Table of contents

Executive summary ........................................................................................................... 2
Disclaimer ....................................................................................................................... 2
Introduction .................................................................................................................... 3
Architecture ................................................................................................................... 3
  Full-mesh controller backplane .................................................................................. 4
HP 3PAR models for SAP ............................................................................................... 4
HP 3PAR features for SAP ............................................................................................ 6
  Common Provisioning Groups and RAID types .......................................................... 6
  Fast RAID .................................................................................................................... 8
  High availability options ............................................................................................... 10
  Thin technologies .......................................................................................................... 10
  Autonomic groups .......................................................................................................... 14
  Virtual domains .............................................................................................................. 15
  Virtual domain sets ......................................................................................................... 17
  Dynamic Optimization ................................................................................................. 18
  Adaptive Optimization ................................................................................................. 19

Tested configuration based on HP 3PAR Storage .......................................................... 21
  Client system configuration used in this verification .................................................. 22
HP 3PAR performance ................................................................................................... 22
  Low level I/O tests ......................................................................................................... 22
  OLTP load I/O tests ........................................................................................................ 24
  Wide striping effectiveness test ..................................................................................... 27
  Dynamic Optimization effectiveness test ..................................................................... 27
  Adaptive Optimization effectiveness test ..................................................................... 28

SAP configuration on HP 3PAR ..................................................................................... 29
  SAP system layout ......................................................................................................... 29
Reference architectures ................................................................................................ 31
  Small ERP ..................................................................................................................... 31
  Medium ERP .................................................................................................................. 31
  Large ERP ...................................................................................................................... 32

SPC-1 benchmark .......................................................................................................... 32
General recommendations .............................................................................................. 33

Conclusion ...................................................................................................................... 33
Appendix A: Bill of materials ........................................................................................ 34
For more information ..................................................................................................... 35
Executive summary

SAP accounts in general and SAP basis and database administrators in particular are challenged with storage issues in a number of different areas. Some examples of particular storage needs in managing SAP landscapes are:

- The demand and management of additional disk space for exponentially growing SAP database instances into the multi-terabyte range.
- The effort to maintain and improve storage performance while increasing the availability for SAP systems.
- The requirement to keep up with storage management needs when rapid deployment of virtualized SAP systems is requested.

Additionally, these situations have to be managed with limited human resources under tight financial constraints, calling for storage architecture with a maximum of flexibility and ease of management.

This paper provides an understanding of how these storage-related challenges are addressed by HP 3PAR Storage. The key areas addressed are:

- Industry leading Thin Provisioning features capable of defining the SAP database size of tomorrow while paying for the hardware requirements of today, utilizing storage over-provisioning which results in optimal resource usage and dramatically reduced database storage management.
- SPC-1 benchmark champion performance capabilities of scaling the HP 3PAR architecture with multiple storage controller nodes and wide striping over available disk drives to meet SAP demand for low latency I/O response times under all conditions.
- Performance support on the ASIC level that enables space-efficient RAID level configurations when deploying multiple SAP databases instances in the TB range to result in additional optimization in resource utilization.
- Flexible and scalable HP 3PAR Storage configuration for SAP by configuring up to eight HP 3PAR Storage controller nodes in combination with nearly 2000 disk drives.
- Built-in Dynamic and Adaptive Optimization features moving SAP data between RAID levels or the storage tiers of Solid State (SSD), Fibre Channel (FC), or Nearline (SATA) disks for optimal resource usage and performance.
- Autonomic Groups and Virtual Domain concepts to simplify SAP database provisioning and organize storage resources.

This paper describes tests that HP performed to demonstrate the benefits and capabilities of an HP 3PAR solution resulting in a high-performing, easy-to-manage storage solution for an SAP environment with the most efficient resource utilization.

Target audience: This white paper is intended to assist SAP solution architects, SAP database and Basis administrators or IT professionals who are involved in planning and deploying an SAP implementation. For introductory information, it is useful to read the HP 3PAR Storage brochure.

This white paper describes testing performed in January and February 2012.

