Optimize Thin Storage Utilization with Hitachi Dynamic Provisioning and Veritas Storage Foundation by Symantec

Thin Provisioning and Storage Reclamation

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Executive Summary

Thin provisioning has the potential to deliver on three long elusive goals of data center architects and administrators:

1. Eliminate storage waste and ensure that the amount of physical storage allocated to a host closely matches the actual amount of data generated by the applications it supports.

2. Simplify storage provisioning by provisioning large volumes up front and relying on the thin provisioning functionality in the storage systems to allocate physical storage on an as needed basis; this dramatically reduces the time typically spent adding storage to hosts in a data center.

3. Automate the difficult tasks of storage performance optimization, including disk or spindle layouts and system load balancing.

As more and more people take advantage of Hitachi storage system-based thin storage, it is becoming clear that to get a fully optimized thin storage environment that delivers on the promise of waste elimination, there is a need for complementary functionality with a thin-aware host storage management stack, such as Veritas Storage Foundation by Symantec. Hitachi and Symantec collaborated to ensure that the joint thin storage solution integrating Hitachi Dynamic Provisioning and Veritas Storage Foundation is stable, jointly tested and supported.

Veritas Storage Foundation is the first solution in the industry to deliver this continuous, fully automated, nondisruptive optimization of thin storage environments on the server side. Frequent expansions and contractions of data cause thin systems to ultimately become fully populated (i.e. become thick volumes). This paper examines how Veritas Storage Foundation enables smart migration and active storage reclamation in a Hitachi storage thin provisioning environment to achieve initial and ongoing higher storage utilization levels.
Eliminate Overprovisioning of Physical Storage with Thin Provisioning

Thin provisioning is a storage virtualization method for optimizing utilization and performance of available storage. It employs on-demand allocation of blocks of data versus the traditional method of allocating all the blocks up front. This methodology eliminates the overprovisioning of physical storage, which contributes to the poor utilization rates that occur with traditional storage allocation methods, in which storage capacity is allocated to individual servers but remains unused.

The traditional method of provisioning fully populated physical volumes is often called “fat” or “thick” provisioning. Thin provisioned volumes are virtual, with the actual storage being drawn from a larger pool and mapped in blocks only when and where writes come in for the volume. Usually, a fixed number of blocks are mapped in at a time to minimize overhead on the system. Hitachi Dynamic Provisioning calls this group of blocks a “page.” From an application’s standpoint, a virtual thin provisioning volume looks no different from any other storage volume. As applications write data to it, thin provisioning software on the storage system assigns actual capacity from the pool to that virtual volume. Coincidentally, if a virtual thin provisioning volume has garnered all the blocks it could possibly map, then the volume can also be considered a “thick” volume.

With thin provisioning, storage capacity utilization efficiency can be automatically driven upwards with very little administrative overhead. Organizations can purchase less storage capacity up front, defer storage capacity upgrades in line with actual business usage and save the operating costs (electricity and floor space) associated with keeping unused disk capacity spinning.

**TEN WAYS THAT THIN PROVISIONING SAVES MONEY**

1. Less storage is required initially when purchasing a new storage system.
2. Often existing unused storage can be reclaimed and re-used.
3. Since there is less stranded storage capacity, less storage is required over the life of the storage system.
4. The need for additional storage systems is minimized given increased utilization rates.
5. The time and resources required to perform storage provisioning tasks are reduced.
6. The time and resources required to perform storage optimization and tuning are reduced.
7. "Thin provisioning-aware" local and remote volume copy services consume less capacity.
8. Fewer storage system software licenses based on capacity are required.
9. Operating costs stemming from space, power and cooling costs are reduced.
10. Thin Provisioning enables a truly dynamic, on-demand, always optimized storage environment.
Traditional provisioning, or “thick” provisioning, generally required large amounts of storage to be physically pre-allocated because of the complexity and impact of growing a volume’s (LUN) space. Thin provisioning permits larger overallocated LUNs to be provisioned without the cost of physically pre-allocating storage. (See Figure 1.) These LUNs can be allocated while the physical storage allocation is deferred and later added on a “just in time” basis. Oversubscription is when total provisioned LUN capacity exceeds the available physical storage capacity. Storage utilization efficiency is improved by higher subscription levels. Oversubscription can be achieved because LUNs are frequently overallocated.

