# Lowering database storage complexity and management cost with HP Thin Provisioning XP and Oracle Database 10*g* and 11*g*.

HP StorageWorks Division, December 2007

**Table of contents**

# Executive Summary

In today's competitive environment, companies need to accelerate business growth, while keeping costs under control. A primary contributor escalating IT costs is over-provisioning storage space to solve growing database and application capacity requirements. Database and storage administrators often over-allocate storage capacity to resolve short term issues associated with application running out of space. Furthermore, traditional provisioning methodologies require database and storage administrators to endure tedious and manual tasks. As the IT industry continues to make giant leaps towards the Next Generation Data center (NGDC) to provide more agile, modular, automated and more secure data center, reducing management and implementation costs is critical.

This paper explores and outlines how to apply HP StorageWorks XP Thin Provisioning and other HP XP technologies to help simplify and manage an Oracle Database 10*g*/11*g* environment. HP Thin Provisioning (ThP) provides significant capacity usage reductions as it allows administrators to allocate storage based on traditional methods, but only consumes the actual disk capacity accessed by the application. This decreases storage over allocations and reduces wasted capacity. Oracle Database 11*g* features—Automatic Storage Management (ASM), Auto-Extend and Table Partitions—introduce important management cost and time savings through automation of previously tedious and intricate manual database and storage administrator tasks.

This joint solution demonstrates companies can lower their cost of ownership through simplified database administration and storage provisioning and configuration methodologies. Furthermore, significantly higher returns on investment (ROI) are achieved through increasing database administrator productivity, reducing storage usage capacity and faster application deployment.

# The challenges

An Enterprise Strategy Group (ESG) survey in 2006 indicated that 50% of storage customers surveyed were aware they had stranded capacity due to inefficient provisioning methods. Half of these customers had 30-50% of their storage stranded and unused which means for every 10TB of provisioned capacity 3TB to 5TB was unused.

Today, most database and storage administrators would reluctantly admit that they over-allocate storage capacity for their applications; over-allocating storage is a common practice in order to remedy short term database and storage management challenges created when applications run out of storage capacity. In addition to elevated management costs, stranded [1] capacity creates storage allocation and cost issues.

For every terabyte of traditional storage capacity, $459 per year is wasted on power and cooling of unused capacity

For example, data gathered by the department of energy indicates that the average cost per kWh (kilowatt hour) in the US was 9.86c/kWh in 2006. An average enterprise storage solution of 100TB requires about 40 kWh of power. The total daily power consumption for this storage solution can be calculated by using the following formula:

$$\text{Number of kWh} * \frac{\text{Power Cost}}{\text{kilowatt}} = \frac{\text{Power Cost}}{\text{hour}}$$

Source: Power and Storage: The Hidden cost of ownership

[1] Stranded capacity is created when storage capacity allocated to an application is unused by that application and that storage cannot be re-allocated

$$40\,\text{kWh} * \frac{9.86\text{C}}{\text{kilowatt}} = \frac{\$3.94}{\text{hour}} = \frac{\$94.56}{\text{day}} = \frac{\$34{,}514}{\text{year}}$$

This calculation does not take into account required cooling for this storage system which can be estimated by the equation (BTU = British thermal unit):

$$\frac{\text{Number of BTU}}{3.\frac{4}{1000}} * .33 * \frac{\text{Power Cost}}{\text{kilowatt}}$$

Source: Power and Storage—The Hidden cost of ownership

Approximating the number of BTU required to cool a 100TB system at 136,400 BTU the math yields:

$$\frac{136{,}400}{\frac{3.4}{1000}} * .33 * \frac{9.86\text{C}}{\text{kilowatt}} = \$1.\frac{3}{\text{hour}} = \$31.\frac{32}{\text{day}} = \$11{,}\frac{432}{\text{year}}$$

This adds an additional annual cost of $11,434 to the utility charge for a total cost of: **$45,946**.

Considering that 30-50% of capacity is stranded, up to $22,974 is spent annually to keep unused capacity online. This amount is doubled to account for additional storage required when implementing business continuance disk mirrors. Additionally, added costs are incurred through data center floor space usage. This cost is not included in the above calculation.

To address these difficult challenges this paper examines a solution based on key Oracle and HP technologies which considerably reduce total cost of ownership (TCO) while providing tremendous return on investment:

- **Reduce costs:** Cooling, power consumption, and data center footprint savings
- **Increased efficiency:** Stranded and wasted (replication) capacity are reduced
- **Increased productivity:** Automation of complex, tedious, and manual management tasks

---

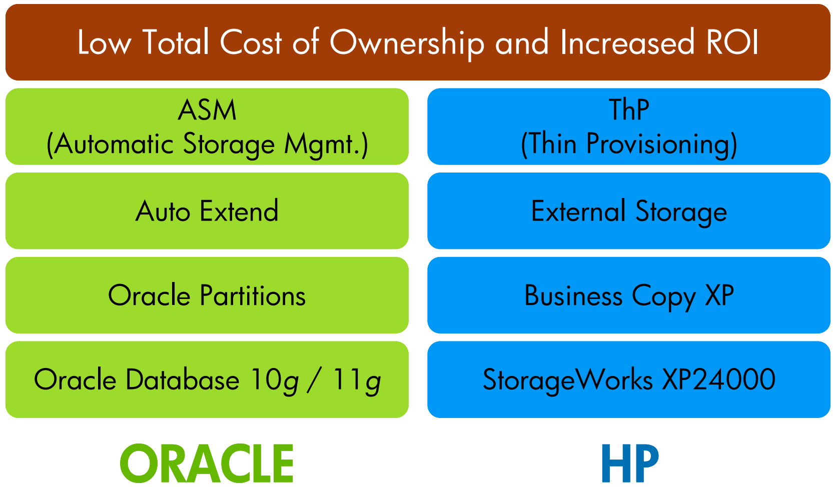
30-50% of traditional storage capacity is unused

Enterprise Strategy Group
2006

---

The solution technology components explored in the paper are as follows:

**Figure 1:** Solution technology components




# Solution technology components

## Oracle technology components

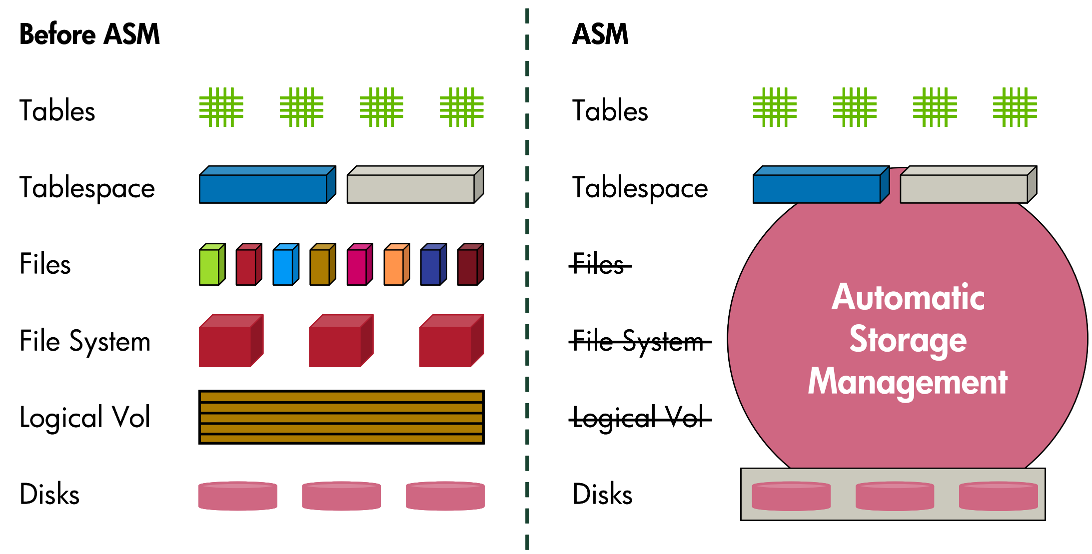
**Oracle Database 11*g***

Oracle Database 11*g* extends Oracle's unique ability to deliver the benefits of grid computing with more self-management and automation. These features allow database administrators to concentrate on more strategic issues other than database management. Furthermore, Oracle Database 11*g* offers innovation that enables organizations to quickly adapt to dynamic environments.

**Automatic Storage Management (ASM)**

Automatic Storage Management (ASM) is a feature of Oracle Database introduced in its 10*g* version which provides cluster file system and volume manager capabilities integrated into the Oracle Database. ASM only manages Oracle Database files at this time. ASM disk groups, as shown in Figure 2, provide a pool of disks that can be managed as a logical unit. ASM also increases I/O performance and availability by spreading Oracle data files into uniformly sized allocation units (AU) across all disks in an ASM disk group. ASM also allows dynamic addition and deletion of disks in a disk group. During addition and deletion operations, ASM automatically rebalances data on the remaining disks to maintain redundancy and performance through an even distribution.

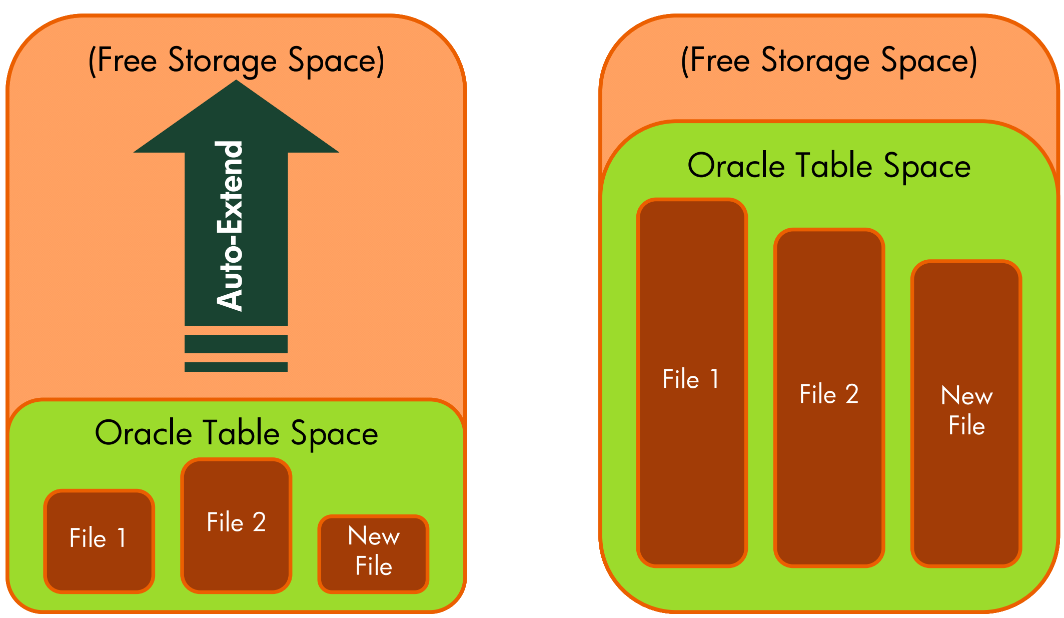
**Figure 2:** ASM operational stack




## Auto-Extend

Auto-extendable datafiles is a feature of Oracle Database introduced in version 7 of the database. Auto-extend allow Oracle Database files to automatically grow on demand to meet the need of incoming or changed data when the tablespace requires additional space. Auto-extend provides Oracle Database great flexibility by enabling a tablespace to initially consume very small amounts of initial capacity and grow as needed (see Figure 3).

**Figure 3:** Oracle Database data file auto-extend feature



**Oracle table partitions**

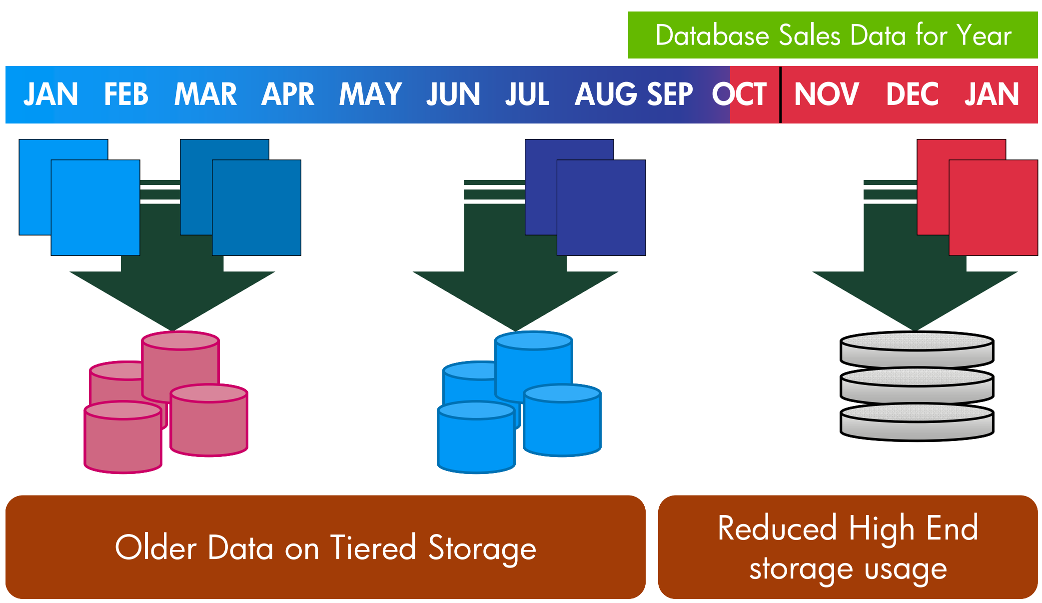
Oracle table partitioning is a feature of Oracle Database Enterprise Edition which allows tables and indexes within a database to be sliced into smaller chunks. Oracle partitioning is completely transparent from an application perspective. No changes are needed at the application level or to the SQL queries. Oracle table partitioning will automatically enhance queries sent to a partitioned database. Oracle table partitioning enables building large size (multiple Terabytes) databases and also facilitates the use of tiered storage to yield significant storage cost reduction and utilization. A study conducted by the Enterprise Strategy Group (ESG) has found that 60% - 80% of all data is dormant 90 days after its creation. Thus, coupling Oracle Partitions and HP External storage enables significant cost savings through the use of storage tiers.