Disclaimer

The configurations in this guide are HP recommended configurations. These configurations are provided as a reference only since customer configurations will vary due to specific needs. The memory, processor amount and speed, and I/O storage recommendations stated here need to be recognized as the minimum amounts that are recommended.
Introduction

HP 3PAR Storage is designed to deliver the agility and efficiency demanded by virtual data centers integrating SAP products. The HP 3PAR family consists of the F-Class F200/F400 systems, T-Class T400/T800 systems and the P10000 V400/V800 systems. All HP 3PAR models are targeted towards the most demanding SAP customers for the highest level SAP production systems and landscapes; they deliver simple yet powerful and autonomically-tiered, multi-tenant storage arrays. They are supported by a powerful suite of software products that provide ease of management, efficient storage utilization through thin technologies, autonomic storage tiering and leading availability features such as persistent cache and full-mesh interconnect.

Large SAP customers tend to consolidate their IT infrastructure, particularly their storage facilities, to achieve greater efficiency. The HP 3PAR Storage system centralizes data stored on a number of high-disk legacy storage arrays into one high-performance, high-availability next generation utility storage system that allows multiple SAP systems to share the same utility storage system. As a result, customers can apply common administration and high-availability processes to all their SAP landscapes and achieve greater agility by dynamically assigning storage capacity according to business needs. The features of HP 3PAR Storage are ideally suitable for integration with SAP systems that rely on a robust, scalable, and efficient storage solution.

Architecture

HP 3PAR architecture, the foundation for HP 3PAR Storage, combines best-in-class, open technologies with extensive innovations in hardware and software design. HP 3PAR Storage features a high-speed, full-mesh, passive system backplane that joins multiple controller nodes (the high-performance data movement engines of the architecture) to form a cache-coherent, mesh-active cluster. This low-latency interconnect allows for tight coordination among the controller nodes and a simplified software model.

Within this architecture, controller nodes are paired via Fibre Channel (FC) connections from each node in the pair to the dual-ported drive chassis (or drive cages) owned by that pair. In addition, each controller node may have one or more paths to hosts (either directly or over a Storage Area Network, or SAN). The clustering of controller nodes enables the system to present to hosts a single, highly available, high-performance storage system.

High availability is also built into HP 3PAR architecture. Unlike other approaches, the system offers both hardware and software fault tolerance by running a separate instance of the HP 3PAR Operating System on each controller node, thus ensuring the availability of user data. With this design, software and firmware failures—a significant cause of unplanned downtime in other architectures—are greatly reduced.

Figure 1. Full-mesh backplane
The Thin Built In ASICs (application-specific integrated circuit) feature a uniquely efficient, silicon-based zero-detection mechanism that gives HP 3PAR Storage the power to remove allocated but unused space without impacting performance. The ASIC also delivers mixed-workload support to alleviate performance concerns and cut traditional array costs. Transaction and throughput-intensive workloads run on the same storage resources without contention, thereby cutting array purchases. This feature is particularly valuable in virtual server environments where storage systems boost virtual machine density so that physical server purchases are slashed in half.

**Full-mesh controller backplane**

Backplane interconnects within servers have evolved dramatically over the last ten years. Recall that in the past most, if not all, server and storage array architectures employed simple bus-based backplanes for high-speed processor, memory, and I/O communication. The growth of SMP-based servers brought about a significant industry investment in switch architectures, which have since been applied to one or two enterprise storage arrays. The move to a switch from buses was intended to address latency issues across the growing number of devices on the backplane (more processors, larger memory, and I/O systems). Third-generation, full-mesh interconnects first appeared in the late 1990s in enterprise servers and HP 3PAR Storage was the first storage platform to apply this interconnect. This design has been incorporated into HP 3PAR Storage systems to reduce latencies and address scalability requirements. Figure 1 shows eight nodes in a P10000 V800, each node has a dedicated path to all the other nodes. The figure also shows that the nodes are paired and each node pair has ownership of twelve disk cages that can have up to 480 drives each.

Complementing the full-mesh architecture is the ASIC-based, zero-detection mechanism for converting traditional “fat” volumes to “thin” volumes without impacting storage performance. The HP 3PAR ASIC leverages a unique, software-based virtualization mapping engine for space reclamation, giving HP 3PAR Storage the power to remove allocated but unused space in existing volumes. The HP 3PAR Storage platform has this fat-to-thin processing capability built-in to the system hardware, this enables the storage to virtualize blocks of zeros “on the fly” to drive these conversions while maintaining high performance levels.

