keys by separating the storage of a wrapped data key that is stored within the device from the storage of the wrap and unwrap keys within the key server. The wrap and unwrap keys are also referred to as the key encryption and key decryption keys. Without the keys that are managed by Security Key Lifecycle Manager, the customer will not be able to decrypt the data on disk. The customer can no longer decrypt the data on disk.

**IBM Tivoli Storage Manager encryption**

Tivoli Storage Manager client data encryption is the ability to encrypt the actual data file payload for a backup, archive, restore, or retrieve session. The encryption and decryption is done on the client, and all data that is transferred between client and Tivoli Storage Manager server is kept in encrypted cypher text for added protection. For the backup/archive client, neither the encryption key or the encryption key password is ever sent to the Tivoli Storage Manager server.

For the Tivoli Storage Manager API client, transparent encryption is also available. When you use this option, the encryption key is sent to the Tivoli Storage Manager server (the encryption key is itself encrypted) and is stored on the Tivoli Storage Manager server.

Authentication traffic between the client and server is encrypted during session setup by default for backup/archive and API client nodes and it cannot be disabled. Data traffic for a file backup/archive session is unencrypted by default, but encryption can be enabled easily.
The primary advantage of client-side encryption is that the data that is sent to the Tivoli Storage Manager server is encrypted, and therefore protected from packet sniffers, before it leaves the client host.

**IBM tape and virtual libraries**

Tape continues to be the most cost-effective, flexible, and scalable medium for high-capacity storage for backup and archiving. Its unique attributes can help management of storage requirements and contribute to the value of tape in the storage hierarchy. Tape is a key element in reducing overall storage costs. Tape is secure, removable, scalable, portable, reliable, and fast.

Tape can help address compliance requirements with encryption and Write Once Read Many (WORM) solutions.

IBM high capacity, high performance tape, and virtual tape offerings can reduce back up windows and allow consolidation of more data onto fewer cartridges. Virtual tape with deduplication can reduce capacity requirements. Tape uses less energy than disk and is a good choice for long-term data retention. Tape automation and virtualization can simplify management and reduce infrastructure requirements.
What does IBM offer for storage cloud

IBM is a proven leader in partnering with clients worldwide to collaborate in solving business problems through the implementation of world class, smart information technology solutions. From hyper-efficient storage arrays and massively scalable virtualization engines to smarter infrastructure management software to comprehensive implementation and operational services capabilities, the IBM portfolio of smart storage cloud capabilities is unmatched in the industry.
4.1 IBM XIV Storage System

The IBM XIV Storage System is a high-end fully scalable general-purpose disk storage system with a design that is an ideal match with cloud delivery models. It offers an outstanding virtualized grid design, which allows massive parallelism that allocates system resources evenly always, and scales performance with capacity, and therefore transparently providing elasticity, which is essential for cloud implementations.

In a cloud environment, workloads can and do spike and change significantly, in response to cloud elastic demand. The XIV distributed grid architecture automatically balances all storage workload evenly across all XIV components, thus providing a guarantee of consistent performance even under the most dynamically changing of environments. This is exactly what is needed in a dynamic, elastic cloud workload environment.

The XIV series offers highly affordable storage to satisfy even the most demanding and changing workloads while providing both high performance and high reliability. The system scales seamlessly without the need for complex, time-consuming tuning, provisioning, or configuration.

IBM XIV system highlights
IBM XIV storage is a keystone in the comprehensive private cloud offering by IBM, providing the features to help you start building your smart storage cloud environment. It provides exceptional levels of integration with cloud platform technologies, such as IBM Scale Out Network Attached Storage or IBM Storwize V7000 Unified, and also IBM Tivoli products.

IBM XIV can provide you with the following features:

- Effective resource sharing
- Virtualization of demanding dynamic environments
- Minimal management to save time and effort

Tip: For more information, see the IBM XIV Storage System series web page:

http://www.ibm.com/systems/storage/disk/xiv

Effective resource sharing
XIV storage provides consistent and predictable performance for heterogeneous workloads that allows the sharing of storage resources without impact across users. The XIV system supports a wide range of simultaneous workloads, from capacity-hungry to ultra-high performance. These features translate into more effective resource consolidation and reliable scalability. The XIV quality of service (QoS) feature places bandwidth limits on each storage volume to ensure that extreme loads on some volumes do not starve or degrade performance for others. Enabling total customer control over QoS parameters, XIV storage simultaneously supports multiple levels of service, promoting effective and efficient managed services for storage. IBM XIV architecture also enables tier 1 storage performance by using commodity disk drives. To provide that performance, XIV system provides “motionless” storage tiering, a highly efficient virtual storage prioritization without the need to copy or move data.

Virtualization of demanding dynamic environments
The XIV architecture inherently lends itself to optimizing server-storage environments. The XIV Storage System provides best-in-class virtual storage architecture for virtual servers. The combination of its optimal resource use and hotspot-free server-storage performance makes for exceptional synergy with the VMware or Hyper-V server infrastructure and products. To keep pace with dynamic cloud demands, the cloud environment needs to enable the provisioning of fully functional virtual machines in a short amount of time. The virtual machine
must include the operating system and business applications installed and ready to go. XIV Volume Copy instantaneously creates a full volume replica. By cloning a template volume previously installed, XIV storage enables immediate provisioning of virtual machines and applications.

**Minimal management to save time and effort**

In platform as a service (PaaS) and infrastructure as a service (IaaS) cloud models, the cloud provider typically does not have visibility into the specific usage of the storage or business application. Therefore, the provider cannot tune storage for specific application needs, fluctuations in demand, or other variables, which can cause suboptimal application performance. The autonomic XIV Storage System is always optimally tuned by design; it automatically maintains optimal performance with no tuning or management throughout an application’s lifetime, regardless of workload growth or fluctuation.

The XIV Storage System can provision and decommission storage almost instantly with no configuration effort, making storage immediately available to new and existing virtual machines in the cloud, while automatically ensuring optimal storage array load balancing. It also allocates data using thin provisioning thus using the physical capacity only when the data is actually written. The XIV grid architecture is designed to handle rapidly evolving environments, retaining great performance and using storage capacity efficiently, and helping maximize effective resource usage.

**OpenStack device support for IBM XIV**

IBM has built and contributed the OpenStack Cinder block storage driver for XIV to the OpenStack community. This allows XIV to be the first enterprise class storage system to have OpenStack software support, allowing XIVs ease of use and fast time to implementation characteristics to be magnified by being able to be automatically managed and provisioned with the OpenStack environment.

The IBM Storage driver for OpenStack Cinder component, supports Folsom, Grizzly, and Havana releases, enables OpenStack clouds to be able to directly access and use the IBM XIV Storage System Gen3.
IBM has written and contributed OpenStack Cinder support for XIV. The OpenStack Cinder XIV management driver is able to control the creation and deletion of volumes on the XIV Storage System Gen3, and manage the attaching or detaching volumes from virtual machines (VMs) running in an OpenStack environment. The driver automatically creates the XIV host mappings on demand that are required to allow running VMs on OpenStack cloud software to access the storage volumes. Access to the XIV volumes is over an iSCSI connection protocol.

**Tip:** For more information about XIV in an OpenStack environment, see the IBM Redpaper publication REDP4971, “Using the IBM XIV Storage System in OpenStack Cloud Environments”, at the following website:

http://www.redbooks.ibm.com/abstracts/redp4971.html
4.2 IBM Storwize family

The IBM Storwize family consists of the IBM SAN Volume Controller, IBM Storwize V7000 and V7000 Unified, IBM Flex System® V7000 Storage Node, IBM Storwize V5000, and IBM Storwize V3700. Benefits of the Storwize family include high-performance thin provisioning, real-time compression, IP replication, Easy Tier, advanced GUI, and storage virtualization. This section highlights SAN Volume Controller, Storwize V7000, and V7000 Unified.

Ongoing IBM contributions to OpenStack Cinder for the Storwize family

The Storwize family, which includes SAN Volume Controller, supports:

- Folsom, Grizzly, Havana
- iSCSI or Fibre Channel
- Advanced Storwize features such as Real-time Compression and Easy Tier,
- Software defined placement via OpenStack filter scheduler
- Storage assisted volume migration (Storwize family is the only storage to support this function in Havana)

With the OpenStack Havana release, there is a new administrator feature for migrating volumes between cinder instances. Volumes can be migrated with Host Assisted Data Migration or by Storage Assisted Data Migration with the IBM Storwize family. Figure 4-2 lists the common use cases for migrating volumes.

Volume Migration in OpenStack Havana Release

Common use cases for migrating volumes:
- Storage evacuation – for maintenance or decommissioning
- Balance capacity and performance over multiple storage systems
- Move volume to a pool with specific characteristics

IBM Storwize family is the only storage in the Havana release to support storage assisted migration. Volumes move between two storage pools managed by a Storwize family system.