A study by the Enterprise Strategy Group has found that 60% to 80% of all data is dormant 90 days after its creation

ESG: Power, Cooling, Space efficient storage. July 2007 by Tony Asaro (Senior Analyst)

For example, with Oracle table partitioning, database data can be subdivided based on access pattern and/or importance. The data that is frequently accessed and changed can be partitioned into its own table and moved to faster and larger storage systems. Less frequently accessed data can be partitioned into tables that reside on lower cost storage systems. This provides an immediate increase in return on investment (ROI) and lower total cost of ownership (TCO). Figure 4 illustrates this implementation.

**Figure 4:** Oracle database table partitioning and tiered storage




## HP technology components

**HP StorageWorks XP24000 disk array**

The HP StorageWorks XP240000 Disk Array is a large enterprise-class storage systems designed for organizations that simply cannot afford downtime or tolerate any data loss. The XP mitigates the risk of business downtime by providing a bulletproof platform with complete hardware redundancies, hot-swappable components, and non-disruptive online upgrades. The XP24000 makes an excellent choice for large-scale database applications, such as Oracle Database. The

XP24000 also decreases the cost and complexity of data management with a broad portfolio of software and features. Through Thin Provisioning (ThP), organizations can reduce their IT total cost of ownership from significant power and cooling costs savings and reduced capacity utilization. Through virtualization the XP24000 enables important functions such as heterogeneous data migration, array repurposing, and storage tiers. Furthermore, consolidating to an XP simplifies backup & disaster recovery solution implementation and reduces the time required to manage complex environments.

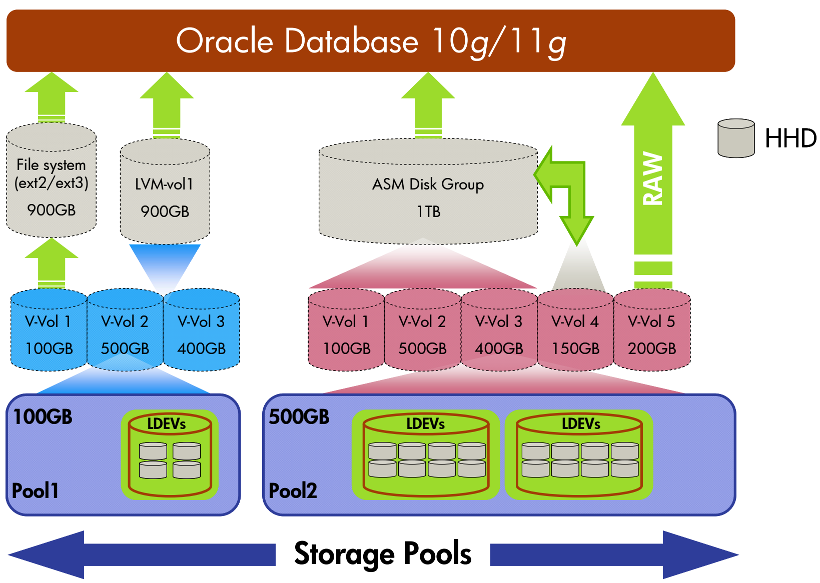
**HP Thin Provisioning (ThP)**

The HP ThP technology allows storage administrators to pre-plan user capacity needs and allocate virtual storage based on the expectation, but only consume the actual disk space the user is accessing. (See figure 5).

The components of the HP ThP implementation are:

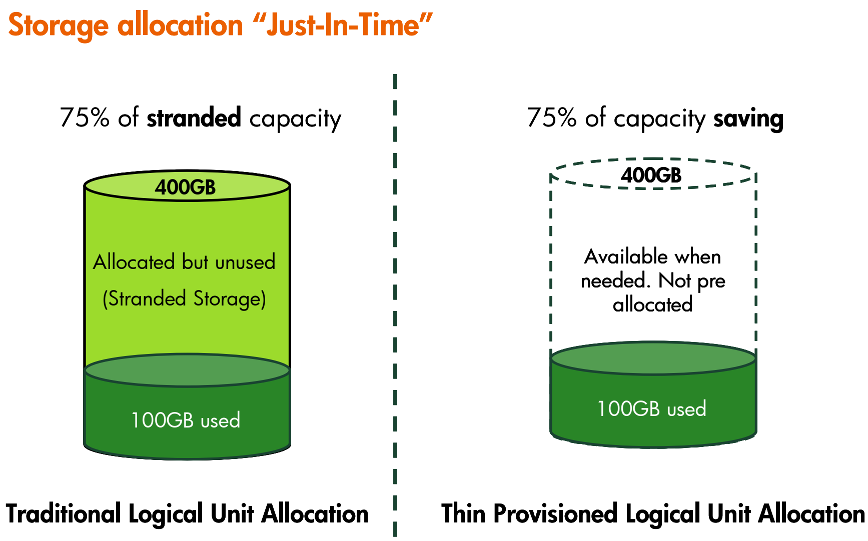
- ThP pool volumes—XP LDEVs, which make up the pool of actual storage.
- ThP pool—The aggregate of the pool volumes.
- ThP volume—The virtual volume (V-VOL) presented to the host. Virtual volumes are created with the desired size that will satisfy its user's needs. However, which appears to have much more capacity than is actually the case. Pages of actual storage are allocated from the pool as needed to accommodate writes to the host-facing volume.