Besides reclaiming unused space, the ASIC can also handle processing mixed workloads more efficiently than traditional storage controller nodes. The ASIC can process the control and data information in separate paths instead of the single path that is used on a traditional storage. This unique hardware capability gives HP 3PAR Storage the power to remove allocated but unused space without impacting performance. The accelerated performance provided by the ASIC combined with Rapid RAID rebuild capabilities enables businesses to achieve the performance of traditional RAID mirroring from Fast RAID 5 with up to 66 percent less overhead for data protection.

**HP 3PAR models for SAP**

Depending on the size and requirements of an SAP system, there are six models of HP 3PAR Storage from which to choose. Each model in the family can accommodate different size and performance requirements for all SAP systems. The two models of the F-Class system are F200 and F400. The F-Class is one of the world’s first cache-coherent, quad-controller architecture for scalable, efficient departmental and remote office consolidation.

At the high end are the T-Class systems, T400 and T800, and the 3PAR P10000 V400 and V800. The T-Class and the P10000 are among the fastest and most efficient single-system arrays available, delivering excellent consolidation and performance headroom for enterprises and service providers. The HP 3PAR P10000 is the latest high-end storage, offering scale-up capacity to 1600TB. The V800 and T800 models accommodate up to eight controller nodes; the V400, T400, and F400 accommodate up to four controller nodes; and the F200 supports two controller nodes. Note that unless otherwise specified, the examples in this paper are based on the specifications of the F400.
A suitable HP 3PAR model depends on installation size, storage capacity, workload and how much growth an SAP system will have. The Reference architectures section of this paper provides a visual figure of three commonly seen installation sizes, that is, Small, Medium and Large. Appendix A: Bill of materials in this paper provides a list of servers, storage and other equipment required for setting up SAP.

An SAP system can benefit from the unique architecture of the HP 3PAR models by starting with a small single system landscape. A system landscape is a layout of servers containing SAP software and applications. A typical SAP landscape consists of a development system, quality assurance system, and production system. An SAP system could initially start with just the transaction system landscape by using SAP ERP. As the business grows, a second landscape can be added for analysis and migrated by using HP 3PAR software utilities.

Table 1. Comparison of the six models of HP 3PAR Storage systems

<table>
<thead>
<tr>
<th></th>
<th>F-Class F200</th>
<th>F-Class F400</th>
<th>T-Class T400</th>
<th>T-Class T800</th>
<th>P10000 V400</th>
<th>P10000 V800</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description and use</strong></td>
<td>F-Class is the Cache coherent, Mesh-Active controller with quad controller architecture for scalable, efficient departmental and remote office consolidation.</td>
<td>T-Class is designed to deliver enterprise IT as a utility service simply, efficiently, and flexibly. Delivers massive consolidation and performance headroom for virtual and cloud data centers.</td>
<td>3PAR P10000 establishes the new benchmark for tier 1 storage performance in virtual and cloud data centers. Designed to deliver consolidation of thousands of virtual machines and ensure that applications never lose access to data.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Controller nodes</strong></td>
<td>2</td>
<td>2 or 4</td>
<td>2 or 4</td>
<td>2, 4, 6 or 8</td>
<td>2 or 4</td>
<td>2, 4, 6 or 8</td>
</tr>
<tr>
<td><strong>Built-in gigabit Ethernet ports</strong></td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Fibre channel host ports</strong></td>
<td>0-12</td>
<td>0-24</td>
<td>0-64</td>
<td>0-128</td>
<td>0-96</td>
<td>0-192</td>
</tr>
<tr>
<td><strong>iSCSI host ports</strong></td>
<td>0-8</td>
<td>0-16</td>
<td>0-16</td>
<td>0-32</td>
<td>0-16</td>
<td>0-32</td>
</tr>
<tr>
<td><strong>Drive chassis</strong></td>
<td>2-12</td>
<td>2-24</td>
<td>2-16</td>
<td>2-32</td>
<td>2-24</td>
<td>2-48</td>
</tr>
<tr>
<td><strong>Drive types (mixable)</strong></td>
<td>Fibre channel Nearline (enterprise SATA) SSD</td>
<td>Fibre channel Nearline (enterprise SATA) SSD</td>
<td>Fibre channel Nearline (enterprise SATA) SSD</td>
<td>Fibre channel Nearline (enterprise SATA) SSD</td>
<td>Fibre channel Nearline (enterprise SATA) SSD</td>
<td></td>
</tr>
<tr>
<td><strong>Max capacity (approximate)</strong></td>
<td>128TB</td>
<td>384TB</td>
<td>400TB</td>
<td>800TB</td>
<td>800TB</td>
<td>1600TB</td>
</tr>
<tr>
<td><strong>Cabinets</strong></td>
<td>HP 3PAR 2-M or third-party EIA-standard 19-inch cabinet</td>
<td>HP 3PAR 2-M or third-party EIA-standard 19-inch cabinet</td>
<td>HP 3PAR 2-M cabinet(s)</td>
<td>HP 3PAR 2-M cabinet(s)</td>
<td>HP 3PAR 2-M cabinet(s)</td>
<td>HP 3PAR 2-M cabinet(s)</td>
</tr>
</tbody>
</table>
HP 3PAR features for SAP