Key benefits to using the Storwize family storage assisted migration is:

- No interaction with the host, no impact on VM and Node
- Instantaneous - no restriction on VM operations or volume management

1 Not available with IBM Storwize V3700
IBM SAN Volume Controller
SAN Volume Controller is a storage virtualization system that enables a single point of control for storage resources to help support improved business application availability and greater resource utilization. The objective is to manage storage resources in your IT infrastructure and to make sure they are used to the advantage of your business, and do it quickly, efficiently, in real time, while avoiding increases in administrative costs.

IBM SAN Volume Controller can help you solve the problem of your storage requirements growing too fast, reduce the cost of managing that growth and making better use of your existing storage without adding complexity to your storage infrastructure.

**IBM SAN Volume Controller highlights**
Improving efficiency and delivering a flexible, responsive IT infrastructure are essential requirements for any cloud deployment. Key technologies for delivering this infrastructure include virtualization, consolidation, and automation. SAN Volume Controller provides these technologies to help you on your journey of building your storage cloud.

IBM SAN Volume Controller offers you the following features:
- Scalability and performance
- Enhanced data mobility and availability
- Simplified productivity

Figure 4-3 shows an overview of the IBM SAN Volume Controller architecture.

Details: A more detailed description of the features that the SAN Volume Controller provides are in “IBM Storwize Family: SAN Volume Controller” on page 41.
Scalability and performance
SAN Volume Controller combines hardware and software into an integrated, modular solution that is highly scalable. An I/O group is formed by combining a redundant pair of storage engines based on highly reliable hardware foundation designed to avoid single points of hardware failure. Scaling from a single I/O group up to four I/O groups allows you to support every small or large storage environment. With the introduction of solid-state drives (SSD), outstanding performance for critical applications can be delivered, as needed, without any disruptions.

SAN Volume Controller also includes the Easy Tier function designed to help improve the performance at lower cost through more efficient use of SSDs. SAN Volume Controller is designed to help increase the amount of storage capacity that is available to host applications by pooling the capacity from multiple disk systems within the SAN. This way helps you to reach beyond traditional islands of SAN storage and deploy storage in ways that can help best meet your storage cloud needs.

A performance dashboard provides access to key high-level real-time system performance information, which helps you monitor and optimize the virtualized environment. IBM Tivoli Storage Productivity Center provides analysis and access to historical performance data.

Enhanced data mobility and availability
Because it hides the physical characteristics of storage from host systems, SAN Volume Controller is designed to help insulate host applications from physical changes to the storage pool. This ability can help applications continue to run without disruption while you make changes to your storage infrastructure, which can help your business increase its availability to customers. The SAN Volume Controller Volume Mirroring function is designed to store two copies of a volume on separate storage systems. This function helps improve application availability in the event of failure or disruptive maintenance to an array or disk system. Replication services, such as FlashCopy, or Metro and Global Mirror enable you to implement backup or disaster recovery solutions seamlessly and regardless of the complexity of your storage environment. In high availability and load balancing situations, SAN Volume Controller stretched-cluster configuration can support storage and servers in two data centers. In combination with the previously mentioned replication services, SAN Volume Controller can provide high availability and disaster recovery in a single solution.

Simplified productivity
SAN Volume Controller provides an easy-to-use graphical interface for central management. With this single interface, administrators can perform configuration, management, and service tasks in a consistent manner over multiple storage systems, even from different vendors. Interface also provides many IBM best practices to help simplify storage provisioning. The thin provisioning function helps you automate provisioning and improve productivity by enabling administrators to focus on overall storage deployment and utilization, and longer-term strategic requirements, without being distracted by routine everyday storage provisioning. Because SAN Volume Controller appears to servers as a single type of storage, virtual server provisioning is also simplified because only a single driver type is needed in server images, which also simplifies administration of those server images. Similarly, SAN Volume Controller eases replacing storage or moving data from one storage type to another because these changes do not require changes to server images. Without SAN Volume Controller, changes of storage type could require disruptive changes to server images.

More information: See the IBM Tivoli Storage Productivity Center site:
http://www.ibm.com/systems/storage/software/center
**Storwize V7000 and V7000 Unified**

IBM Storwize V7000 Unified is a virtualized storage system designed to consolidate block and file workloads into a single storage system for simplicity of management, reduced cost, highly scalable capacity, performance, and high availability. IBM Storwize V7000 Unified storage also offers improved efficiency and flexibility through built-in solid-state drive (SSD) optimization, thin provisioning, and nondisruptive migration of data from existing storage. The system can virtualize and reuse existing disk systems offering a greater potential return on investment. Integrated IBM Active Cloud Engine enables you to use all those features to build your storage cloud.

Figure 4-4 describes how IBM Storwize V7000 Unified uses the best of IBM storage technologies in a midrange disk system.

![IBM Storwize V7000 Unified](image)

**IBM Storwize V7000 Unified highlights**

By using the proven technology of IBM Storwize V7000, and extending it with file capabilities and IBM Active Cloud Engine, the IBM Storwize V7000 Unified can become an essential building block in storage cloud implementations.

IBM Storwize V7000 Unified provides the following features:

- Unified storage management
- Block capabilities
- File capabilities

**Details:** More details about the IBM Storwize V7000 Unified features and how they can help you build a storage cloud are in Chapter 3, “What enables a smart storage cloud” on page 37.
**Unified storage management**

IBM Storwize V7000 Unified has a single graphical user interface to manage both your block and file-level storage. This approach helps in keeping a streamlined user interface regardless of your workload and can help previous IBM Storwize V7000 users to more easily provision file storage without needing to learn a new interface. Installation of a new IBM Storwize V7000 Unified is also simplified with usage of Storwize USB key, which enables you to quickly get the system running and start provisioning your storage, whether it is a block or file. Unified interface also provides coordinated monitoring and reporting facilities, which can be enhanced with IBM Tivoli Storage Productivity Center.

**More information:** See the IBM Tivoli Storage Productivity Center web page:

http://www.ibm.com/systems/storage/software/center

**Block capabilities**

IBM Storwize V7000 Unified provides storage efficiency by providing virtualization, thin provisioning, and Easy Tier functions, which help you consolidate and optimize your storage. Data protection is provided with the standard and proven set of features such as FlashCopy, Metro and Global Mirror, and volume mirroring. IBM Storwize V7000 Unified also provides flexibility and investment protection, with the ability to virtualize your existing environment and perform online volume migrations without disrupting business continuity.

**File capabilities**

File module software is based on IBM common network-attached storage (NAS) software and roadmap, which enables faster delivery of file functions and file ISV certifications across multiple products. IBM Active Cloud Engine is included to reduce costs through policy-based management of files and use of tiered storage, and improves data governance. Information lifecycle is provided with automated movement of less frequently used files to lower tiers of storage, including tape in an IBM Tivoli Storage Manager system. File replication, backup, and recovery, and snapshot features are provided to extend your data protection to the file level. Data is also protected by providing antivirus capabilities with the Antivirus Connector, which integrates with the external antivirus scan nodes. Files can be provisioned to various host types by using open file protocols such as NFS, CIFS, FTP, HTTPS, and SCP.

### 4.3 IBM flash storage

For businesses to take action that is based on insight from data and transform it into competitive advantage, the data driven applications must operate at high availability and peak performance. IBM flash delivers extreme performance to derive measurable economic value across the data architecture: Servers, software, applications, and storage. IBM offers a comprehensive flash portfolio with the IBM FlashSystem™ family, richly featured software defined flash solutions, as well as flash optimized XIV, Storwize V7000, and DS8000 storage.

The IBM FlashSystem family empowers organizations to take advantage of best-in-breed solutions that provide extreme performance, macro efficiency, and microsecond response times. The IBM FlashSystem V840 Enterprise Performance Solution and the IBM FlashSystem 840 members of the FlashSystem family are described in this section.

**IBM FlashSystem V840 Enterprise Performance Solution**

Now with the newest addition to the FlashSystem family of storage systems, IBM FlashSystem V840 Enterprise Performance Solution, flash technology and software-defined storage are available in one solution, in a compact 6U form factor. Leveraging IBM Storwize
family functions, management tools, and interoperability, this product solution combines the extreme performance of FlashSystem architecture with the advanced functions of software-defined storage to deliver performance, efficiency, and functionality that meets the needs of enterprise workloads demanding IBM MicroLatency™ response time.