**Figure 5:** HP Thin provisioning implementation




Thin provisioning eliminated storage over-allocation by providing applications physical storage allocation right when the application needs it (just-in-time storage allocation). With Thin Provisioning, a storage administrator now has the ability to tailor capacity increments and allocation to the exact capacity utilization of the application regardless of the amount of capacity requested by users. For example, in a traditional logical unit provisioning, more storage than necessary is allocated to the logical unit. With Thin Provisioning a virtual LUN of a large size is provisioned however the logical unit physical capacity utilization matches the actual usage of the application (See Figure 6).

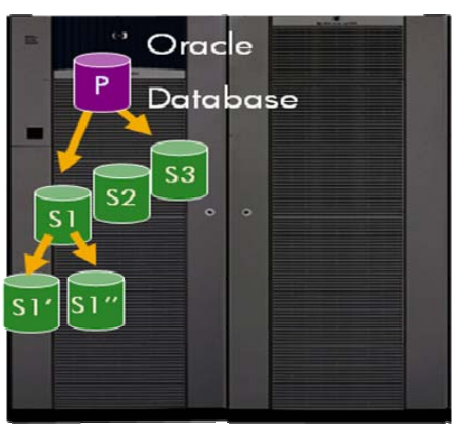
**Figure 6:** Traditional vs. Thin Provisioned Logical Unit Allocation




### HP StorageWorks Business Copy XP (BC)

HP StorageWorks Business Copy XP (BC) maintains internal copies of use data on disk arrays for purposes such as data backup or replication. Replicated volumes are created on the same disk array as the primary volume at hardware speeds. BC reduces backup time and provides point-in-time backup. BC primary volumes (P-VOLs) contain original data; BC secondary volumes (S-VOL can be maintained as an independent copy set that can also be split, resynchronized, and deleted separately from other S-VOLs assigned to the same P-VOL (See Figure 7).

**Figure 7:** XP Business Copy XP maintains point-in-time copy relationship between P-VOL and S-VOL




### HP StorageWorks External Storage XP (ES XP)

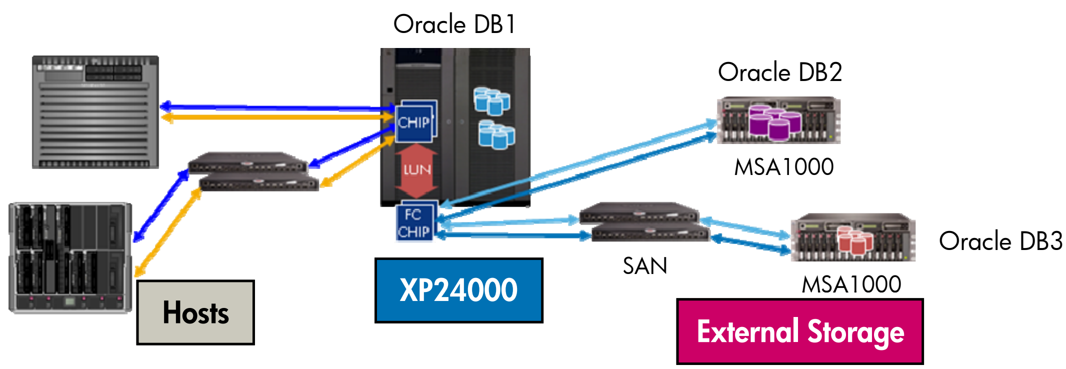
HP StorageWorks External Storage XP[2] allows administrators to host XP24000 Disk Array datasets on select external storage subsystems, including HP Modular Smart Array (MSA) storage systems, HP Enterprise Virtual Array (EVA) storage systems, legacy XP arrays, as well as current and legacy arrays from other storage providers. Because ES XP data is accessed from a unified

---

[2] External Storage XP is also available on XP20000, XP12000 and XP10000

set, it significantly decreases the stress of everyday heterogeneous data management by reducing the amount of effort needed to manage a group of storage systems. Simplified and unified management in turn yield immediate savings on total cost of ownership. Figure 8 illustrates a typical ES XP configuration.

**Figure 8:** Storage Works XP utilizing External Storage XP to virtualize storage




# Case study objectives

The key focus of this paper is to demonstrate that Oracle Database 11*g* and relevant database features when coupled with HP Thin Provisioning XP and other key storage technologies provide a unique and robust solution that automates storage provisioning, database tuning, and administration all while significantly reducing the data center footprint and capacity usage. To achieve the deliverable this paper:

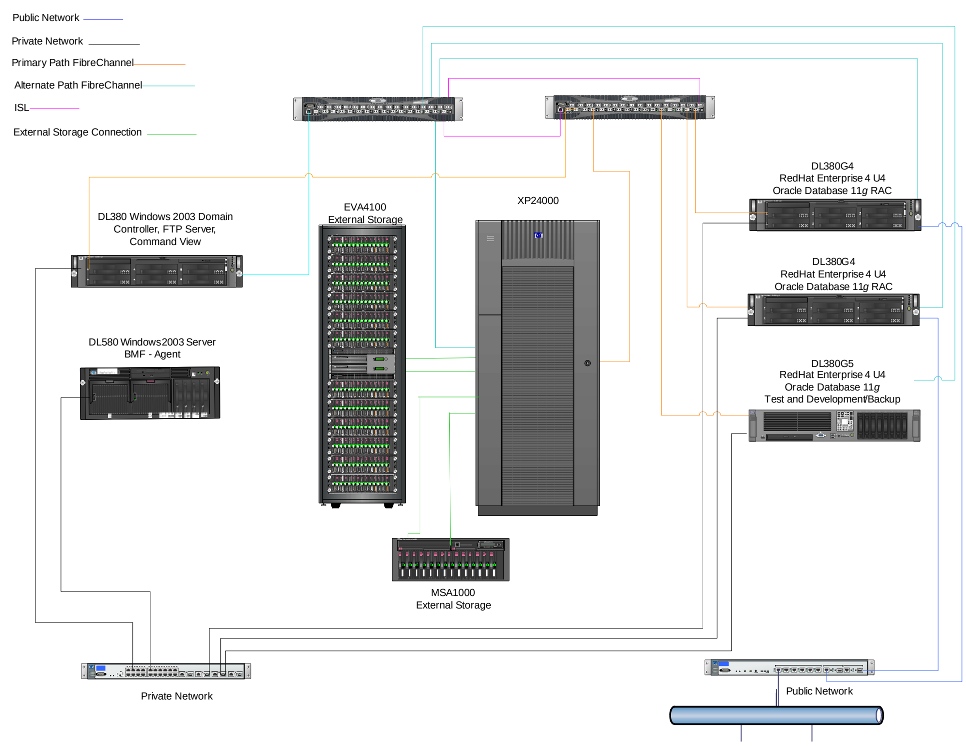
1. Characterizes the efficiency of using ASM and Oracle table space capacity allocation on XP Thin Provisioning XP volumes
2. Showcases the complementary functionality of Oracle datafile auto-extend feature on XP Thin Provisioning XP volumes
3. Demonstrates the ease of management of the XP Thin Provisioning pool, virtual volumes and alarms
4. Demonstrates how additional management and provisioning cost savings can be attained through the use of tiered storage
5. Provides best practice recommendation critical to deploying this solution in the most efficient way

This solution yields increased return on investment and lower total cost of ownership.