Common Provisioning Groups and RAID types

A Common Provisioning Group (CPG) is a virtual pool of logical disks that allows virtual volumes to share its resources and allocate space on demand. A CPG can contain fully-provisioned virtual volumes and Thinly-Provisioned Virtual Volumes (TPVVs) that draw space from the CPG logical disk pool. Logical disks are widely striped across all the available physical disks of the same type, by using chunklets from all the physical drives.

CPGs are fundamental to administration and reporting of HP 3PAR Storage. CPGs automatically provision logical disk capacity on demand. CPGs are the combination of a RAID type and a drive type which equals service level and availability level; they are the containers for virtual volumes. CPGs enable fine-grained, shared access to pooled logical capacity. Instead of pre-dedicating logical disks to volumes, the CPG allows multiple volumes to share the buffer pool of logical disks. For example, when a TPVV is running low on user space, the system automatically assigns more capacity to the TPVV by mapping new regions from logical disks in the CPG associated with that TPVV. As a result, any large pockets of unused but allocated space are eliminated. Fully-provisioned virtual volumes cannot create user space automatically and the system allocates a fixed amount of user space for the volume; they can however co-exist with a TPVV in the same CPG. By default, a CPG is configured to auto-grow new logical disks when the amount of available logical disk space falls below a configured threshold. The initial buffer pool of logical disks starts off at a fraction of the exported virtual capacity of mapped volumes and automatically grows over time as required by application writes.

Table 2. CPG and RAID types

<table>
<thead>
<tr>
<th>Domain</th>
<th>RAID level</th>
<th>Disk type</th>
<th>CPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROD</td>
<td>RAID10</td>
<td>SSD*</td>
<td>CPG_PROD_10_SSD</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID50</td>
<td>SSD</td>
<td>CPG_PROD_50_SSD</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID10</td>
<td>FC</td>
<td>CPG_PROD_10_FC</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID50</td>
<td>FC</td>
<td>CPG_PROD_50_FC</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID60</td>
<td>FC</td>
<td>CPG_PROD_60_FC</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID10</td>
<td>NL</td>
<td>CPG_PROD_10_NL</td>
</tr>
<tr>
<td>PROD</td>
<td>RAID60</td>
<td>NL</td>
<td>CPG_PROD_60_NL</td>
</tr>
</tbody>
</table>

- CPGs can be used for reporting on the storage space consumed by each SAP instance which can be further used for charge back.

- In SAP environments, CPGs are used to create virtual volumes for running SAP instances. The factors to be considered for deciding on the number and types of CPGs required are: database size, drive types available on the array, RAID protection level desired, size of growth increment, required level of reporting granularity and whether or not Adaptive Optimization needs to be implemented. The general recommendation is shown in Table 2. This table is generic in that it tries to cover all RAID levels offered and all disk types available. It does not, however, consider the set size within a RAID type and also the disk drive RPM.

- While creating the CPGs in a real production environment, use CPG names that broadly express the groups’ key attributes as this action will help the storage administrator to maintain the environment over time. The table below may be modified to suit the other environments or domains like QA, DEV, or TEST.

- If the SAP database size is large (>5TB) it is better to have separate CPGs dedicated to it.

- For Adaptive Optimization, separate CPGs should be created for each storage tier.
Note
* For SSDs, the growth increment should be set to the minimum of 16GB.

