

Regaining Control of Storage Growth with Thin Provisioning

Using Virtual Storage Capacity to Simplify Administration, Reduce Application Downtime, and Lower Infrastructure Costs

A Performance Brief

By Nigel Hall

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Executive Summary

Enterprise storage growth is out of control. New storage-hungry business applications and more stringent data retention demands are partly to blame. But the most significant cause of storage proliferation is the compound growth of unused and unusable capacity.

Industry analysts estimate that as much as 75 percent of storage allocated to enterprise applications remains unused. This surplus is a result of routine over-allocation and under-utilization of storage capacity, and it is imposing an enormous burden on the information technology (IT) infrastructure. Stranded capacity not only wastes capital resources but also massively inflates the cost of managing storage, as administrators host, provision, manage, back up, mirror, and replicate unused space.

Thin provisioning addresses the problem of over-allocated and under-utilized capacity by improving storage allocation efficiency and dramatically simplifying storage provisioning. Using virtual storage volumes, applications are given access to as much storage capacity as they can usefully use, without requiring matching physical resources. Behind the scenes, the storage infrastructure provides just enough physical capacity to satisfy today's data requirements. As demand grows, the application is assigned more capacity from a common pool of physical resources. The provisioning of new capacity takes place automatically, without requiring application downtime or operator intervention.

Thin provisioning is a radical new approach to storage, but a logical next step for storage virtualization. By divorcing application servers from the day-to-day mechanics of the physical storage infrastructure, thin provisioning helps to create a dynamic IT environment that is more responsive to business user needs.

With the release of the Hitachi Universal Storage Platform™ V, Hitachi Data Systems offers support for thin provisioned storage allocations on the world's most advanced storage system. Offering instantaneous access to virtual capacity, the thin provisioning capabilities of the Universal Storage Platform V promise to ease storage management, reduce application downtime, speed the delivery of new business functionality, simplify capacity planning, and deliver substantial capital and operational cost savings.



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Analyzing the Cost of Excessive Storage Growth

Accurately predicting the future storage needs of an organization has always been a perplexing problem for enterprise IT managers. Knowing when and how much capacity to add to the infrastructure in time to avoid application shortages is a balancing act. Add too much and capital expenditures are wasted on idle and unused resources. Add too little and risk application outages and downtime for business users, with the consequent effects on revenue, customer satisfaction, and employee productivity.

With 24-by-7 access to business applications now commonly viewed as a baseline service level, and under intense pressure to respond faster to the needs of developers and business users, storage managers have understandably erred on the side of safety and over-allocated physical storage resources. Unfortunately, this has had disastrous results. The combination of unprecedented demand for disk space and routine over-allocation has led to an explosion in the growth of enterprise storage.

Managing the huge amounts of storage capacity deployed in the enterprise data center is a major problem for IT. Instead of speeding application deployment and making IT more dynamic, over-allocation has made storage management more complex and slowed administrator responsiveness to the needs of the business. With more storage to manage, routine maintenance tasks take longer to complete, backup run times increase, data replication becomes more complicated and requires more space, recovery from failure is slower, and costs escalate.

The Failure of Capacity Planning

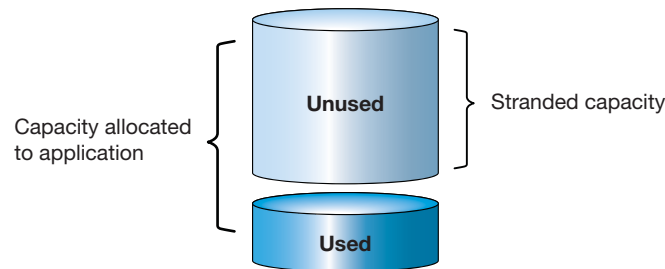
In the conventional application development lifecycle, capacity planners would make a detailed assessment of the storage needs of a business process before physical resources were allocated. However, the complex process of capacity planning, which requires specialized tools, experienced IT staff, input from a variety of groups around the organization, and, most importantly, time, is increasingly being viewed as an unacceptable delay in the application development timeline. In the rush to roll out new functionality to business users, formal capacity planning is now routinely bypassed. And this is leaving storage managers with sparse insight into the resource needs of the business.