# Case study configuration

The environment consisted of 2 cluster nodes running Oracle Database 11*g* RAC connected to an XP24000 through a Fibre Channel SAN. A third server hosted a single instance Oracle Database 11*g* database. Business copies taken from the RAC cluster data LUNs are brought online on the third server. Benchmark factory served as the load generator. Command View XP served as management interface for the XP. Finally an MSA and EVA array were attached to the XP24000 as external storage.

**Figure 9:** Hardware configuration




## Storage and server hardware configuration

Table 1 and 2 respectively detail the storage and servers' hardware configuration:

**Table 1: XP24000 configuration**

| |
|---|
| 1 set (2 pairs) of Array Control Processor (ACP) |
| 1 disk array unit—R0 |
| 40 GB total cache |
| 16 GB of shared memory |
| 72 * 300 GB 10K rpm disk drives |
| 4 CHA pairs |
| RAC cluster nodes accessed the XP through ports 1G, 3G, 5G and 7G |
| The EVA was connected externally to the XP |
| The MSA was connected externally to the XP |

**Table 2 : HP ProLiant server configuration**

| **RAC Cluster—2 nodes** | **Single Instance** |
|---|---|
| 2 DL380 G4 dual core | DL380 G5 dual core |
| 4 GB RAM | 4 GB RAM |
| 1 Dual Channel 2 GB HBA | 1 Dual Channel 2 GB HBA |
| 2 Gig-E Broadcom network cards | 2 Gig-E Broadcom network cards |

## System storage configuration

**Table 3: 2 Node RAC configuration**

| |
|---|
| Redhat Enterprise Linux 4.4 |
| Oracle Database 11*g* RAC |
| 1 ASM disk group for data on ThP volumes |
| 1 ASM disk group for logs on ThP volumes |
| 1 tablespace called ThP11*g* |
| 25-100 user Oracle load |

**Table 4: ThP pool and V-Vol configuration**

| |
|---|
| 1 ThP pool (Pool1) for data ASM disk group |
| 1 ThP pool (Pool2) for logs ASM disk group |
| Pool 1 initially configured with 50GB of capacity |
| Pool 2 initially configured with 100GB of capacity |
| 7 * 100GB V-VOL were attached to pool 1 |
| 14 * 100GB V-VOL were attached to pool 2 |

# Case Study

In a traditional data center, provisioning additional storage to an application that is running out of storage capacity can be a very tedious process. Performing such action minimally requires the following steps:

1. Identify out of space condition
2. Understand how fast additional storage must be added before application availability is interrupted
3. Determine the most efficient method of adding additional storage
4. Characterize performance and application availability impact that may be induced by the chosen method given in step 3
5. Determine how much storage capacity need to be added or can be added
6. Determine if additional storage needs to be purchased or if it can be obtained from an existing available pool
7. Reconfigure SAN zoning if necessary for host to gain access to new storage system
8. Set protections such as LUN masking to enable host access to the device
9. Add new storage to host and make certain all storage is properly discovered by host
10. Provision new storage to the application
11. Configure backup system so that newly added LUN are also backed up
12. Refill the storage pool as necessary

Analyst surveys indicate that 75% of surveyed users felt that storage provisioning was a time and resource drain on their IT organizations

Often times a failure of any of these steps can compromise application availability. The HP and Oracle solution discussed in this whitepaper provides a solution that lessens tedious manual steps through automation, maintains application availability, and significantly reduces cost of ownership.

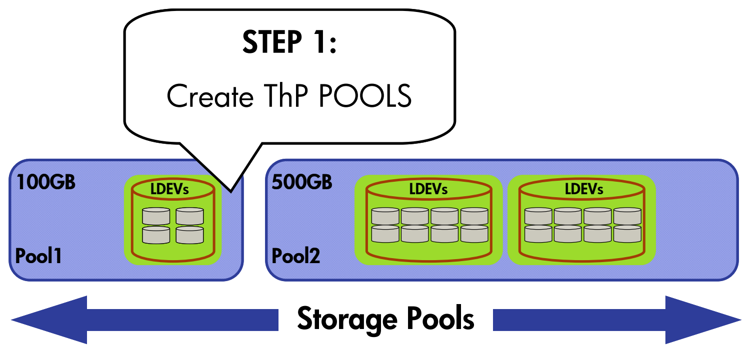
## How is XP Thin Provisioning (ThP) configured on the XP24000?

Analyst surveys indicate that 75% of surveyed users felt that storage provisioning was a time and resource drain on their IT organizations. To mitigate this growing trend, Thin Provisioning XP is configured in two easy steps:

- **STEP1:** Creation of a Thin provisioning pool
- **STEP 2:** Creation of virtual volume to attach to a pool

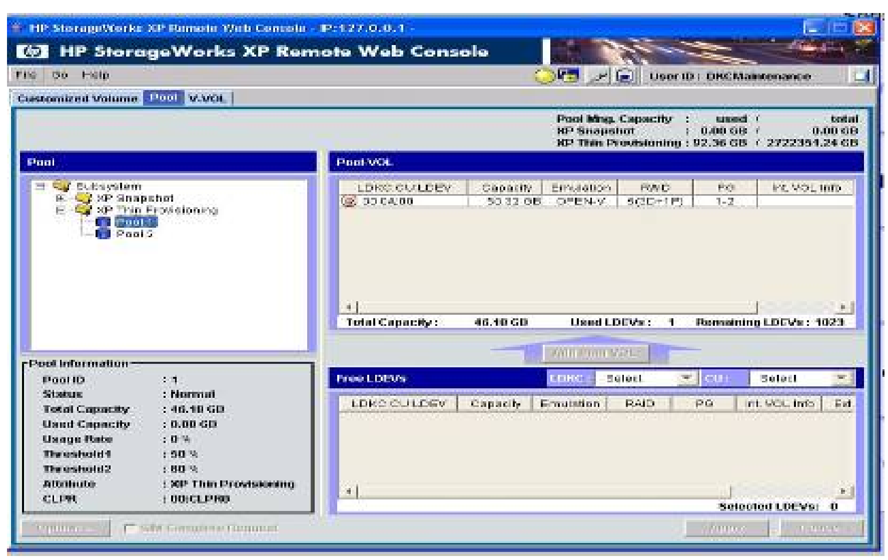
The first configuration step for Thin Provisioning XP is to create a provisioning pool. This pool should be comprised of regular XP LDEVs configured with the same size, type and RAID level to maintain a more predictive performance characterization of the pool. The ThP pool is used to provide physical capacity increments to virtual volumes created later.