**Chunklet-based RAID**

HP 3PAR Storage incorporates several enhancements over conventional storage arrays. By making more effective use of all drive resources in the array, these enhancements allow higher performance with less hardware, which in turn, leads to cost reduction. HP 3PAR Storage supports the following RAID types:

- RAID 10 (RAID 1)
- RAID 50 (RAID 5)
- RAID Multi-Parity (MP) or RAID 6

While all storage vendors offer most of these RAID levels in one form or the other, the key difference here is that in HP 3PAR Storage, the RAID protection is not at the spindle level but at the chunklet level. The HP 3PAR Operating System (OS) divides physical drives into several equally sized slices called chunklets. The chunklets size is 1GB for HP 3PAR P10000 and 256MB for F-Class and T-Class. Each of these can be viewed as its own small disk. RAID groups are constructed from chunklets on separate drives throughout the array. Depending on the storage administrator’s choice, the HP 3PAR OS selects chunklets in such a way that the array continues to be available even if an entire disk cage (16 or 40 disks) goes offline.

- Chunklet based RAID allows thin and fat virtual volumes to co-exist on the same set of physical disks. This could be helpful to migrate existing SAP fat volumes from legacy arrays to HP 3PAR without creating any additional CPGs for fat volumes.
- Chunklet based RAID is an enabler for wide striping, the benefits of which are detailed in the next section.

**Wide striping**

In a traditional storage array, small volumes either suffer from poor performance by using few drives or waste expensive resources by using more drives than required for capacity in order to obtain sufficient performance.

With HP 3PAR Storage, even modest-sized volumes are created with wide striping using chunklets spread over all drives of the same type. As shown in Figure 2, wide striping provides the full performance capabilities of the array to small volumes without provisioning excess capacity and without creating hot spots on a subset of physical drives. Other chunklets on the drives are available for other volumes. The figure also shows several RAID groups on traditional storage arrays that are created directly from pools of physical disks. The RAID groups, in red, blue, green and yellow, could have unbalanced I/O loads on a subset of disks and cause performance issues.
Figure 2. Wide striping on HP 3PAR Storage compared to traditional RAID

Fast RAID

With HP 3PAR Storage, RAID groups are constructed from chunklets, not from whole drives. Different chunklets on a physical drive can be used for volumes with different RAID levels. On a traditional array, a storage administrator might be forced to use RAID 1 for an archival volume in order to use space that is available on a RAID 1 disk even though RAID 5 would deliver adequate performance for an archive volume with less overhead. The chunklet-based approach deployed by HP 3PAR Storage allows all RAID levels to coexist on the same physical drives, using the optimal RAID level for each volume.

Fast RAID 5

Fast RAID 5 combines the HP 3PAR ASIC, a battery-backed memory cache, and wide striping for reducing spindle contention to offer performance that approaches that of RAID 1 in traditional arrays, thereby minimizing the performance impact typical of RAID 5 on legacy storage architectures. For certain workloads, RAID 5 can provide higher performance than RAID 1. The write-back cache in HP 3PAR Storage allows sequential writes (as generated by transaction journals, logs, and similar performance-sensitive workloads) to be collected until a full parity group can be written, reducing disk I/O traffic and possible back-end bottlenecks. RAID 5 is also appropriate for volumes that are dominated by read activity.

HP 3PAR Storage allows selection of the number of data blocks per parity block (n+1) to suit different needs. For RAID 5, 3+1 is the default, but any value from 2+1 to 8+1 can be selected. Higher values of n result in higher storage efficiency but can reduce the performance of random writes.
SATA disks and Fast RAID 6

Exponential growth in disk capacity without commensurate improvements in reliability or performance results in greater risk of data loss. For example, consider the 300-GB FC disks and 2-TB Nearline (Enterprise SATA) disks available with HP 3PAR Storage. The capacity difference alone implies that reconstruction of a failed disk on a replacement can be expected to take more than six times as long with the 2-TB disk. The Nearline disks are slower, as well, which further increases the mean time to repair (MTTR) relative to smaller, faster FC disks. A longer MTTR creates a larger window during which a second disk failure could cause data loss when using RAID 1 or RAID 5.

RAID 6 was created to address this problem. Like RAID 5, RAID 6 uses distributed parity, but it stores two different parity values, calculated from different parts of the stripe in a manner that allows the data to be reconstructed, even in the event of two disk failures.

HP 3PAR RAID MP (multiple, distributed parity) initially supports dual parity, equivalent to RAID 6. However, even the extra protection of RAID 6 relative to RAID 5 is less important for Nearline disks on HP 3PAR arrays than it is on traditional storage arrays where slower rebuilds make RAID 6 crucial.