Figure 1. Oversubscription of storage in thin provisioning environments allows for the delay of physical storage purchase.

Thin provisioning implementations also offer significant performance benefits. Dynamic Provisioning pages mapped to virtual volumes are drawn from and balanced across a large number of physical disk spindles. In contrast, a traditional LUN would normally only use the few spindles in a single RAID group. The virtual volume I/Os are actively load balanced since the shared pool effectively combines many application I/O patterns and spreads the I/O activity evenly across a wide amount of physical resources. This optimization eliminates the challenges of predicting I/O patterns that may result in contention and performance bottlenecks (hot spots), which often subsequently must be addressed manually. Thin provisioning optimizes the aggregate throughput and generally delivers the best performance automatically. Traditional thick volumes cannot easily permit the storage administrator to achieve a balanced I/O workload across physical storage resources while thin provisioned volumes, even in a “thick” state, automatically achieve a balanced workload.

Thin provisioning is seeing increased adoption in the IT data center and is available in some form from most major vendors for their storage platforms. According to TheInfoPro’s recent Storage Study (Q4 2009), over a six month period (from Q2 2009 to Q4 2009), thin provisioning became more than twice as likely to be a top initiative for Fortune 1000 storage professionals, moving it to the top of the TheInfoPro’s Storage Management Technology Heat index.
Hitachi Storage Controller-based Thin Provisioning

**Hitachi Dynamic Provisioning Software**
The Hitachi Dynamic Provisioning software is the thin provisioning solution for Hitachi Universal Storage Platform® V and Universal Storage Platform VM systems and the Hitachi Adaptable Modular Storage 2000 family. Dynamic Provisioning software simplifies storage administration, improves performance and offers storage capacity cost savings. Using the "just in time" method, the Dynamic Provisioning software allows storage to be allocated to an application without being physically mapped until it is used. This ensures storage is only allocated when it is needed and allows the storage allocation to actually exceed the amount of storage physically installed. It also proactively alerts storage administrators before more physical storage is required; physical storage is then nondisruptively added to the storage systems as it is needed. Using the Hitachi Universal Storage Platform V or Universal Storage Platform VM with Universal Volume Manager and Dynamic Provisioning organizations can extend the life of externally virtualized storage by enabling new methods to improve performance and minimize cost (see Figure 2).

**Figure 2. Hitachi Dynamic Provisioning helps to enable new methods for performance improvement and cost reduction.**

![Diagram](image)

Hitachi Dynamic Provisioning offers:
- Improved operational provisioning capabilities
- Optimized aggregate throughput, which generally delivers the best performance automatically
- Effectively combined application I/O patterns, which spread I/O activity across all available physical resources
- Virtual volumes, which support capacity savings
- Compatibility with Hitachi TrueCopy® Synchronous/Extended Distance, Hitachi Universal Replicator, Hitachi Copy-on-Write Snapshot, Hitachi ShadowImage® Heterogeneous Replication and ShadowImage Replication software products
- Decoupled provisioning of storage to an application from the physical addition of storage capacity to the storage system

Dynamic Provisioning provides the following benefits:

- **Ease Storage Additions, Reduce Cost and Complexity:** With Hitachi Dynamic Provisioning software, application storage provisioning is much simpler, faster and less demanding on the administrator than the extensive orchestration required by traditional provisioning. An administrator can, independent from hardware management concerns, provision Dynamic Provisioning volumes to applications. Administrators can then centralize their system management attention on a few Dynamic Provisioning pools, whether the storage is internal to the Hitachi Adaptable Modular Storage system, the Hitachi Universal Storage Platform V, the Universal Storage Platform VM or any other externally virtualized storage.