With insufficient information about future demand, estimates of anticipated storage consumption are little more than a best guess. And, because new application adoption is unpredictable and planned developments can get shelved, the best guess approach to estimating storage needs invariably leads to capacity being over allocated and in the wrong place.

Over-allocated and Unusable Capacity

The consolidation and sharing features of storage area networks (SANs) and massively scalable storage systems have substantially improved storage infrastructure utilization rates. Unlike direct attached storage (DAS) configurations, where capacity was held captive by each host server, today's shared storage environments are much more efficient. However, the problem of stranded infrastructure capacity persists, as shown in Figure 1. Once storage is assigned to an application, it becomes costly and complicated to reclaim any over-allocated space.

Figure 1. Stranded Storage Capacity



Over-allocated and unused storage capacity is often stranded in the infrastructure.

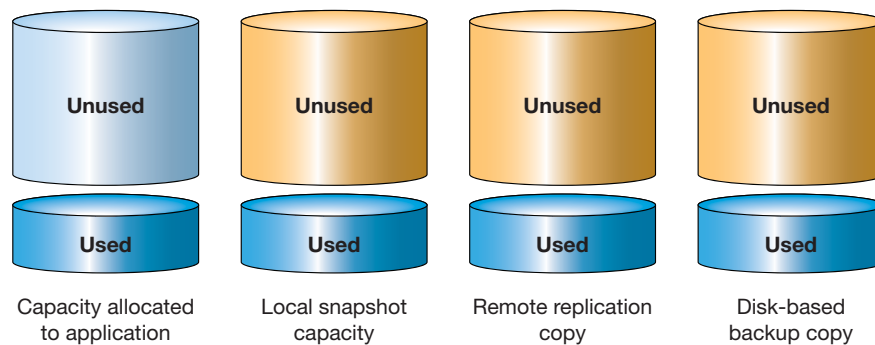
Whether due to over-zealous, best-guess capacity planning or to applications not proving as popular as planned, over-allocated storage capacity is almost never retrieved. Reassigning the unused capacity requires taking applications offline while smaller allocations are provisioned and data is moved. For many business users this overhead is too costly, and rather than incur downtime, stranded capacity is simply left in the infrastructure.

Storage Provisioning and Application Availability

Storage provisioning—allocating new physical storage resources to an application—is a cumbersome process. Based on space estimates, physical storage resources are purchased, often annually. Hard disk capacity is then made available to the storage system. After this, new resources are mapped to each application host. And, the logical representation of the physical disk is finally made available to the application, database, or file system. Along the way, administrators must bind storage allocations to ports, modify switch zoning, and adjust disk, LUN, volume, backup, and replication configurations.

The overwhelmingly manual process of provisioning application storage capacity is responsible for much of a storage administrator's daily workload. Adding new capacity involves scheduling activities with multiple groups in the organization and frequently requires application downtime while resources are assigned to each host server. As the total amount of storage capacity deployed in the infrastructure grows (see Figure 2), the task of provisioning resources to applications becomes increasingly complicated, time-consuming, and error prone.

Figure 2. Unused Storage



The compound growth of over-allocated capacity inflates storage infrastructure size.

Storage administrators rarely have visibility into the capacity allocated to an application. Without insight into how much storage is actively being used, backups, snapshots, and data replication must copy all allocated resources. The copying of unused capacity compounds the problem of storage growth by increasing the size of the storage infrastructure, raising the cost of business continuity and backup processing, tying up tape library resources, and extending the time taken to recover application data from failure.

Escalating Cost of Storage

The systemic over-allocation and under-utilization of storage capacity has led to massive over-provisioning of the storage infrastructure. Analysts estimate that enterprise storage allocation efficiency ranges from 25 percent to 50 percent. This represents an enormous waste of resources and means that organizations are paying far too much for the usable capacity of their storage infrastructure. As the demand for storage grows and infrastructure costs escalate, the over-allocation of capacity ties up valuable capital resources and frequently leads to the premature purchase of new storage systems.