Choosing the right RAID level

In traditional arrays, RAID 1 is used to increase performance, despite the cost it adds by using two raw drives for every drive’s worth of user data. RAID 5 is used to improve storage utilization where performance is less important. RAID 6 can be used to provide adequate data protection for large, slow disks.

Fast RAID 5 allows more cost-effective RAID 5, instead of RAID 1, to be used on HP 3PAR Storage. Testing of OLTP throughput performed by Oracle showed that Fast RAID 5 (3+1) delivered 91% of the performance of RAID 1 while using 33% less raw storage for the same amount of usable storage.

RAID 1 may be used on FC disks for BIN volumes to get a higher I/O on production volumes. If SSD disks are available, RAID 5 will be sufficient for BIN volumes.

In an SAP landscape, all non-production SAP instances like QA, DEV, TEST, and snapshots may be stored on RAID 6 on NL disks to get better storage capacity utilization. Further, the set size also may be increased from 8 to 16 to improve storage utilization. Fast RAID 5 may also be used for some production instances but a few points need to be considered, such as choosing FC or SSD drives and selecting a set size of 3+1, to get better performance.

Refer to the OLTP load I/O tests section for test results that are representative of an SAP I/O load.
Fast RAID reconstruction

Chunklets, wide-stripping, and the HP 3PAR ASIC combine to provide extremely fast RAID reconstruction after a drive failure, with minimal impact to performance for ongoing activity. Fast rebuilds reduce the window during which loss of an additional drive could lead to data loss, allowing the use of RAID 5 to provide a level of data protection that would require the additional storage cost of RAID 6 in other arrays.

There are two reasons for the speed of reconstruction. First, rebuild is faster because only allocated chunklets need to be reconstructed, not the entire drive. The platform’s unique thin technologies help by not allocating physical storage for unwritten or zeroed data. The data required to reconstruct allocated chunklets comes from many other drives in the array, even from simple RAID 1 mirror pairs. This data allows the wide striping that aids normal performance to speed reconstruction without causing hot spots on other drives. Spare chunklets used during reconstruction are also wide-striped, so the bottleneck of a single spare drive is avoided. Secondly, the ASIC helps to speed reconstruction by efficiently moving data and by accelerating parity calculations.

High availability options

Physical drives in HP 3PAR Storage are mounted on magazines that are contained within drive chassis. Each magazine on HP 3PAR P10000 Storage and T-Class Storage contains four drives, with up to ten magazines (40 drives) per 4U drive chassis. The midrange F-Class Storage uses single-drive magazines with up to 16 magazines per 3U drive chassis. Each drive chassis has redundant access paths via two FC connections, one to each controller node in a pair.

With RAID 1 and RAID 5, virtual volumes default to a configuration in which access to the data will survive the failure of an entire drive chassis (also known as a drive cage); in this configuration, the default High Availability (HA) value while creating a CPG is HA-cage, which causes each chunklet in a RAID group to be allocated from a physical drive in a different chassis. For RAID 6, HA-cage means the CPG or virtual volume will tolerate the failure of two physical drives in the same chassis.

In cases where it is desirable to create volumes that do not meet the HA-cage requirements, but survive the failure of two drive magazines the HA-magazine option can be used to specify that the volume must survive the failure of any two magazines.

Thin technologies

The key thin technologies of HP 3PAR Storage are Thin Provisioning, Thin Conversion, Thin Persistence, and Thin Copy Reclamation. Since their introduction, these thin technologies have been widely considered as the gold standard in thin provisioning technology.
Thin Provisioning

Thin provisioning is a feature of HP 3PAR Storage that allows administrators to reduce costs by more efficiently using available storage capacity. For example, the full future capacity of an SAP database can be allocated today, but with only today’s required capacity of physical disks actually installed. Adding more disks and disk chassis increase the physical disk capacity as needed at a later time, without affecting the database. Thin provisioning helps reduce the cost of ownership by removing the requirement to purchase and allocate capacity up front, as well as by reducing the cost of power, cooling, maintenance and floor space for storage that is not actively being used. Without thin provisioning, it is common to over-allocate storage capacity by 75% or more in an attempt to avoid future service interruptions.