The V840 Storage System is a rack mount shared flash memory device that is based on enterprise multilevel cell (eMLC) flash technology. It provides Macro Efficiency in a 6U form factor, IBM Variable Stripe RAID™ plus two-dimensional flash RAID for enterprise reliability, extreme performance with IBM MicroLatency, all-flash 40 TB RAIDed data capacity, business continuity with Copy Services, FlashCopy services, FlashCopy for backup and optimal workload availability, value with Thin provisioning and Real-time Compression at the Terabyte level, Drive storage efficiency with Easy Tier, external virtualization, and space efficient copies.

IBM FlashSystem 840
IBM FlashSystem 840 is data center-optimized to enable organizations to strategically harness the value of stored data. By providing flexible capacity and extreme performance for the most demanding enterprise-class solutions, including OLTP and OLAP databases, virtual desktop infrastructures, technical-computing applications and cloud-scale environments, FlashSystem 840 delivers a competitive advantage for the modern enterprise. The IBM system accelerates response times with MicroLatency, that is, less than 135-microsecond access times, to enable faster decision making. In addition to optimizing performance, FlashSystem 840 delivers best-in-class reliability in a storage device that is both space and power efficient.

IBM FlashSystem benefits
Flash technology has fundamentally changed the paradigm for IT systems, enabling new use cases and unlocking the scale of enterprise applications. Flash technology enhances the performance, efficiency, reliability, and design of essential enterprise applications and solutions by addressing the bottleneck in the IT process (data storage), enabling truly optimized information infrastructure. IBM FlashSystem shared flash memory systems offer affordable, high-density, ultra low-latency, high-reliability, and scalable performance in a storage device that is both space and power efficient.

IBM Flash products, which can either augment or replace traditional hard disk drive storage systems in enterprise environments, empower applications to work faster and scale further. In addition to optimizing performance, the IBM FlashSystem family brings enterprise reliability and macro efficiency to the most demanding data centers, allowing businesses to receive the following benefits:

- Reduce customer complaints by improving application response time
- Service more users with less hardware
- Reduce I/O wait and response times of critical applications
- Simplify solutions
- Reduce power and floor space requirements
- Speed up applications, thereby enhancing pace of business
- Improve utilization of existing infrastructure
- Compliment existing infrastructure
- Mitigate risk

From the client business perspective, IBM FlashSystem provides focus benefits and value in four essential areas:

**Extreme Performance** Enable business to unleash the power of performance, scale, and insight to drive services and products to market faster.
MicroLatency  Achieve competitive advantage through applications that enable faster decision making due to microsecond response times.

Macro Efficiency  Decrease costs by getting more from efficient use of the IT staff, IT applications, and IT equipment due to the efficiencies flash brings to the data center.

Enterprise Reliability  Durable and reliable designs that use enterprise class flash and patented data protection technology.

4.4 IBM System Storage DS8870

The IBM DS8870 is the IBM flagship enterprise class Tier 1 block storage device. In the most recent release of DS8870, release 7.2, IBM enhanced the OpenStack Cinder driver with DS8870 support. This is first available as a DS8870 RPQ for the OpenStack “Havana” release, available in the 4Q 2013. The intent for the DS8870 Cinder support is for it to become a generally available function (no longer require an RPQ) in a future DS8870 release.

A diagram showing the OpenStack Cinder support for DS8870 is shown below in Figure 4-5.

OpenStack Support for DS8870

With the availability of the IBM Storage Driver for the OpenStack Cinder component, the IBM DS8870 storage system can now participate in an OpenStack cloud environment.

The IBM Storage Driver for OpenStack Cinder enables OpenStack clouds to access the DS8870 storage system. The OpenStack cloud connects to the DS8870 storage system over an iSCSI or Fibre Channel connection. Cloud users can issue requests for storage volumes from the OpenStack cloud.
These requests are routed to, and transparently handled by the IBM Storage Driver. The IBM Storage Driver communicates with the DS8870 storage system and controls the storage volumes on it.

Tip: For more information about using the DS8870 in a OpenStack environment, see the IBM Redbooks TIPS document TIPS1150, “Using the IBM DS8870 in an OpenStack Cloud Environment”, available at the following website:
http://www.redbooks.ibm.com/abstracts/tips1150.html

4.5 IBM Scale Out Network Attached Storage

IBM Scale Out Network Attached Storage is designed to embrace and deliver cloud storage in the petabyte age. Scale Out Network Attached Storage can meet today’s storage challenges with quick and cost-effective IT-enabled business enhancements that are designed to grow with unprecedented scale. Scale Out Network Attached Storage can also deliver storage services that make the supporting technology almost invisible. It allows applications and services to be uncoupled from the underlying infrastructure, enabling businesses to adjust to change quickly. As a result, Scale Out Network Attached Storage can easily integrate with your organization’s strategies to develop a more dynamic enterprise.

IBM Scale Out Network Attached Storage highlights

IBM Scale Out Network Attached Storage can provide you with the following benefits:

- Unified management of petabytes of storage
  Offers automated tiered storage, which is centrally managed and deployed.

- Global access to data regardless of your location
  Uses the advanced General Parallel File System (GPFS), providing a single global name space across petabytes of data. With Active Cloud Engine, global name space can be extended to support multiple Scale Out Network Attached Storage appliances.

- Based on standard, open architectures
  Using non-proprietary protocols and technologies allows you to avoid lock-ins and use worldwide open source innovative technology.

- Flexibility and elasticity
  Provides and exceeds today’s needed requirements for scale-out capacity, performance, and global virtual file server while allowing for extreme scalability with modular expansion.

- High return of investment (ROI)
  Offers significant cost savings because of automatic tune, automatic balance, and automatic tiered storage.

- Cloud ready
  Is positioned to take advantage of the next generation of storage technology with Active Cloud Engine.

Scale Out Network Attached Storage appliance architecture

The Scale Out Network Attached Storage appliance consists of a minimum of two network facing interface nodes and one or more storage pods. The interface nodes are clustered and provide an image of a common NAS name space and data to users. The Scale Out Network Attached Storage Cluster Manager coordinates resources and ensures data integrity across the multiple nodes in the Scale Out Network Attached Storage cluster.
Each interface node is capable of serving thousands of clients simultaneously. A Scale Out Network Attached Storage file system can have up to eight logical storage pools. Scale Out Network Attached Storage supports CIFS, NFS, HTTP and HTTPS, FTP, and SCP file protocols. Scale Out Network Attached Storage can add more storage without an outage, the ability to remove storage without taking the file system offline, and the ability to relocate file data to match access patterns and storage criteria appropriate to the data by using a sophisticated internal and inline Active Cloud Engine.

A Scale Out Network Attached Storage storage pod consists of two storage nodes and up to four enclosures of 60 drives, each making up to 240 drives per pod. Storage nodes work as a clustered pair to manage and present the storage to the Scale Out Network Attached Storage parallel file system known as GPFS. Up to 30 storage pods and up to 30 interface nodes can exist in a Scale Out Network Attached Storage appliance.

A Scale Out Network Attached Storage appliance can store billions of files and can use automated policy-based management to control backups, restores, snapshots, remote replication, archiving, antivirus scanning, and Active Cloud Engine integration.

## 4.6 IBM cloud services

In previous chapters, we described how IBM can help you build a storage cloud on your storage cloud journey. In 2014, IBM continues to rapidly expand our major commitment to cloud technologies and service offerings that give our customers the ability to enjoy the benefits of a storage cloud without having to build their own infrastructure. IBM provides these offerings as part of the IBM SmartCloud family, supporting public, hybrid, and private cloud delivery models.

Figure 4-6 on page 96 shows the two major IBM overall offerings for public, private, and hybrid clouds:

- IBM Cloud Managed Services
- IBM SoftLayer

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2 IBM Cloud Managed Services was formerly named IBM SmartCloud Enterprise+. IBM renamed this service in February 2014. IBM also discontinued IBM SmartCloud Enterprise and migrated those clients to SoftLayer.
You can think of IBM SoftLayer as ideal for:

- Requiring a highly built out and resilient, steady workload, transaction-oriented IT infrastructure
- Suitable for traditional three tier traditional IT application models, that is, application, middleware, and database
- Typical applications appropriate for IBM Cloud Managed Services would be SAP, Oracle ERP solutions, and similar database management systems

You can think of IBM SoftLayer as ideal for:

- Cloud native, internet native applications
- Associated requirements for internet scale, widely varying and quickly changing workload levels
- Modern internet applications where resiliency is built into the application layer
- Web-centric, native cloud programming environments
- Bare metal server capability, allowing the client the option and flexibility to load their own software stack as appropriate for their needs
- Full self-service API control of all aspects of the client's SoftLayer infrastructure to allow the flexibility and control access to manage their SoftLayer infrastructure however the client wants

Figure 4-6 shows the SoftLayer and Cloud Managed Services strengths to highlight the broad scope of the two offerings. The overlapping bars at the bottom of the figure illustrate that there are functional similarities between the offerings.
Within each of these two complementary IBM Cloud Services offerings are many individualized offerings, which includes (but is not limited to):

**Private Modular Cloud**  
Patterns of expertise that can be purchased and applied to your private, public, or hybrid cloud

**IBM PureSystems® as a Service**  
New ability to purchase portions of the IBM PureSystems software stack running in off-premise, pay-per-use version in IBM SoftLayer

**Software as a Service**  
Off-premise, pay-per-use ability consumes IBM software products inside SoftLayer: products that previously only existed in on-premises versions. Examples include IBM General Parallel File System

Regarding positioning IBM Cloud Managed Services and IBM SoftLayer, see Figure 4-7 for a short description of the high-level characteristics of each.