When more physical storage is needed the administrator can simply and nondisruptively install additional physical disks and add them into the Dynamic Provisioning pools. The decoupling of physical resource acquisition and management from application provisioning simplifies storage management, reduces application outages, saves time and keeps costs down.

- **Simplify Storage Performance Optimization:** Dynamic Provisioning software effectively combines many application I/O patterns and spreads the I/O activity across all available physical resources. This optimization eliminates the challenges of predicting I/O patterns that may result in contention and performance bottlenecks, which subsequently must be addressed manually by migrating application data over more spindles. Dynamic Provisioning software optimizes aggregate throughput and generally delivers the best performance automatically. (See Figure 3.)

Figure 3. Hitachi Dynamic Provisioning software delivers for a major retail chain.
Reduce Storage Acquisition Costs by Minimizing Costs Due to Overprovisioning: A volume larger than the physical disk can be defined. This allows all anticipated capacity needed by the application to be configured initially, while only the required physical disk capacity is initially purchased and over time incrementally increased, keeping costs down. Additional physical disks can be purchased at any time and installed transparently without an application service interruption. The reduction in physical disk installed also provides savings in space, power and cooling requirements.

Reduce Application Outages When Provisioning: Because large virtual volumes can be defined in the beginning, the volume capacity does not have to be increased and the application and system configurations do not have to be changed as often, thus reducing risk and improving application availability.

Simplify Replication Provisioning: Since the desired capacity of a volume can be defined regardless of the physical disk capacity, using complex techniques such as LUSE for volume expansion is no longer necessary. Thin provisioning simplifies creation of LUNs, expansion of LUNs and subsequent definition of LUNs for replication pairs. It also saves money because the replication capacity license required is based on storage actually used. Cost benefits are further enhanced in replication environments because the savings from thin provisioning are also duplicated in the replicated volumes.

Simple Management of Dynamic Provisioning with Hitachi Storage Command Suite
Dynamic Provisioning software is integrated with Hitachi Storage Command Suite (see Figure 4) and is managed through Hitachi Device Manager and Storage Navigator programs. Management is available through both graphical and command line interfaces.

In addition, system monitoring, alerting and reporting are key components of a successful thin provisioning implementation. Providing long term capacity usage trend reports and thresholds monitoring, Hitachi Tuning Manager software assists efficient management operations for Dynamic Provisioning virtualized volumes on Universal Storage Platform V and Universal Storage Platform VM.
Optimize Hitachi Thin Storage with Veritas Storage Foundation

As more and more people try and take advantage of thin storage, it is becoming clear that getting all the potential benefits of thin provisioning requires more than advanced functionality in the underlying storage systems. While thin provisioning enables on-demand allocation of physical storage to support data written on thin LUNs, it is a well known issue that data deleted from a host does not result in physical storage being released from the thin LUN. Over time, as applications continuously write and delete data on host file systems, thin storage grows thicker as chunks of physical storage end up stranded on the thin LUN. The reason for this is that the storage system by itself cannot truly differentiate between "used" space and "unused" space.

To get a truly optimized thin storage environment, delivering on the promises of waste elimination and increased automation, there is a need to complement storage system functionality with a thin-aware host storage management stack. Veritas Storage Foundation is the first solution in the industry to deliver continuous, fully automated, nondisruptive optimization of thin storage environments.

Veritas Storage Foundation (SF) works seamlessly with Hitachi Dynamic Provisioning to provide an optimized and complete thin storage management solution that:
- Provides efficient online storage migrations from thick to thin with **Veritas Storage Foundation SmartMove**. SmartMove is the only solution in the industry that automatically reclaims all unused space in the file system during online migration from traditional storage to thin storage.