**Figure 10:** ThP pool creation




Create a storage pool using HP StorageWorks XP Remote Web Console which can be launched directly within Command View AE for XP. Figure 11 displays a screen shot of the pool management window within Remote Web Console.

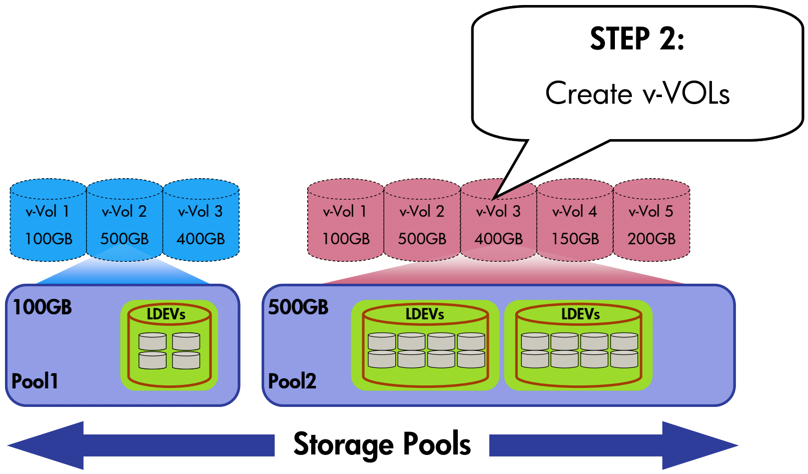
**Figure 11:** ThP Pool creation remote web console



One of the key advantages of using Thin Provisioning is that once created, ThP pools only need to be monitored and replenished as capacity depletes. Alarms greatly facilitate monitoring of the ThP pool. Adding additional capacity to a ThP pool is as simple as dropping an additional LDEV from the XP into the desired pool.

Next, create virtual volumes (V-VOLs) which will later be provisioned to the host for data access.

**Figure 12:** ThP V-VOL creation




The XP Remote Web Console provides an alternative way to create virtual volumes. The two important parameters to specify are the number of V-VOLs that should be created and what capacity they should be (See Figure 11). Virtual volumes of identical sizes are created. These V-Vols will be used in the Oracle Database ASM disk group. This topic will further be discussed in the best practice section.

**Figure 13:** V-VOL creation using remote web console

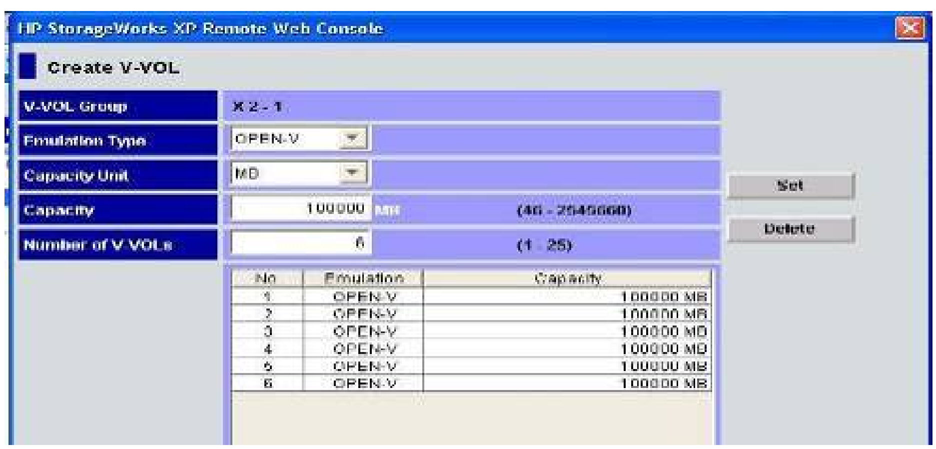
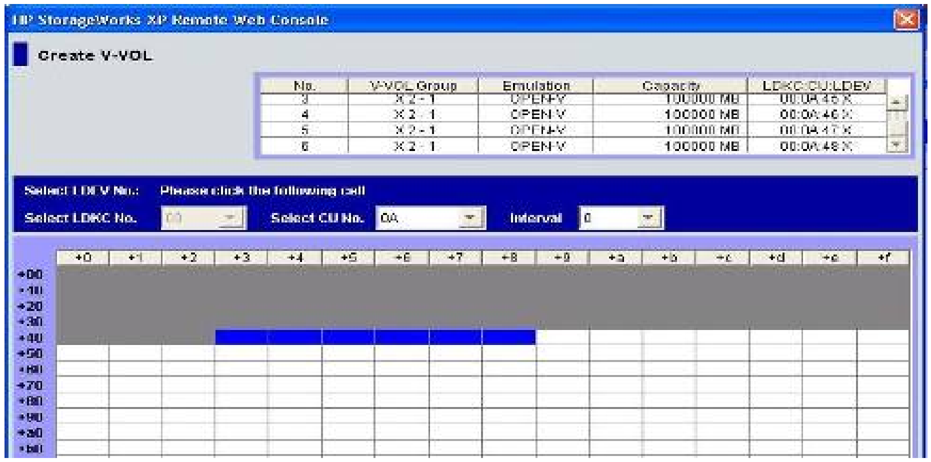


**Figure 14:** V-VOL creation, CU:LDEV selection using remote web console



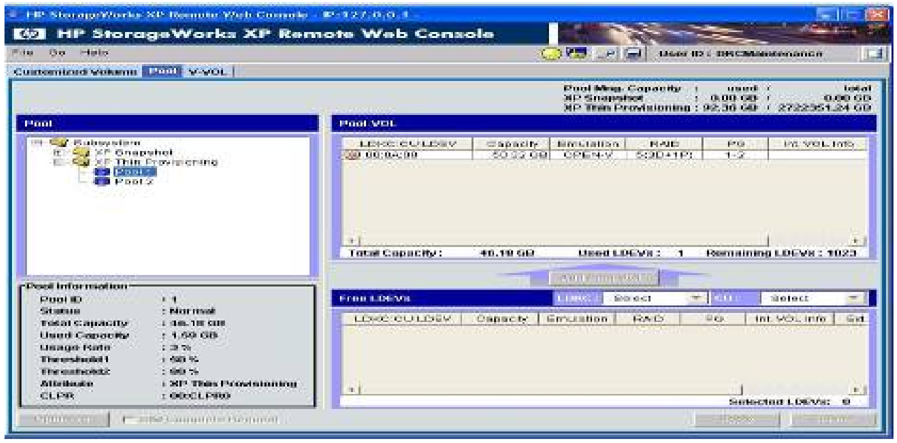

Once created the V-VOL can be provisioned to any host just like normal LDEVs would. Carefully record the CU:LDEV range chosen for the V-VOL during their creation (See Figure 12).