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**Figure 4-7  IBM Cloud Managed Services and IBM SoftLayer characteristics**

Figure 4-7 highlights the major characteristics of IBM Cloud Managed Services and SoftLayer to show the breadth of the offerings together. For example, the Managed Services Requirements column shows the focus areas of Cloud Managed Services and SoftLayer. Unmanaged is displayed for SoftLayer they also have options for managed services.

### 4.6.1 IBM SoftLayer


SoftLayer currently has 22,000 clients and 13 data centers. In January 2014, IBM announced an additional investment of $1.2 billion in IBM cloud services infrastructure to expand the SoftLayer infrastructure to an additional 15 new data centers, in China, Washington, D.C.,
Hong Kong S.A.R. of the PRC, London, Japan, India, Canada, Mexico City, and Dallas. With this announcement, IBM plans to have data centers in all major geographies and financial centers with plans to expand in the Middle East and Africa in 2015. For more information, see the press release:


IBM is establishing SoftLayer as the foundation of the IBM cloud portfolio, as the scalable, secure base for the global delivery of cloud services spanning the IBM extensive middleware and software as a service (SaaS) solutions. SoftLayer's flexibility and global network will also facilitate faster development, deployment and delivery of mobile, analytic, social solutions as clients adopt cloud as a delivery platform for IT operations and manage their business.

Following are some of the features of SoftLayer:

- Complete self-service capability to acquire, spin up, allocate, and de-allocate IT infrastructure for public, private, and hybrid clouds
- Wide choice and flexibility in options in the specific infrastructure to be provisioned, including bare metal server capability
- APIs provided to manage all aspects of the SoftLayer provisioned infrastructure as wanted by the IT users and administrators

SoftLayer offers storage that is attached to compute servers, and also stand-alone storage as a service. SoftLayer provides a complete object storage solution with OpenStack Swift that includes powerful tagging, search, and indexing capabilities, so that a client can assign rich metadata tags for ease of finding and serve objects when requested.

For more information about IBM SoftLayer, see the following website:


4.6.2 IBM Cloud Managed Services

On February 24, 2014, IBM renamed the former IBM SmartCloud Enterprise+ to its new name: **IBM Cloud Managed Services**.

IBM Cloud Managed Services is a multitenant, IBM hosted, IaaS cloud-delivery offering that is built on an enterprise class infrastructure with an architectural design capable of supporting workloads, which require 99.5% and higher availability. IBM currently delivers these cloud services out of 12 data centers located worldwide. Current technology is implemented on high performance tier 1 XIV storage arrays within a resilient, SAN Volume Controller virtualized, SAN fabric, which includes options for local and remote mirroring in support of high availability and disaster recovery implementations.

IBM Cloud Managed Services supports both vertical and horizontal scaling workloads with the capability of delivering robust storage solutions for demanding transactional systems. Leveraging automation for service activation, IBM Cloud Managed Services provides managed service capabilities with rapid storage capacity provisioning activation (days versus weeks) based on formal availability service-level agreements. This offering affords IBM clients the flexibility of a smaller up-front commitment, while providing enterprise class infrastructure facilitating growth as needed.

The February 2014 announcements for IBM Cloud Managed Services added the following important new features:

- **Lite Sites/Remote Pods** - Giving clients the ultimate in choice of deployment options in an IBM data center and can be set up in any country.
- Disaster Recovery - fail over to and fail back from a secondary site.
- New Standards supported
  - HIPPA Compliance for Healthcare Industry
  - PCI Compliance for credit card transactions or handling of personal information
- New Storage options enable support of dedicated servers for SAP HANA and Oracle Databases on Intel servers

IBM Cloud Managed Services continues to provide the following key features and capabilities:
- VMWare, IBM AIX®, x86, or Power platform
- Resilient dual fabric FC SAN
- Tier 1 enterprise class storage
- Storage Zoning + Hypervisor isolation
- Production level enterprise transactional application full stack enablement
- Multitenant managed hosting
- Approximately 1-day provisioning activation
- Complete ITIL process support
- Client ITSM Integration, integrated across client's non-cloud and cloud environments
- Formal SLA support for 98.5 - 99.9% image availability
- Local and remote mirroring options
- Service management above and below the hypervisor
- Integrated backup and recovery service
- Optional tape encryption and off-site tape capability
- Scheduled separate guest OS-based Tivoli Storage Manager backup to prevent cross-contamination of backup data
- Shared or dedicated managed environments
- Standard set of software images (OS, middleware, databases) offered in fixed sizes and SLA packages
- Server create/modify/destroy requests through web portal as pre-approved changes
- Cloud-based ITIL management processes:
  - Image lifecycle
  - Asset/license
  - Configuration

IBM Cloud Managed Services provides 12 global deployment sites worldwide.
Other offerings: Other storage-related IBM SmartCloud service offerings:

- IBM SmartCloud Managed Backup

- IBM Information Protection Services Managed Data Vault

- Smart Business Storage Cloud

- IBM SmartCloud Federal Community
Chapter 5. What are others doing in the journey to storage cloud

Smart storage cloud is a reality within numerous infrastructures worldwide. IBM clients have successfully implemented smart storage cloud solutions across industries in large enterprises and in small and medium businesses to improve IT agility and support for business process requirements, while controlling costs. Proven technology in conjunction with skilled implementation assistance and services make IBM a leader in smart storage cloud deployment.

This chapter describes smart storage cloud solutions across various industries. Each description covers the client’s needs, proposed solution, and results.
5.1 Large enterprise OpenStack cloud supporting XIV

A large Internet commerce company provides online marketplace services to online buyers and sellers. One of the core environments provides cloud-based e-commerce capabilities to commercial-level users of the marketplace. These capabilities include hosting, website building, transaction and order fulfillment, and customer relationship management tools.

Business needs
In order to remain competitive in the hyper-pace change of the worldwide Internet commerce marketplace, this customer needs to continuously up-level their functional services provided to their users, while maintaining absolute reliability and consistency of service regardless of Internet-scale peaks and spikes in workloads, all while operating at competitive Internet-scale costs of operation.

Proposed solution
To provide these capabilities, this company has strategically chosen OpenStack software as the cloud computing platform upon which to provide cloud services to the marketplace commercial customers. OpenStack cloud software is implemented on a large and growing commercial enterprise class Intel server farm, as shown in Figure 5-1.

![Figure 5-1](Internet commerce company)

XIV systems
10GbE ports
500 TBs usable

Open source
eCommerce tools

Hosted Cloud Services
Magento Go
Magento Commerce
Various Public Products

~2,000 hosted service users

What is notable is that the OpenStack environment is implemented entirely on commodity enterprise class components, except for storage. This was purposely chosen to be IBM XIV storage.

In the client’s worldwide customer-centric, Internet-based cloud environment, extreme variability in workloads is the norm. The ability of XIV to deliver a guaranteed service level
agreement (SLA) for the cloud storage service is uniquely valuable. The consistent, auto-tuning performance of XIV, results in the predictability of I/O response time.

Benefits of the solution
With XIV and its support of the OpenStack Cinder component, the client is able to meet a very demanding SLA. The client is able to ingest a lot more concurrent users on the same compute and storage platform and can scale out to multiple compute platforms, all while delivering a predictable performance curve.

The consistent, auto-tuning performance, and predictability of I/O response time are the characteristics of XIV that led this client to choose XIV storage for their cloud OpenStack environment to enforce the service level agreement (SLA) that they wanted to give to their customers.

5.2 IT storage cloud with SmartCloud Storage Access

A large IT service organization servicing over 6000 users for a systems development team.

The average number of requests for storage resources was increasing and the pressure to manage the growing IT infrastructure was increasing. The client had already taken steps to invest on automation-based solutions like the IBM Tivoli Service Automation Manager-based cloud resource provisioning and was looking for a similar storage model.