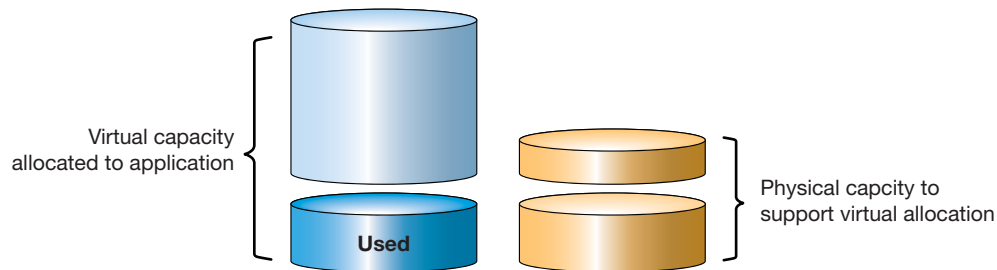
In addition to raising capital expenses, maintaining an under-utilized enterprise storage infrastructure increases day-to-day operational costs. Regardless of whether capacity is fully utilized, the disks in each storage system are still spinning, consuming data center power and cooling resources. As deployed capacity grows, more administration staff is needed to maintain the storage infrastructure. And, license fees for storage software solutions based on total physical capacity managed also increase. The combined effect of over-allocation substantially raises the cost of the storage environment.

Thin Provisioning: Extending Storage Virtualization to the Server

Poor utilization of storage capacity is a major problem for all enterprise IT organizations. But a new approach to allocating application storage resources promises to significantly improve utilization rates, and in the process ease the burden of storage provisioning, reduce application downtime, rein in capacity growth, and lower storage infrastructure costs.

Thin provisioning is a special application of storage virtualization technology that abstracts the interface between a host server and the physical storage infrastructure (see Figure 3). Mapping only data that is written by the application to physical storage, thin provisioned volumes enable administrators to allocate virtual capacity without requiring all physical resources to be in place to support the allocation. As more capacity is needed, the storage system dynamically allocates additional space to the virtual volume from a common pool of physical resources. This dynamic adjustment of the available space takes place without intervention from the administrator and without downtime for application users.

Figure 3. Virtual Capacity Allocation



Thin provisioning requires fewer physical storage resources.

An example clearly illustrates the thin provisioning concept. Imagine an application that is predicted to use 2 terabytes (TB) of storage capacity over its anticipated 10-year life span, but needs only 200 gigabytes (GB) to function today. In a thin provisioned world, the application is allocated 2TB of virtual capacity at the very beginning of its life. But, under the covers, the storage system assigns only 200GB of actual physical space. As the application adds data, the storage system automatically increases the amount of physical storage available to meet the new demand. When the pool of physical capacity requires more resources, preset alerts notify the administrator that storage must be added. The process of automatically allocating capacity to the application and of adding new physical resources to the pool takes place without affecting service to end users. As far as the application is concerned, nothing has changed.

Easing the Burden of Storage Provisioning

Thin provisioning dramatically eases the administrative burden of storage provisioning. With allocation of application disk space automatically managed by the storage system, administrators no longer need to perform the complex process of manually adding new capacity.

Adding physical storage resources to the infrastructure is also simplified. Thin provisioning allows administrators to top up the storage pool with disk capacity at any time without affecting application availability.

Speed Application Deployment and Reduce Downtime

Thin provisioning virtualizes the interface between the application and the physical IT infrastructure. Using thin provisioned volumes, applications and business users are effectively insulated from the day-to-day operation of the storage environment. With access to virtual capacity, developers are free to deploy applications without waiting for all physical storage resources to be in place. This speeds the rollout of new business functionality by eliminating the traditional delays associated with storage provisioning and capacity planning.



As application demand for storage capacity grows, the amount of physical disk space allocated to virtual thin provisioned volumes is automatically increased. The storage system adds physical resources to the virtual allocation without any interruption to application service levels.