- Enables automated nondisruptive optimization of thin storage with **Veritas Storage Foundation Thin Reclamation**. Storage Foundation Thin Reclamation ensures that no physical storage is tied up supporting unused space in file systems on Microsoft Windows, UNIX and Linux hosts.

With Veritas Storage Foundation SmartMove and Thin Reclamation, Hitachi thin storage will start optimally thin and automatically remain optimally thin over time. The combination of Storage Foundation on the host with Hitachi Dynamic Provisioning leverages deep SAN automation to eliminate storage waste and ensure that only the amount of physical storage required for application data is consumed in the environment.

**Automatically Eliminate Waste During Online Thick-to-Thin Migrations**

Traditional online storage migrations invariably rely on block level copy operations, either using storage system tools, SAN switch tools or host tools. These tools all ensure that every block on the destination device are identical to the corresponding block on the source device. One problem with typical block level copy operations is that it is impossible to differentiate between a used block and an unused block without block level knowledge. As a result, block level copy operations treat all blocks equally and copy all unused blocks during a migration. When the target device is a thin LUN, the process of meticulously writing on every block of the target device triggers full allocation of the thin LUN, defeating the capacity savings purpose of virtually provisioning the storage. This is depicted in the Standard Block Level Migration in Figure 5.

**Figure 5. Veritas Storage Foundation SmartMove results in 0% wasted storage on target thin LUNs.**

![Diagram showing Standard Block Level Migration and With SmartMove™ Comparison]
The challenges associated with the traditional migration methods can only be addressed by software that is capable of differentiating used blocks from unused ones. This knowledge resides on the host file system. Veritas Storage Foundation SmartMove technology leverages this knowledge from the file system [Veritas File System (VxFS) on UNIX and Linux, and NTFS on Windows] to enable efficient online migrations of only the used blocks from thick to thin storage, effectively reclaiming unused free space.

Veritas Storage Foundation tightly integrates Veritas Volume Manager (VxVM) and the file system. Throughout an online migration operation, VxVM requests the free space map from the file system using SmartMove technology (see Figure 6). Equipped with the free space map, Storage Foundation can find out exactly which blocks are used without having to resort to block content heuristics (such as the popular but unreliable zero content check). The migration steps are identical to those performed in traditional storage system migrations and yet only used blocks are migrated. This results in faster migrations and no unnecessary space allocation on the target thin LUN. Take the example of the migration of a 500GB file system that is only 30% utilized (150GB of used space) to a 500GB thin LUN. Using traditional block level migration tools, the thin LUN after the migration would in actuality be thick, having 500GB of physical storage allocated to it. Using Storage Foundation SmartMove, the thin LUN after the migration will only have 150GB of physical storage allocated to it, just the amount required to support the used space in the file system. Storage Foundation SmartMove is the only online data migration solution that automatically ensures no physical storage is wasted supporting unused space in the file system.

**Figure 6. Veritas Storage Foundation SmartMove only migrates blocks used in the file system.**
Automatically Drive Up Storage Utilization with Storage Foundation Thin Reclamation

By definition, thin storage follows the "write-once, allocate forever" principle: the first I/O write on a block will trigger allocation of a chunk of physical storage to support it. If the data on that block is subsequently deleted in the file system, some metadata in the file system is updated, but the physical storage stays allocated, effectively stranded on the thin LUN. This simply results from the fact that by itself, the storage system cannot know whether a block is used or not and thus cannot perform reclamation of physical storage that is no longer used.

Consider a scenario where large file deletions are common. Significant number of unused storage blocks are not reclaimed by the storage system. In case that no files of similar size are created in the near term, many of these blocks will still remain unused but allocated, unavailable to other LUNs and applications. In such cases and many others, reclaiming the unused space would be beneficial to the overall physical space utilization.