Business needs
Here are some of the issues that are related to the growth of the business and the manual efforts making it difficult to support the growth and meet the service level agreements:

- There is a 100% capacity growth on storage resources requested per year.
- The service requests handled by the storage services team doubles every year.
- The storage services team had to manage services that included installing storage devices, provisioning resources, and troubleshooting. With a team of four people, the service request management was cumbersome.
- More than 50% of requests per year are for storage allocation.
- The existing service request management system did not include approval work flow management. The approval management was manual and depended on email.
- The reclaiming resources and expiration of storage resources were more manual processes. These processes depended on the resource user.
- The metering and charge back were labor-intensive because it involved manual processes for report collection, validation, and estimation.
- There were predefined service levels set for each team or department with standard approval authority.

Client background
Here is some vital information regarding the client background and the IT infrastructure that was already in place:

- Category: IT Service Industry
- Adopter: IT Services wing servicing a particular client. The services provided include network, servers, storage, and an IBM Tivoli Service Automation Manager-based cloud service
- Storage Infrastructure - 1 petabyte of storage that included block storage devices like IBM XIV, IBM SAN Volume Controller (virtualization system for third-party storages like EMC, Hitachi), IBM Storwize V7000 Unified, and IBM Scale Out Network Attached Storage
- Number of users: More than 6000
- User Management Model: Test and development teams of the client

Relevant information:
- IBM Tivoli Directory Server was used as the authentication and user management system.
- The IT environment includes many IBM System p®, IBM System x®, and VMWare ESX servers.
- The IT environment already had existing SAN backbones with Cisco and Brocade SAN switches and directors serving more than 5000 servers including the virtual servers.
- The users were using a private cloud service from the same IT Services providers and this service was based on IBM Tivoli Service Automation Manager. The storage capacity requested for this private cloud environment was the highest. The storage provisioning was a manual process and there was no storage cloud solution deployed.
- The client had three data centers across three cities and the users were distributed across these locations.
- There were centralized teams that supported Tivoli Service Automation Manager-based cloud services, platform management services, software engineering services, operating system management, and application management.
- The centralized teams previously mentioned act as the user focal points for requesting storage resources for their servers.
- Apart from the central service teams previously mentioned, there were a few departments that had their own server infrastructure and depended on the storage services from the central storage services team.
- The storage resources were already monitored through IBM Tivoli Productivity Center.
- There was a service request management system in place.
- The storage services given included file and block services and were supported by a small team of four people.

Proposed solution
IBM proposed a solution with SmartCloud Storage Access (SCSA) to meet the requirements and remove the pitfalls of the method that is used by the client.

Table 5-1 shows the requirement versus proposed solution matrix.

<table>
<thead>
<tr>
<th>Requested functionality</th>
<th>Matching SCSA feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request process simplification.</td>
<td>Self-service portal.</td>
</tr>
<tr>
<td>Approval process management.</td>
<td>Approval workflow management.</td>
</tr>
<tr>
<td>Department-wise resource allocation and workflow.</td>
<td>Departmental model.</td>
</tr>
<tr>
<td>Automated resource allocation and workload reduction.</td>
<td>Automated share creation on request approval.</td>
</tr>
</tbody>
</table>
Chapter 5. What are others doing in the journey to storage cloud

### Solution description

The storage environment was made for the SCSA-based storage cloud solution. Though there were diverse components like storage systems from different vendors, the client had prerequisites already in place for an SCSA solution implementation. The only missing piece was the charge back automation for which the IBM SmartCloud Cost Management was proposed.

Figure 5-2 shows the high-level IT environment.

<table>
<thead>
<tr>
<th>Requested functionality</th>
<th>Matching SCSA feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central resource reservation at customized service levels.</td>
<td>Resource pools through storage environments and service levels.</td>
</tr>
<tr>
<td>Metering.</td>
<td>SCSA-based metering.</td>
</tr>
<tr>
<td>Alignment to existing policies.</td>
<td>SCSA policy management.</td>
</tr>
<tr>
<td>Driving resource expiration with warnings.</td>
<td>SCSA expiration settings during the request.</td>
</tr>
<tr>
<td>Reduction in resource allocation turn-around times.</td>
<td>SCSA resource allocation automation in integration with IBM Tivoli Storage Productivity Center.</td>
</tr>
</tbody>
</table>

Figure 5-2 shows the high-level IT environment.

![Figure 5-2 IT Services client environment](image)

Figure 5-3 on page 106 shows a high-level implementation of different entities on SCSA and IBM Tivoli Storage Productivity Center for a particular data center and its users.
A high available LDAP-based authentication system was already in place to which SCSA integration was proposed. For the data center example shown in Figure 5-3, there were predefined policies like the SWES department needs all its storage resources from SSD and NL SAS Drives on RAID 10. Such policies were realized to an SCSA policy model easily. The client was already in a departmental model with specific departments and managers. These managers were the department administrators and the central storage team took the responsibility of the cloud storage administrator.

**Solution benefits**

By deploying SCSA-based storage cloud for the client there were significant benefits by overcoming the pitfalls of the resource request system that they had in place.

The following benefits are realized by the solution:

**Automation and administrator overhead reduction**

The administrator overhead reduction is the biggest factor here with automation in place. With an SCSA-based solution in place, the rapid growth in the storage capacity can be managed effectively by the storage administrators.

**Automated metering**

SCSA provided reports are a boon for the storage department as it takes away the manual report collection, estimation, and validation process before the charge back.
Turn around time reduction for resource allocations
The reduction of turn around times for resource provisioning was reduced from few days to few hours.

Expiration and reclaiming the resources
The storage team was relieved of the manual validation and expiration since the SCSA has an automated expiration that is based on policy selection.

Process simplification
The overall resource provisioning process was simplified. The users had to do a few clicks with the SCSA self-service portal instead of entering much information about the call service management system. The approval and resource creation policy was fully automated and removed the pitfalls on manual intervention of the earlier call service management process.

Effective monitoring on utilization of resources
Because the resource expiration is automatic and is supported by an able metering and charge back system, the efficiency in reclaiming resources and monitoring the resource utilizations improved dramatically.
5.3 National library public cloud

The client is a national library whose mission is to collect and archive documents and publications about the country from the early 1900s. The organization helps develop international standards and works with other entities on national and international matters. The central location develops and manages the central database for the national library and produces and distributes bibliography services across the entire country.

Business needs
The national library needed a dynamic infrastructure consisting of a storage solution that could start with a few terabytes of storage and eventually grow into several petabytes over the next few years. In addition, the client was looking for a storage cloud solution to be able to synchronize information in various sites spread across the country. When the organization received a mandate by the federal government to digitize the national cultural assets, it sought a new storage solution to meet the requirements.

Proposed solution
After the proof of concept (POC) was presented, the client engaged IBM to implement two IBM System Storage Scale Out Network Attached Storage devices with 240 TB of storage each. In the POC, client data was used to show how its base configuration with two interface nodes and two storage devices could be used to store digitized cultural assets, such as scanned books and documents. With Active Cloud Engine, the replication and the hierarchical storage lifecycle of the information between the two main sites was transparently managed by the Scale Out Network Attached Storage solution. The second step of the solution proposed was to implement in the small sites across the country Storwize V7000 Unified to guarantee fast access to the information from the local library.

Figure 5-4 on page 109 shows the high-level diagram of global namespace and Active Cloud Engine functions in Scale Out Network Attached Storage.
Benefits of the solution

By engaging IBM to implement two Scale Out Network Attached Storage systems, the client gained the ability to manage multiple petabytes of storage and up to a billion files in a single file system, and achieved operational efficiency with automated policy-driven tiered storage. The client reduced its total cost of ownership (TCO) with automated lifecycle management and migration to tape.

The solution provides the capability to the national library to distribute bibliography services across the country through the public intranet.

5.4 Video surveillance solution for public safety

The client is a government organization that took an initiative to improve public safety in the areas under its responsibility. The scope of the organization is to be able to monitor critical public locations for identification and rapid response to accidents, crimes, and so on.
**Business needs**
The requirement was to store at least three days of recorded content, providing access to the police and justice departments when necessary. The client was looking for a storage infrastructure that could support the simultaneous storage of many thousands of video streams. The solution needed to allow hundreds of simultaneous reads and for particular public locations the images needed to be archived for 10 years for security reasons. The solution must be implemented in various cities across the country.

**Proposed solution**
In addition to the deployment of an end-to-end video surveillance solution, IBM provided two Scale Out Network Attached Storage systems with Active Cloud Engine to implement a scalable global file storage system. For archiving and backup, the solution includes Tivoli Storage Manager with the hierarchical storage manager (HSM) component. Tape libraries were part of the solution to provide enhanced, cost-effective scalability, meeting business requirements to keep some video images for 10 years.

Scale Out Network Attached Storage was paired with a specialized video software provider, delivering a broadband cable network solution and video network displays.