Effective Capacity Planning

Thin provisioning reinvents and legitimizes the process of enterprise storage capacity planning. Aggregating demand for application storage in a common pool gives capacity planners a real-time picture of demand, without laboriously cataloging the individual needs of each business process. Rather than purchase new resources based on a best guess at future consumption, thin provisioning enables administrators to monitor the pool of physical capacity and top up the storage when actual usage reaches predetermined thresholds.

Rein in Storage Growth

For organizations struggling to cope with the phenomenal increase in demand for storage, the excessive slack in the infrastructure introduced by over-allocated and stranded capacity distorts the calculation of how much new space is needed to satisfy growth. Each new purchase of capacity originating from this inaccurate baseline only aggravates the problem.

Thin provisioning eliminates the slack in the storage environment and ensures all physical capacity is optimally allocated to applications. For many organizations, this will result in a reduction in size of the storage infrastructure and future growth will reflect the true needs of the organization.

Reduce CAPEX and OPEX Costs

The ability to incrementally add storage capacity to the common pool of physical resources used by thin provisioned volumes saves capital and operational expenses (CAPEX and OPEX). Rather than purchase a full year of anticipated storage capacity ahead of time, thin provisioning allows IT planners to make incremental purchases as and when needed to keep the physical pool of storage within acceptable thresholds.

By eliminating under-utilized and stranded storage capacity, thin provisioning also lessens the amount of space needed for backup, snapshot, and replication copies. The cumulative effect of this decrease in space can reduce the size of the storage infrastructure, freeing data center floor space, lowering cooling and power requirements, and reducing software licensing fees.

With the introduction of the Hitachi Universal Storage Platform V, the latest generation of the industry's most sophisticated storage system, Hitachi Data Systems provides a thin provisioning capability that promises to revolutionize the enterprise storage infrastructure and rein in rampant storage growth.

Hitachi Dynamic Provisioning™ Software

The Universal Storage Platform V is a comprehensive, fully integrated, universal storage services platform offering the highest levels of storage capacity, availability, functionality, and performance at the lowest total cost of ownership (TCO). An evolution of the industry-leading Hitachi Universal Storage Platform, the Universal Storage Platform V offers improved performance, higher availability, and greater scalability than its predecessor, in addition to refining existing features and providing substantial new functionality (see Table 1).

Table 1. Hitachi Universal Storage Platform™ V—New Features Summary

Extended Performance 3.5M IOPS
Extended Scalability 247PB
224 Fibre Channel ports
112 IBM® ESCON® ports
112 IBM FICON® ports
Thin Provisioning option
FICON-attached External Storage Support*

* 4Q2007

Building on the proven technical superiority and industry thought leadership established by the Universal Storage Platform, with its 100 percent data availability guarantee, logical partitioning, and Hitachi Universal Replicator software; the Universal Storage Platform V extends these capabilities with the fourth generation of the massively scalable crossbar switch architecture and the second generation of the unique embedded virtualization layer.

The Universal Storage Platform V supports optional thin provisioning capabilities that promise to fundamentally alter the way storage is allocated to applications. Using the new Hitachi Dynamic Provisioning™ software, the Universal Storage Platform V divorces the logical allocation of capacity to business applications from the physical landscape of the storage infrastructure. This virtualization of application storage allocations has an enormous affect on enterprise IT, simplifying storage provisioning, speeding application deployment, reducing downtime, improving I/O performance, controlling storage growth, and lowering costs.

One-shot Storage Provisioning for Enterprise Applications

Dynamic Provisioning software transforms the process of allocating storage to enterprise applications from a mundane daily chore to a one-time event. Using thin provisioned volumes, an administrator can allocate as much virtual storage capacity as an application will need during its lifetime.

Once allocated, the Universal Storage Platform V monitors usage of thin provisioned volumes and automatically assigns new physical disk resources when needed. Administrators no longer need to manage the storage allocations of each application. And, as long as the application does not outgrow its virtual volume, and physical disk space is available in the resource pool, Dynamic Provisioning software ensures the application will never run short of storage.