## The ASM advantage

The use of ASM in this database solution provides great flexibility and performance advantages. As previously discussed, manual steps required to provision storage for an application running out of space are very tedious. ASM allows the ability to dynamically add and remove a disk from an ASM disk group while maintaining application availability and distributing data for improved performance. This feature automates the previously manual and tedious steps required to provisioned additional storage to an application running out of space. All an administrator is now required to do is add an additional V-VOL to an ASM diskgroup and watch ASM automatically import the additional capacity and redistribute database data to the newly acquired space for performance. Despite these advantages it is equally important to understand what, if any, is the capacity overhead associated with utilizing ASM in this solution. Many filesystem/volume managers are not suitable for Thin Provisioning because they are not capacity efficient. Such filesystem can cause physical space allocation in the ThP pool for the entire size of the virtual volume which would negate the benefits of utilizing Thin Provisioning. For more information on these filesystems, refer to the HP Thin Provisioning XP Best Practices White Paper.

After creating an ASM instance on Pool1 backed by a total capacity of 50 GB less than 3% of the Thin Provisioning pool capacity was used for ASM metadata (See figure 14).

**Figure 15:** ASM capacity space consumption in ThP pool




Note that the capacity usage shown also contains a small allocation for ThP metadata. This shows that ASM is extremely space efficient with Thin Provisioning.

ASM and Thin Provisioning provide significant automation to a database environment. Thin Provisioning XP simplifies and automates storage deployment at the hardware level while ASM simplifies and automates capacity provisioning of the Oracle Database. Maintaining application availability through tedious manual and error prone tasks performed by database and storage administrator are simplified from the 12 steps discussed above to a few simple tasks:

1. Monitor ThP alarms
2. Incrementally expand the ThP pool as needed
3. Incrementally expand ASM diskgroup as needed

## Oracle Tablespace and Auto-extend

Automatic Storage Management (ASM) in Oracle Database 10*g* and 11*g* currently only manages database datafiles. Datafiles exist inside tablespaces. In the previous section we discussed how and why ASM is space efficient on Thin Provisioning pools. To maintain this efficiency through all layers of the implementation, Oracle tablespace and datafiles also need to maintain a level of capacity efficiency. Figure 15 depicts the creation of a 25 GB datafile in tablespace ThP11*g* and Figure 16 shows its corresponding capacity usage within the ThP pool.

**Figure 16:** ThP11*g* tablespace creation

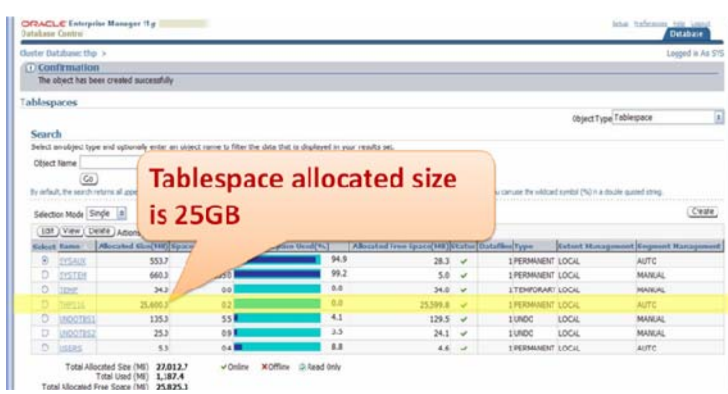
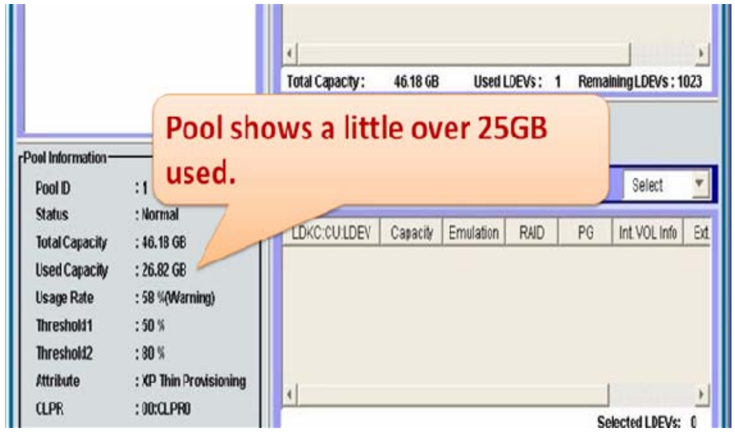


**Figure 17:** ThP11*g* tablespace capacity usage in ThP pool




Auto-Extend enables Oracle datafile to be ThP space efficient by providing the flexibility of consuming a small initial storage capacity and growing on demand based on user defined capacity growth intervals.

Unlike ASM, Oracle datafiles are not Thin provisioning capacity efficient because they physically allocate the entire size of the datafile at creation even though no actual data is written to the datafile yet. To remedy this problem the solution employs the Oracle datafile auto-extend feature. Auto-Extend enable Oracle datafiles to be ThP space efficient by providing the flexibility of consuming a small initial storage capacity and growing on demand based on user defined capacity growth intervals.

## ThP threshold and alarms

Thin Provisioning XP provides two thresholds with associated alarms:

- ThP Pool threshold
- ThP volume threshold

These are critical to maintain and facilitate application availability.

The ThP pool threshold is the percentage of the used pool capacity versus the total pool capacity. For increased application availability protection, ThP XP defines two thresholds for the ThP pool. A user configurable threshold which can vary between the values of 5% to 95% and a non-configurable value set to 80%. ThP pool thresholds should be set based on the pool size, the application data growth rate and filesystem employed. For example:

- If the ThP pool total capacity is 10TB and the alarm is set to 60%
- When the pool capacity usage reaches 6TB then the alarm will be triggered through a SIM and SNMP trap.