Figure 5-5 shows the general view of the project, with the example of the various video collectors and their integration with Scale Out Network Attached Storage Active Cloud Engine replication.

![Figure 5-5 Video collector and Scale Out Network Attached Storage Active Cloud Engine replication](image_url)
Benefits of the solution
The high performance storage cloud solution was able to guarantee collection of all the information that was created by the various video collectors and the implementation of data replication and collaboration that was delivered by Active Cloud Engine. In addition, using data mobility to tape, the Scale Out Network Attached Storage system provided a cost-effective solution for the archiving requirements, too. Information that is managed by Active Cloud Engine is available from all police stations and the courts of the country in case of accidents, crimes, and civil and criminal cases.

5.5 Telecommunication company public cloud

The client is a telco company, based in Europe, which offers technological infrastructures and platforms in which voice and data are converted to advanced telecommunications services. One of the missions of the company is to sell cloud IT services with the main focus on infrastructure as a service (IaaS) and platform as a service (PaaS):

- IaaS: That offers CPU, storage space, and other IT components
- PaaS: To address application deployment

The client's cloud computing environment is managed by a proprietary application.

Business needs
The client wants to add to its IaaS cloud offering the capabilities of disaster recovery and high availability of the information, and backup for all its customers. This emerging model of delivering disaster recovery as a service (DRaaS) offered by service providers is gaining popularity mainly because of the pay-as-you-go pricing model, and infrastructure resource sharing that can lower costs. This model should offer several options and use various technologies depending on the SLAs:

- Both primary production and disaster recovery instances that are provisioned in the cloud are handled by a managed service provider.
- Primary production on-premises and disaster recovery instances are provisioned in the cloud.

The company has many data centers that are distributed across the country, and the storage infrastructure is based on various many SAN and NAS storage systems from various vendors, including IBM XIV and IBM DS8800. The requests for this project were to find a solution that could reduce the complexity in the management activities to save time and expedite the delivery of the service.

Proposed solution
The solution took a phased implementation approach because of the complexity of the existing environment and the need to guarantee the access to the information for the customer of the IaaS cloud hosted by our client.

Phase 1
Implementation of SAN Volume Controller is in a split-cluster configuration between the two production sites (150 km (93 mi) apart) to provide an abstraction layer between the physical storage resources and the applications, hiding the complexity of the environment, making management easier, and increasing utilization. The SAN Volume Controller represents a key enabler at the infrastructure level to implement an efficient data replication mechanism for high availability and disaster recovery as a cloud service. For disaster recovery, SAN Volume
Controller provides consistent synchronous and asynchronous mirroring across sites (campus and long distance).

Figure 5-6 shows the high-level description of phase one of the solution with SAN Volume Controller in split cluster configuration and Global Mirror for disaster recovery.

**Phase 1: Primary production and disaster recovery instances in the storage cloud**

![SAN Volume Controller split cluster configuration and Global Mirror for DR](image)

**Phase 2**

Implementation of one IBM Scale Out Network Attached Storage Gateway system in Site1 where the SAN Volume Controller is the storage node for all the storage cloud services that are required in the IaaS cloud. In addition, the solution will be the second site for external customers of the DRaaS services. For each external client, the solution provides IBM Storwize V7000 Unified.

Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication were used to simplify and monitor the entire environment and to collect data for Tivoli Storage Automation Manager for the automation staff.

For the entire cloud client base, the solution is able to deliver replication and collaboration on the access of the information, using both SAN Volume Controller replication functions, supported by Storwize V7000 and Active Cloud Engine between Scale Out Network Attached Storage and Storwize V7000 Unified.
Figure 5-7 shows the design of the second phase of the project for file replication and collaboration.

Phase 2: Primary production on-premises and disaster recovery instances in the storage cloud

**Benefits of the solution**

SAN Volume Controller provides flexibility in a multivendor environment, supporting multiple hypervisors and operating systems (VMware, Power, and others) and a wide variety of storage devices from IBM and others (EMC, HP, HDS, Oracle, Dell, NetApp, Fujitsu, NEC, Bull). The mirroring that is integrated with recovery automation tools provides management of disaster recovery SLAs as requested by the client. All the storage operations are managed from a central point with Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication.

The built-in capabilities of SAN Volume Controller for thin provisioning, application snapshot integration, mirroring, performance optimization and tier management, data mobility, and compression maximize the use of existing storage that natively does not have these capabilities.

Scale Out Network Attached Storage and Storwize V7000 Unified Active Cloud Engine for the NAS component allow multiple sites to collaborate on information exchange, lower storage costs by moving files transparently to the most appropriate tier of storage, and control storage growth by moving older files to tape and deleting unwanted or expired files.
5.6 Life Science healthcare private cloud

The client is a health sciences company whose mission is DNA sequencing and analysis research. The client creates and delivers excellence in biomedical research to better understand chronic human diseases and aging, as influenced by metabolism, genetics, and the environment.

Business needs
The client's intention was to build a large-scale computing infrastructure to allow the storage of massive genomic data sets to perform complex processing of that data. The solution needed to provide high-performance computing (HPC) scalability and performance in an environment with a very progressive growth of DNA sequencing data. The HPC application requires collecting data directly on a global file system. The company has two main research centers; in a second phase of the project the client could create a secondary data center to help guarantee the best performances and continuous availability to the information. The client expected 2 PB of data growth each year. For this quantity of data, the customer needed a solution to integrate hierarchical storage management (HSM) and backup to tape.

Proposed solution
The proposed solution provides IBM iDataplex as the ideal platform for HPC DNA analysis, and Scale Out Network Attached Storage as a storage appliance. All the integrated information lifecycle management (ILM) functions are provided by Scale Out Network Attached Storage to move files from fast disks to economical disks, HSM to "archive" files to tape while still keeping them accessible, and integration with backup. As an option for future evolution, the solution offers the possibility to implement a second Scale Out Network Attached Storage in the new data center. This approach would provide access to the scientist by using Active Cloud Engine replication and global namespace to enlarge collaboration between the two research centers.
Benefits of the solution

Genomics and cancer research companies and also university research generate gene sequencing and other vital information in laboratories. This information is received from various sequencers and other research instruments worldwide, to a central repository for analysis. DNA-based risk assessments and other high-value-added research is performed. Results can be shared or sold to other genomic organizations by using the global management capabilities of Active Cloud Engine.

Using the Active Cloud Engine local management capabilities, as data ages, the results can be stored as a means to lower-cost storage, including tape. The stub information needed to recall the data on tape remains in the researcher’s folder. In future years, data can be recalled from tape and compared to newer genetic results by using local management capabilities of Active Cloud Engine. The solution provides the best integration with tape backup by using Tivoli Storage Manager.
5.7 University file sharing in private cloud

The client, a university, is an institution that is dedicated to higher learning and research. Together with several other universities and four research institutes, it forms the federally directed country domain. The institutions of the country uphold their autonomy and identity based on the federal law and in the full awareness of their social, economic, and cultural responsibilities to the nation and its citizens. In its role as a pioneering institution, the client aims to try new approaches, broaden its scope, develop new perspectives, and play its part in ensuring that the nation is able to maintain its presence on the global education stage.

Business needs
The university wanted to provide multiple capabilities in its IT organization to consolidate and share information. The client had requirements for tiering of files to the most effective, and most efficient and economical media, and transparent recalls for repeated analytical processing.

The university was challenged to find a solution to provide highly efficient storage management and administration to decentralize provisioning, and to provide self-service by portal, which provides capacity usage reporting and accounting data that matches to storage requests. A final challenge was to include various existing file systems, mainly shared by servers with dedicated SAN storage, and to reuse the existing storage devices to protect the previous investments.

Proposed solution
The proposed solution provides IBM SAN Volume Controller as the ideal storage virtualization platform to consolidate all the existing block-based storage boxes of various suppliers. SAN Volume Controller provides one single point of management for each site and it is supported by Scale Out Network Attached Storage in a Gateway configuration. The solution includes one Scale Out Network Attached Storage Gateway for the main data center, and for the other research centers, four IBM Storwize V7000 Unified systems with external virtualization for reuse of the existing block-based space. In using Active Cloud Engine provided by Scale Out Network Attached Storage, the solution integrates ILM functions.

IBM Tivoli Storage Automation Manager is part of the solution to provide all the policies for a self-service, metering, and provisioning of the storage resources.
Figure 5-9 describes the use of Active Cloud Engine.