In addition to simplifying the process of provisioning application storage, Dynamic Provisioning software makes it easier to add physical capacity to the Universal Storage Platform V. Because application storage allocations are abstracted from the physical infrastructure, adding new storage system capacity does not affect availability. This allows administrators to increase the size of the shared physical storage pool without compromising end-user access to data.

Faster Application Deployment with Less Downtime

The virtual storage capacity provided by Dynamic Provisioning software liberates application developers from the constraints of the physical storage infrastructure. With the ability to over-allocate application storage capacity, administrators can quickly deploy thin provisioned volumes without the risk of stranding storage capacity in the infrastructure.



Providing applications with instant access to storage capacity alleviates a significant source of delays in the application development process. The automated provisioning of physical space to virtual volumes also eliminates the potential for downtime when additional capacity is required after an application is rolled out to business users.

In-house Expert on I/O Performance

Optimizing application I/O performance is a complex task that involves spreading individual storage allocations of an application across all available spindles in the storage system to avoid hot spots. This process becomes even more complicated when the I/O patterns of multiple applications sharing the same storage system are taken into account. For many organizations, the specialized knowledge needed to maintain well-balanced I/O must be obtained externally, because in-house IT staff does not have the necessary expertise.

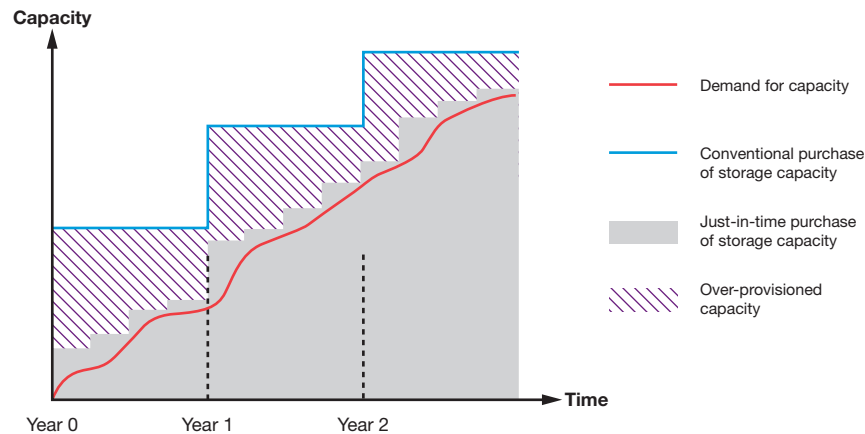
Dynamic Provisioning software eliminates the need for outside experts when fine-tuning application I/O performance. The Universal Storage Platform V controls the precise location of each physical allocation in a thin provisioned storage volume. Using wide striping techniques, the storage system automatically spreads the I/O load of all applications accessing the common pool of storage across the available spindles. This process eliminates hot spots and optimizes I/O response times, leading to consistently high application performance.

Just-in-time Control of Storage Growth

The thin provisioning capabilities of the Universal Storage Platform V give IT managers and enterprise capacity planners more control of storage growth than ever before possible. Abstracting the uncertainty of application demand for disk space from the physical storage infrastructure, the Universal Storage Platform V makes actual growth and true capacity usage visible for the very first time. With this information in hand, enterprise capacity planners can make more informed choices about how to provision for the future storage needs of the organization without wastefully over-allocating resources.

The Universal Storage Platform V does not simply provide greater insight into storage growth and usage; it offers a completely new way to leverage this information when provisioning capacity for enterprise applications. Thin provisioning supports the purchase of new physical storage resources on an as-needed basis. Like the just-in-time method of inventory planning that revolutionized manufacturing industries by eliminating the need to maintain costly stocks of goods for yet-to-be-determined orders, the Universal Storage Platform V supports just-in-time storage provisioning, allowing administrators to purchase and provision new resources only when they know that the storage is going to be effectively used. (See Figure 4.)

Figure 4. Just-in-time Provisioning



The advantage of just-in-time provisioning of physical storage capacity is the avoidance of over provisioning.