The ThP volume threshold represents the relationship between the unallocated ThP volume and the available pool space. Only one user configurable value tracks the ThP volume threshold setting. This threshold can be set anywhere from 5% to 300%. Given that a ThP pool is typically comprised of multiple virtual volumes, it is desirable to have free space larger than the unused capacity of a ThP volume. For this the ThP volume threshold is typically set between 100% and 300%. For example:

- Suppose 1TB (terabyte) ThP volume has an alarm threshold of 200%.

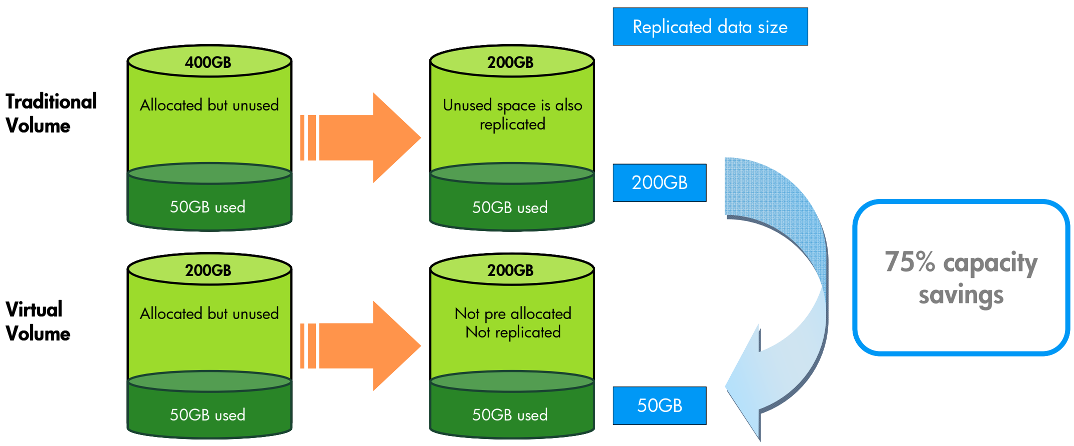
- When the ThP pool capacity becomes smaller than (1TB * 200%) = 2TB then the alarm triggers through a SIM and SNMP trap.

ThP Pool and V-Vols thresholds and alarms should be closely monitored, and they must be set in a predictive fashion taking into account the application data growth rate, the file system type employed and the size of the ThP pool.

## Efficiencies and capacity savings during replication of ThP volumes

Data replication is a critical part of an enterprise storage solution. ThP XP extends its value in the area of replication by providing additional capacity savings and efficiencies. Business Copy XP increases capacity efficiency when coupled with ThP. Full copies of ThP virtual volumes only consume as much capacity as the actual physical capacity used by the Thin Provisioning volume. This dramatically reduces wasted and stranded capacity.

**Figure 18:** Business copy capacity saving with ThP




# Best Practices

1. Use as many physical disks (LDEVs) of identical speeds and models in as many from as many RAID Groups with the same RAID levels for the ThP pool
   **Reason:** Enables ThP pool and Virtual volume to take advantage of the multiple spindle count. Furthermore, this avoids potential disk access hot spots and enables a more predictive performance characterization.
2. ThP Pool and V-Vols thresholds and alarms
   a. Should be closely monitored
   b. Set them in a predictive fashion based on data growth rate, file system type employed and size of the pool.
   **Reason:** The availability of an application will be greatly compromised when it runs out of physical capacity, so it is critical to monitor alarms in order to make certain that they are augmented as needed. Alarms should be set in a predictive fashion as discussed earlier. This allows ThP pool and V-Vol alarms to be tailored to the growth needs and availability requirements of the specific application in use.
3. When selecting the more efficient datafile auto-extend size; consider ASM allocation units (AU), the ThP page (allocation unit) size and the data growth rate.
   **Reason:** For a database environment where the data growth rate is rapid, auto-extend datafile extend-size size should be large to keep up with the data growth. Furthermore,

selecting the auto-extent size of the datafile as a multiple of the ASM AU and ThP pool page allocation data can be nicely laid out on disk.

4. When removing V-VOLs from an ASM diskgroup, make sure to format the V-VOL and detach it from the pool. This offsets the space consumed by the ASM rebalance operation and offers data security.
   **Reason:** Formatting the V-Vol makes sure that the data it contains is destroyed. This may be desirable for security reasons. Furthermore, detaching the V-Vol from the ThP pool it is associated with frees up the allocated pages from the pool and makes that space available for use by other V-Vols.

5. Storage capacity increments to the ASM diskgroup should be made in larger infrequent increment for better efficiency.
   **Reason:** When a V-Vol is added to an ASM disk group, ASM will rebalance a portion of the data from other V-Vol to the newly added V-Vol. The data movement allocates additional pages in the ThP pool. So performing ASM diskgroup increments frequently can be space wasteful and cause more fragmentation of data.
6. Archive and redo logs are better suited on regular (non-ThP) volumes unless they are multiplexed.
   **Reason:** This can be wasteful in space because the allocated ThP pages are not reclaimed following deletions. Multiplexing redo logs provides the user with a method to reclaim allocated pages caused after deletion.

# Conclusion/Summary

By combining HP StorageWorks XP24000 and Oracle Database 11*g* technologies this case study provides customers with the business value and technical solution to help resolve the difficulties they currently experience during database and storage administration in a cost effective manner. IT managers can now take advantage of:

- Significant reduction in Total Cost of Ownership
  - Storage Capacity usage reduction
  - Footprint, power and cooling savings
  - Reduced storage system licenses based on capacity
  - Reduced management costs
- Simplified Management
  - Ease of use
  - Storage provisioning made simple
  - Reduced complexity in storage and database configuration and management
- Superior Return on Investment
  - Effective and efficient resource utilization
  - Increased consolidation and fast application deployment

## For More Information

- Enterprise Strategy Group (ESG): Power, Cooling, Space Efficient Storage [http://www.enterprisestrategygroup.com/ViewSecureDocument.asp?ReportID=835&ReportType=Lab&ReportField=Attachment1]

- Power and Storage: The Hidden cost of ownership [http://goliath.ecnext.com/coms2/gi_0199-1186510/Power-and-storage-the-hidden.html]

- Hewlett-Packard XP24000 Thin Provisioning Best Practices document
  Hewlett-Packard XP24000 Overview technical document
  Hewlett-Packard XP24000 External Storage technical document
  Hewlett-Packard Business Copy XP External Storage technical document
  [http://www.hp.com/]

- Oracle ASM overview White paper
  Oracle ILM overview White paper
  [http://www.oracle.com/]

- Power and storage: the hidden cost of ownership – Storage Management [http://findarticles.com/p/articles/mi_m0BRZ/is_10_23/ai_111062988]



4AA1-7555ENW, January 2008