Veritas Storage Foundation Thin Reclamation provides a simple and efficient method for reclaiming unused storage in thin provisioned LUNs. Simply exercise one command, either manually or through a script, to perform Thin Reclamation on storage at the granularity of a file system, a device or an enclosure.

Simple Storage Reclamation by Veritas Storage Foundation Thin Reclamation

Contrary to a storage system, Veritas Storage Foundation has detailed knowledge of the locations of unused space in the host file systems. With storage systems implementing the standards-based Storage Foundation Thin Reclamation API, hosts running Storage Foundation can communicate the location of all this unused space to the storage system. This enables the storage system to proceed and internally reclaim all physical storage that was unnecessarily allocated to the thin LUN and return to the common storage system free pool, making it available to other thin LUNs. The Thin Reclamation API leverages the SCSI WRITE SAME command with an UNMAP bit turned on to inform the storage system that all physical storage on a certain range can be reclaimed. This whole process is done "in band" with little to no performance impact on the host and storage system.

Veritas Storage Foundation Thin Reclamation API is integrated with Hitachi storage hardware and has intimate knowledge about storage hardware chunk size. This knowledge allows Thin Reclamation API to precisely calculate the chunk boundaries and the translated offset into a chunk for a certain unused block in the Hitachi storage. As a result, Thin Reclamation API can precisely indicate to the storage hardware which chunks to reclaim through the WRITE SAME SCSI commands and optimize the number of WRITE SAME commands to send to the storage hardware.

Veritas Thin Reclamation makes storage reclamation easy, online and transparent to the host and SAN. No changes to the host file system, volume size or SAN configuration are needed. (See Figure 7.) This maximizes storage availability and thus improves business continuity and agility as a whole.
Figure 7. Veritas Thin Reclamation makes storage reclamation easy, online and transparent to the host and SAN.

Simplify Thin Storage Optimization with Hitachi Storage

Veritas Storage Foundation Thin Reclamation is fully supported by Hitachi Universal Storage Platform V and Universal Storage Platform VM, and the Hitachi Adaptable Modular Storage 2000 family storage systems. Utilizing the Dynamic Multipathing (DMP) feature, Storage Foundation enables the discovery and reporting of thin devices that have been recognized and initialized on the host as "thin" or "thinrclm." The thin devices that are initialized as "thin" are capable of thin provisioning and the ones initialized as "thinrclm" are integrated with Veritas Storage Foundation Thin Reclamation as well. The command "vxdisk -o thin list" provides a list of storage devices with its size, physical allocation and type information. (See Figure 8.)

Figure 8. Output of "vxdisk -o thin list" shows disks allocated from the Universal Storage Platform V.

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>SIZE(mb)</th>
<th>PHYS_ALLOC(mb)</th>
<th>GROUP</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>uspv0_062a</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062b</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062c</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062d</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062e</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062f</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062g</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_062h</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
<tr>
<td>uspv0_0630</td>
<td>10000</td>
<td>84</td>
<td>tagdg</td>
<td>thinrclm</td>
</tr>
</tbody>
</table>
In Figure 8, we see that 10 disks have been allocated from the Hitachi Universal Storage Platform V storage. Each disk has been virtually allocated 10GB while their physical allocation is only 84MB. All 10 disks are integrated with Veritas Storage Foundation Thin Reclamation.

**Experience the Power of Thin Reclamation with Hitachi Thin Storage**

Symantec collaborates with Hitachi to ensure a seamless integration of Thin Reclamation API and Hitachi thin storage. Through the execution of a simple three-step workflow listed below on Veritas Storage Foundation enabled hosts, users can experience firsthand the benefits of Veritas Storage Foundation Thin Reclamation on Hitachi thin storage in achieving high storage utilization and savings.