Thin provisioning puts an end to the tradition of maintaining expensive storage resources that sit idle in the data center. Moving to a just-in-time model of storage provisioning allows the incremental addition of capacity to the common storage pool. This reduces the total cost of storage ownership, provides a faster return on investment for storage purchases, and eliminates waste from the infrastructure.

Lowering the Cost of Enterprise Storage

There are many components that contribute to the total cost of enterprise storage ownership. The capital expenses associated with purchasing storage hardware and software, and operational expenses for storage administration staff and data center power and cooling, are primary. Less obvious are soft costs like data protection effectiveness, disaster preparedness, regulatory compliance, and the speed with which the storage infrastructure can respond to the needs of application developers. The thin provisioning capabilities of the Universal Storage Platform V reduce every identifiable cost associated with the enterprise storage infrastructure.

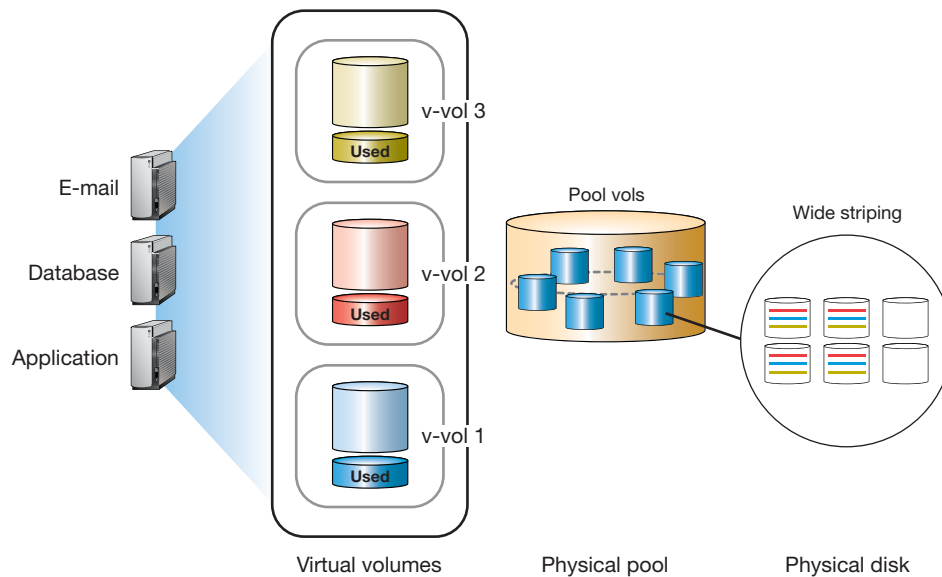
Thin provisioning has a dramatic affect on capital and operating costs. Using virtual allocations, the Universal Storage Platform V is able to satisfy the storage demands of business applications using a small fraction of the total capacity otherwise needed. With more efficient use of resources, organizations can maintain a smaller storage infrastructure. Just-in-time provisioning of future storage growth also leads to smaller, more frequent, but less costly purchases of storage hardware.

With less total capacity to maintain and manage, and the resulting reduction in size of the backup, business continuity, and archiving infrastructures, organizations may find that they are able to reduce storage management head count. Licensing costs for storage management software are also reduced. And with fewer resources on the data center floor, power and cooling costs also go down.

How Dynamic Provisioning Software Works

The thin provisioning capabilities of the Universal Storage Platform V use three primary components: a pool of physical storage capacity, virtual volumes called V-VOLs, and a management area that maps V-VOLs to pools. The Universal Storage Platform V supports up to 32 pools, each of which can contain 256 pool volumes (pool-VOLs). The total physical capacity of a pool is the sum of all pool-VOLs. (See Figure 5.)

Figure 5. Hitachi Dynamic Provisioning™ Software



The Universal Storage Platform V uses Dynamic Provisioning software to present V-VOLs to application host servers.