### Benefits of the solution

IBM Active Cloud Engine local management capabilities allow multiple storage tiering levels to improve storage utilization and to align workloads with the value of the data. The university, with Scale Out Network Attached Storage, is able to allocate high performance storage for the research departments and provide SLAs to reduce departmental islands of NAS storage, unlike the previous configuration. With Scale Out Network Attached Storage, Storwize V7000 Unified, and Active Cloud Engine, the IT infrastructure provides lower storage cost for student home directories. Because of the ILM embedded policies, the infrastructure by itself searches for files that might not be desirable to have reside on university systems (for example MP3 files) and moves them to tape or deletes them, or takes some customized actions.
5.8 Media and entertainment company hybrid cloud

The client is an international multimedia publishing group that operates daily newspapers, magazines, books, radio broadcasting, news media, and digital and satellite TV. It is also one of the leading operators in the advertisement sales and distribution markets.

Business needs
In the last two years, the company defined a new strategy that is based on high-quality editorial production, rethinking products and offers. The client redesigned the business model, mainly regarding new organization of work to develop multimedia and a digital business model. The media company needed a dynamic storage solution that was able to provide up to 20 PB of data, distributed on separate tiers, including a tape library to guarantee a cost-effective solution. The client was looking for a storage cloud solution capable of replicating data in separate sites, where the editors and journalists are based. They needed a system that offered zero downtime while delivering predictable performance in all the digital media information lifecycle phases: Create, manage, distribute, and archive. The storage cloud solution should be used by the client to start to deploy a pay-per-use model for its customers by providing access to old and recent TV programs.

Proposed solution
IBM proposed a solution that is based on Scale Out Network Attached Storage systems with a multitier storage pool, including tape management by Active Cloud Engine and Tivoli Storage Manager to provide the ability to move information to tape for archiving requests. For the regional sites of the media company, the plan was to have Storwize V7000 Unified use Active Cloud Engine to share the information that is managed by the local site and vice versa. Tivoli Storage Productivity Center and Tivoli Storage Automation Manager were part of the proposal to collect and manage storage usage information. Tivoli Usage Account Management (TUAM) was proposed to create reporting for chargeback of the customers of the web services.

Benefits of the solution
With IBM Scale Out Network Attached Storage, the client is able to manage more than 100 million files with tens of thousands of users. The solution provides concurrent profile logons, many of these with over a thousand small files. The embedded function of replication that is supplied by Active Cloud Engine, combined with Tivoli Storage Manager for backup, and the archiving policies of hierarchical storage management, guarantee the continuous availability of the data. By using the information lifecycle management approach, the client is able to move information to the correct storage tier, including tape, to obtain a cost-effective solution.

The IBM cloud storage solution, which is based on Scale Out Network Attached Storage and Storwize V7000 Unified Active Cloud Engine, ensures that the external location has excellent access-response time to the media content.

The Scale Out Network Attached Storage capability to manage multiple file systems with multiuser file sharing, managed by the HSM policies, provided a secure and cost-effective solution for the requirements. The information that is collected by TUAM provided the customer with a solution to start pay-per-use services.

The collaborative benefits of the solution for every phase of the digital-media data process are shown in Figure 5-10 on page 119, Figure 5-11 on page 119, and Figure 5-12 on page 120.
Chapter 5. What are others doing in the journey to storage cloud

Cloud storage value for Broadcast

- Ingest: Satellite, upload servers
- File System: SONAS
- Editing: Direct & Near-line
- Compositing: Dubbing, graphics
- Broadcast
- Media Asset Mgmt: Archive/HSM, DR Copy

Cloud storage value for Post-Production

- Ingest: Scanner, DataCine, Camera
- Editing: Color correction, grain, clean, etc
- File System: SONAS
- Effects: Autodesk, DaVinci, CG, etc
- Film Recorder
- Media Asset Mgmt: Archive/HSM, DR Copy
- Tape
Cloud storage value for Content Archiving and Distribution

Ingest
Upload Server, etc

Transcoding

Distribution
Upload to Content Providers, CDNs

Encoding

File System

 SONAS

Media Asset Mgmt
Archive/HSM, DR Copy

Tape

Figure 5-12  Cloud storage value for Content Archiving and Distribution
What are my next steps

Getting started on the journey to a smart storage cloud implementation can be relatively straightforward or fairly complex, depending on the scope of the project under consideration. It is important to understand current organizational capabilities and challenges, and identify the specific business objectives to be achieved by deploying a smart storage cloud solution in your enterprise. Ask the following questions:

- What strategy should my organization follow to build a “cloud-ready” infrastructure?
- Should storage infrastructure be cloud-based?
- Does IBM have storage cloud offerings that meet my needs (SoftLayer and Cloud Managed Services)?

IBM personnel can assist you in your journey to smart storage cloud by developing a high-level architecture and implementation plan with a supporting business case to justify investment, based on a compelling return on investment (ROI), and based on improved service levels and lowered costs.

In this chapter, we help review your storage strategy, identify where you are on the journey to storage cloud, and your next steps.
6.1 Review your storage strategy

Before embarking on any journey, it is important to understand where you are currently, and where is your chosen destination. Developing your own cloud storage strategy should reflect these important considerations, which will help you to define the path of your journey. So take the time needed to ensure that you understand how cloud storage can help your business. Justify your move by using ROI, total cost of ownership (TCO), and other business measures that are relevant to your organization. Be sure that you consider technical or compliance concerns, and develop risk-mitigation plans as appropriate.

Remember that although storage cloud can be a key component of an overall cloud computing approach, you should determine how a storage cloud strategy will fit within your broader cloud computing architectural plans. Overall integration of system parameters is essential to successful implementations:

- Performance
- Availability and resiliency
- Data management
- Scalability and elasticity
- Operations
- Security
- Compliance

Consider your security needs and how a storage cloud is affected by the confidentiality of the data that you need to store. Data that is highly sensitive, or subject to security-compliance regulations, might not be able to be stored on a public network. Consequently, your storage cloud might need to be located behind an enterprise firewall, indicating a private cloud solution requirement. The same might be true for instances where users need to easily access, share, and collaborate, without compromising data security, integrity, availability, and control of the data.

Your storage strategy must consider the requirements of the various business units within your company, along with your customer expectations of your IT organization. Competitive pressures might dictate that a storage cloud is the only way to meet the quick service provisioning, elastic resourcing, and pay-as-you-go charging model that your customers are looking for.
A framework for aligning a cloud implementation, optimized to business requirements, is shown in Figure 6-1. The figure focuses on key practice areas across IT architecture, process, and organizational structure.

### Cloud Implementation and Optimization Practices

- **Common components and processes**
- **Seamless integration of virtualized infrastructure**
- **Develop virtualized cost allocation strategy**
- **Manage cloud across IT service lifecycle**
- **Standardization and automation supports all dimensions and is critical to effective cloud deployment and management**
- **Enterprise Systems Management**
- **Policy Driven Systems Management**
- **Tools**
- **Advanced security and resiliency**
- **Security Governance, Risk management & Compliance**
- **Ability to account, budget, and charge effectively for virtualized workloads**

*Figure 6-1 Framework for cloud infrastructure implementation and optimization practices*

When considering the use of any new technology, a common mistake is to focus on the technology itself, rather than on the business requirements to be addressed by a technical solution. To stay on track with your storage strategy, identifying several significant use cases in your organization can be helpful. Start by analyzing a use case and its importance to your business, and then determine how the introduction of a storage cloud will affect your business operations and costs.

With the use-case approach, you can gain an understanding that a private cloud is not only a storage infrastructure, but rather an ecosystem of cloud storage clients, backup, and archive solutions, special purpose data movers, management, and support. When these components are combined with cloud storage infrastructure, a complete solution for storage is achievable.

### 6.2 Identify where you are in the journey

As described in Chapter 2, “What is a storage cloud” on page 19, the journey to delivering a storage cloud depends on where you are in the storage journey, and how far you are from a traditional storage infrastructure.

From internal experiences of IBM and from hundreds of cloud engagements with clients worldwide, we know that there are key steps in the progression to deployment of a storage cloud. These steps can overlap; there is no need to necessarily complete one step before moving to the next. Rather, the steps represent a progression. For example, in some organizations, the consolidation step might require major effort because the infrastructure...
might be highly heterogeneous and distributed. For others, consolidation might be more evolutionary, and performed simultaneously with other steps. Although there is no single approach to performing and completing these steps, they are all important considerations in the journey to a storage cloud. Figure 6-2 illustrates a high-level approach to the development of an optimized storage cloud strategy.

Consolidate physical infrastructure
Consolidating assets reduces infrastructure complexity, increases economies of scale, and enables more efficient IT management, focused on fewer aspects, which can all lower operational costs.