**Experience the Power of Thin Reclamation**

**Step 1:** Find out how much physical storage has been allocated in thin storage via:

`vdisk -o thin list`

**Step 2:** Perform Thin Reclamation via:

`vdisk reclaim [<disk>|<dg>|<encl>]`

**Step 3:** Observe the difference in physical allocation after Thin Reclamation via:

`vdisk -o thin list`

In an environment where storage has been frequently expanded and contracted through file creation and deletion, users will observe a stark difference in physical allocation in the outputs for Step 1 and Step 3 as a result of Thin Reclamation that reclaims the unused but allocated space on Hitachi thin storage.

**Aggressive Reclamation Option**

Over time, free space can get fragmented and reduce the ability to reclaim free chunks of storage on thin LUNs. To deal with this problem, Storage Foundation\(^1\) provides an option whereby all data in the file system is moved to the front of the file system. This creates the largest possible amount of contiguous free space at the end of the file system, maximizing the effectiveness of thin reclamation.

**Conclusion**

More companies are realizing the benefits of using thin provisioning and the ability for a storage team to provision capacity on a pay-as-needed basis. Thin provisioning improves capacity utilization and performance, simplifies storage administration costs and lowers costs of ownership while cutting the up front costs of the storage system. Its flexibility largely reduces the complexity for capacity planning, maximizes availability and allows storage administrators to focus on a few storage pools.

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\(^1\) To perform aggressive reclamation on mount point/thinfs, issue the command: "fsadm -R -A /thinfs"
**Hitachi Data Systems** offers Hitachi Dynamic Provisioning on both the Hitachi Universal Storage Platform V and Universal Storage Platform VM, as well as the Hitachi Adaptable Modular Storage 2000 family storage systems.

**Veritas Storage Foundation** complements thin provisioning by offering SmartMove and Thin Reclamation API to optimize storage utilization in a thin provisioned Hitachi storage system. Storage Foundation provides simple-to-use tools to optimize Hitachi storage utilization and keep Hitachi storage “right-sized.”

Together, Symantec and Hitachi products offer a comprehensive suite of capabilities to enable you to fully optimize your storage utilization in thin provisioned storage systems.
Appendix A — Resources

Further information on the Hitachi products and solutions discussed in this white paper can be found at: www.hds.com.

Further information on Symantec products and solutions discussed in this white paper can be found at: http://go.symantec.com/storagefoundation. Product guides for Veritas Storage Foundation can be found at: http://sfdoccentral.symantec.com/.

Product Versioning

Hitachi Adaptable Modular Storage 2000 systems support these features with microcode 0883/b and later. Hitachi Universal Storage Platform V and Universal Storage Platform VM systems support these features with microcode 60-06-05-00/00 and later.

Veritas Storage Foundation supports SmartMove and Thin Reclamation API in version 5.0 MP3 and above. Supported host platforms include Microsoft Windows, UNIX and Linux. Hitachi Universal Storage Platform V and Adaptable Modular Storage systems are supported with Veritas SmartMove and Thin Reclamation API.

For further information, refer to the Veritas Storage Foundation and High Availability Solutions 5.1 Hardware Compatibility Lists provided below.

UNIX/Linux

- Storage Foundation 5.0 MP3: http://seer.entsupport.symantec.com/docs/283161.htm
- Storage Foundation 5.1: http://seer.entsupport.symantec.com/docs/330441.htm

Windows

- Storage Foundation 5.1 SP1: http://seer.entsupport.symantec.com/docs/337683.htm
Appendix B — Contacts

Below are contacts for further information on what is provided in this white paper.

Veritas Storage Foundation
- Visit the Symantec website: www.enterprise.symantec.com
- To speak with a Symantec Product Specialist in the U.S.: call toll-free 1 800 745 6054.
- To speak with a Symantec Product Specialist outside the U.S.: please visit our website for specific country offices and contact numbers.

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Hitachi Dynamic Provisioning
- Visit the Hitachi Data Systems website: www.hds.com
- If your business is in North America: call Hitachi toll-free 1 888 234 5601.
- For contact information for Hitachi offices worldwide: please visit our website for specific country offices and contact numbers.