The Universal Storage Platform V presents V-VOLs to application host servers. Unlike the pool and pool-VOLs, V-VOLs are virtual. A V-VOL can contain up to 2TB of capacity, but the size of the V-VOL has no effect on the physical space of the storage system. Each V-VOL is associated with a single pool of capacity, and a pool can host up to 4096 V-VOLs.

Once a V-VOL is associated with a pool, a path definition is created to assign the V-VOL to an application host server. As the application writes data to the V-VOL the Universal Storage Platform V allocates physical capacity from the pool. Administrators monitor pool usage with the Hitachi Storage Navigator interface. Multiple thresholds can be set to alert administrators when more capacity is needed.

Qualifying Applications

Thin provisioning is a simple-to-implement, easy-to-use technology that promises to revolutionize storage provisioning. However, as with any new technology, universal adoption is not instantaneous.

Not all applications are designed to take advantage of thin provisioned volumes. Some file system and database applications pre-initialize their storage allocations, effectively writing pre-formatted data records to all assigned capacity. For these applications, the physical capacity allocation from using Dynamic Provisioning software will equal that of traditional provisioning processes. Although there is no capacity advantage, Dynamic Provisioning software still offers these applications the benefit of simplified storage provisioning and automated performance management.

The benefits from thin provisioned storage volumes are so great that it is likely that vendors will respond by introducing features that can take advantage of the technology. Already, Oracle has included auto-extend capabilities in its 10G database product to support the incremental growth of database files, automating the process of increasing storage allocations.

A Thin Provisioning Return on Investment (ROI) Scenario

A Return on investment (ROI) calculation is very individual. Different organizations favor inclusion of different sets of costs, and the base value of those costs can vary significantly depending on geography, type of business, and other factors. The ROI analysis represented in Table 2 is, by design, rudimentary. The intent is not to include all conceivable storage infrastructure costs in the analysis, but to highlight the magnitude of the capacity cost savings achieved by implementing a thin provisioning solution. All US dollar values in the calculations are provisional.

Table 2. Analyzing Thin Provisioning Return on Investment

	<i>Conventional</i>	<i>Thin provisioned</i>
Application storage requirement (TB)	8	8
RAID-1 overhead	8	8
Additional local copy	16	16
Business continuity remote copy	16	16
Active capacity @ 50% utilization	24	24
Total storage capacity provisioned	48	24
Anticipated growth @ 30% CAGR	15	8
Thin provisioning 20% margin		6
Total TB capacity for year	63	38
Cost of storage @ \$8,000 per TB	\$504,000	\$304,000
Price of thin provisioning solution per TB		\$2,000
Extended thin provisioning cost		\$76,000
Total cost of thin provisioning (hardware and software)		\$380,000
Saving on initial capacity purchase		\$124,000
First year ROI		32%

A more comprehensive ROI calculation would include other infrastructure costs that are dependent on storage capacity. These include: storage management overhead, data center floor space costs, data center power and cooling expenses, software licensing fees, business continuity costs, backup infrastructure costs, compliance costs, and data archival costs. Factoring in all IT infrastructure expenses associated with the amount of deployed storage capacity will substantially boost the ROI results beyond the 32 percent achieved in this example.

Conclusion

Excessive growth of the enterprise storage environment is a widespread problem. No organization or industry is immune. It is easy to find fault with any of a number of IT processes that contribute to the problem, but the real issue is in the interface between an application and its storage.

Business users understandably want a fast-moving application development process that can respond quickly to new opportunities. And the physical storage infrastructure is, by nature, inflexible, requiring time and resources to change.



Thin provisioning solves this problem. A completely new approach to allocating capacity, thin provisioning virtualizes the interface between an application and its physical storage, adding flexibility and speed where before there was neither. A logical next step for storage, thin provisioning is destined to become a standard feature of all enterprise storage systems.

Recognizing the importance of moving the value of storage virtualization closer to business users, the new Hitachi Universal Storage Platform V adds thin provisioning capabilities to its existing lineup of best-in-class features. The most comprehensive and fully integrated universal storage services platform on the market today, the Universal Storage Platform V continues to set the standard for enterprise-class storage.



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