Virtualize: Increase utilization
Storage virtualization complements consolidation by making better use of existing resources. The virtualization step is about pooling storage resources so that the available storage appears to be a single storage system, however, in reality it might be distributed across many storage devices. Another important aspect of storage virtualization that demonstrates increased utilization is the implementation of features, which, to the storage user, appears to be more storage than the user actually was granted. Thin provisioning is one such feature, which is described in more detail in 3.2.4, “Thin provisioning” on page 48.
Optimize operational efficiency

Optimizing operational efficiency is achieved in part by consolidation and virtualization, but also by implementing advanced storage features such as the following items:

- Data tiering: Categorizing data storage performance and data performance requirements, and matching those automatically
- Deduplication: Removing duplicate data
- Compression: Reducing the physical space taken by data
- Self-tuning: Disk failure management, array rebuilding, call home, proactive test on performance degradation

Each of these items is discussed in further detail in 3.2, “Storage efficiency” on page 41.

Automate

Automated processes result in significant cost reductions within the storage management discipline. Opportunities to automate can include the following items:

- A service catalog with self-provisioning capability
- Monitoring user activity and integrating this data with a chargeback system, which enables pay-per-use
- Policy-driven automation for data movement (replication, tier management, backup)

A different approach

So what really differs about provisioning cloud storage services by using these steps? The traditional IT approach to storage tends to pull together resources and deploy them in support of a business function workload in silos. The resources are dedicated to the workload and are unable or ill-suited to support other workloads when they might be needed.

By contrast, cloud storage uses a pool of optimized shared resources in an environment that uses virtualization of the physical assets to support multiple workloads. To achieve efficiency of the delivery of the storage services, self-service and self-management are required. These in turn rely on standardization of the assets and automation to enable a responsive user experience.

By following these steps to storage cloud, your infrastructure should be able to provide resources in support of any storage cloud delivery model (public, private, hybrid, or community), and will finally be cloud-ready.

When you have a roadmap for your journey to storage cloud, you can take the next step.

6.3 Take the next step

Now that you have identified where you are in your storage cloud journey, where you want to be, and what you need to do to get there, you are ready to take the next step. You can focus on how you are going to take the next step. Do you have sufficient resources to take the next step on your own? Do you have sufficient skills to navigate the options? Will a technology partner make a cost-effective contribution?

Cloud storage, as with any other emerging technology, is experiencing growing pains. Some facets are immature, fragmented, and lack standardization. Vendors are promoting their own particular technology as the emerging standard. Although standards might be lacking, we believe that a set of web services API-based capabilities, accessed through non-persistent
connections on public or private networks, provides the fundamental frame of reference for accessing storage cloud services. Their definition allows for both public service offerings and private use, and provides a basis for expansion of solutions and offerings.

As a leader in cloud computing, IBM has the resources and experience to assist businesses to use or implement cloud services, including storage cloud. IBM offers technologies (hardware and software) and also key services to support you in your journey to taking advantage of cloud computing. We can assist you in planning, designing, building, deploying, and even managing and maintaining a storage cloud environment.

Whether on your premises or someone else's, IBM can make the journey move more quickly, and in many cases deliver value to the business much more rapidly, ultimately saving you money.

Clients that have implemented an IBM Smart Business Storage Cloud solution, are projecting savings as follows:

- A large client with 1.5 PB of usable unstructured file system capacity projects a savings of over $7.1 million (USD) over the course of five years in hardware acquisition and maintenance, and environmental and administration costs.
- A medium client with 400 TB of usable unstructured file system capacity projects a savings of over $2.2 million in hardware acquisition and maintenance, and environmental and administration costs.
- A small client with 200 TB of usable unstructured file system capacity projects a savings of over $460,000 in hardware acquisition and maintenance, and environmental and administration costs.

More information: The latest information that is related to IBM cloud offerings is available at the following website:


IBM personnel can assist you by developing a high-level architecture and implementation plan with a supporting business case to justify investment based on a compelling return on investment, with improved service levels and lowered costs for your cloud infrastructure. IBM consultants use a unique cloud adoption framework (CCRA) and the IBM Cloud Workload Analysis Tool to help you analyze your existing environment and determine the cloud computing model that is best suited for your business. They help you identify the business areas and workloads that, when migrated to a cloud computing model, can enable you to reduce costs and improve service delivery that is in line with your business priorities.

Figure 6-1 on page 123 illustrates the comprehensive structured approach that IBM brings to a cloud implementation engagement. This approach helps IBM to perform a rigorous analysis of your IT and application infrastructure, and provides recommendations and project planning for streamlining your infrastructure and processes. The IBM methodology incorporates key practices, learned from engaging with leading businesses around the globe, and partnering with them on their storage cloud journey.
Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this paper.

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.

- Cloud Computing Patterns of Expertise, REDP5040
- IBM SmartCloud: Building a Cloud Enabled Data Center, REDP4893
- IBM System Storage Data Encryption, SG24-7797
- IBM System Storage Solutions for Smarter Systems, SG24-7945
- IBM XIV Storage System Gen3 Architecture, Implementation, and Usage, SG24-7659
- Implementing IBM FlashSystem 840, SG24-8189
- Implementing the IBM SAN Volume Controller and FlashSystem 820, SG24-8172
- Implementing IBM Storage Data Deduplication Solutions, SG24-7888
- Implementing the IBM Storwize V7000 Unified, SG24-8010
- Implementing the IBM Storwize V7000 V6.3, SG24-7938
- Implementing the IBM System Storage SAN Volume Controller V6.3, SG24-7933
- SmartCloud Storage Access V1.2 Implementation Guide, SG24-8120
- SONAS Implementation and Best Practices Guide, SG24-7962
- Tivoli Storage Productivity Center V5.1 Technical Guide, SG24-8053
- Using the IBM XIV Storage System in OpenStack Cloud Environments, SG24-4971

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

Online resources

These websites are also relevant as further information sources:

- European Storage Competence Center (ESCC) CoC for OpenStack storage
- IBM Cloud Computing Reference Architecture v2.0
  https://collaboration.opengroup.org/cloudcomputing/documents/23840/CCRA.IBMSubm ission.02282011.doc
IBM SmartCloud Virtual Storage Center Solution, IBM Redbooks Solution Guide
http://www.redbooks.ibm.com/abstracts/tips0991.html

IBM SmartCloud Storage
http://www.ibm.com/systems/storage/solutions/cloud

IBM Cloud Offerings

IBM SmartCloud Service offerings
- IBM BCRS Cloud Managed Backup
- IBM SmartCloud Managed Data Vault
- IBM Smart Business Storage Cloud
- IBM SmartCloud Federal Community

IBM SAN Volume Controller (SVC) Information Center

IBM Scale Out Network Attached Storage (SONAS) Information Center

IBM Storwize V7000 Unified Information Center

IBM XIV Storage System Information Center
http://publib.boulder.ibm.com/infocenter/ibmxiv/r2/index.jsp

Implementing FlashSystem 840 with SAN Volume Controller, IBM Redbooks Solution Guide
http://www.redbooks.ibm.com/abstracts/tips1137.html

Managing IBM Storwize V7000 Storage with OpenStack
http://www.youtube.com/watch?v=W54xvxz-Gvc

OpenStack GPFS Block Storage Driver: Havana Highlights
https://www.youtube.com/watch?v=q-0-VPs0K8w

OpenStack volume migration and IBM Storwize systems
http://www.youtube.com/watch?v=cwt1n6s83mQ

Patterns for Cloud Computing, IBM Redbooks Solution Guide
http://www.redbooks.ibm.com/abstracts/tips1071.html

Thoughts on Cloud: cloud computing conversations led by IBMers
http://thoughtsoncloud.com

Using the IBM DS8870 in an OpenStack Cloud Environment, IBM Redbooks Solution Guide
http://www.redbooks.ibm.com/abstracts/tips1150.html

- XIV for Cloud with OpenStack demo
  http://www.youtube.com/watch?v=RgAYTUNrWe0

Help from IBM

IBM Support and downloads
ibm.com/support

IBM Global Services
ibm.com/services
What is a storage cloud?

This IBM Redpaper publication takes you on a journey that surveys cloud computing to answer several fundamental questions about storage cloud technology. What are storage clouds? How can a storage cloud help solve my current and future data storage business requirements? What can IBM do to help me implement a storage cloud solution that addresses these needs?

Why would I want one?

We show how IBM storage clouds use the extensive cloud computing experience, services, proven technologies, and products of IBM to support a smart storage cloud solution designed for your storage optimization efforts. Clients face many common storage challenges and some have variations that make them unique. We describe various successful client storage cloud implementations and the options that are available to meet your current needs as well as position you to avoid storage issues in the future. IBM Cloud Services (IBM Cloud Managed Services and IBM SoftLayer) are highlighted as well as the contributions of IBM to OpenStack cloud storage.

How can I get one?

This paper is intended for anyone who wants to learn about storage clouds and how IBM addresses data storage challenges with smart storage cloud solutions. It is suitable for IBM clients, storage solution integrators, and IBM specialist sales representatives.