Many arrays have thin provisioning technology and the ability to over-allocate capacity; however, what sets 3PAR apart is that the management of a thin provisioned LUN is exactly the same as a “thick” LUN, no capacity is reserved in creating the LUN, and performance is relatively the same between thick and thin, making 3PAR thin provisioning ideal in mission-critical environments.

Figure 3. Traditional stranded capacity compared with thin provisioning on an SAP system

In SAP, system administrators typically allocate more storage than required in order to accommodate for planned growth. In Figure 3, the SAP ERP configuration requires five volumes of different sizes with 300 GB of SAP data. However, based on the traditional storage allocation analysis and consideration for future growth, the system administrator has allocated a volume of 2 TB. If an SAP data volume is created with 1 TB of space, this space is typically dedicated to that application volume only and no other application can use it. However, in many cases the full 2 TB is never used, so the remainder is essentially wasted—a major problem while managing storage capacity that is often referred to as stranded storage. The same situation holds true for the other smaller volumes of the binaries, archive, and logs.

The inefficiencies of traditional storage provisioning can impact capital costs and storage administration resources negatively. The most obvious issue is the amount of storage that remains unused and, therefore, increases the total cost of ownership. Additionally, since this allocated but unused storage capacity cannot typically be reclaimed for other applications, customers have to buy more storage capacity as their environments grow, increasing costs even further. At some point, customers may actually be required to buy a completely new storage system in addition to the one they have in place. Figure 3 shows that Thin Provisioning can reduce an SAP system’s traditional storage allocation by half.
Thin Conversion

HP 3PAR Thin Conversion software is an optional feature that converts a fully-provisioned volume to a Thinly-Provisioned Virtual Volume (TPVV). Virtual volumes with large amounts of allocated but unused space are converted to TPVV that are much smaller than the original volume. During the conversion process, allocated but unused space is discarded and the result is a TPVV that uses less space than the original volume.

- In SAP landscapes, this capability can be useful to migrate the existing fat LUNs on a legacy array to thin LUNs on an HP 3PAR array. This function can enable convergence from multiple midrange arrays with fat LUNs to a midrange HP 3PAR F-Class array with thin LUNs, thereby saving on power and floor space.

- When converting from traditional storage to HP 3PAR Storage, the longer the database instance has been in use, the greater impact will be witnessed from Thin Conversion as deletes and other changes within the instance typically continue to occupy capacity on the storage despite it is no longer being used by users.

Thin Persistence

Most storage vendors have implemented thin provisioning in their own ways. HP 3PAR Storage, however implements thin persistence over and above conventional thin provisioning. The HP 3PAR ASIC aids thin persistence by enabling a zero detection mechanism that drops the pages of zeros from being written to the storage. This feature works in real-time and analyzes the data before it is written to the source TPVV or read/write snapshot of the TPVV. Freed blocks of 16 KB of contiguous space are returned to the source volume, and freed blocks of 128 MB of contiguous space are returned to the CPG for use by other volumes. This results in the ability to reclaim storage space stranded in thin provisioned volumes, further increasing storage efficiency. Thin persistence tasks can be performed with either the HP 3PAR Operating System’s Command Line Interface (CLI) or the HP 3PAR Management Console.
Typically, SAP databases store data in the form of a matrix (tables and indexes) consisting of rows and columns. Most of the columns in these tables are fixed in length and there are several leading or trailing zeroes in these columns. The 3PAR ASIC uses this opportunity to detect and drop zeros and save on storage space. This process has been tested on SAP using ERP6. In the test setup, as shown in figure 4, we provisioned thin LUNs on two hosts and enabled zero detection on one node only. After installing SAP ERP, the storage space consumed by zero detect-enabled LUNs was 6% less than the storage space consumed on traditional thin LUNs. The storage space savings could be much higher in an actual production environment with real data. Additionally, a significant amount of space savings can be attained with zero detection turned on in conjunction with Thin Conversion because many zeros and deletes would have accumulated in the traditional array over time.
Thin Copy Reclamation

HP 3PAR Thin Copy Reclamation is similar to Thin Persistence but instead of reclaiming space from thin volumes, this software reclaims unused space from thin copies such as virtual copy snapshots and remote copies. As snapshots are deleted, the snapshot space is reclaimed from a Thinly-Provisioned Virtual Volume (TPVV) or fully-provisioned virtual volume and returned to the CPG for reuse by other volumes. The Thin Copy Reclamation feature works on any class of system. The HP 3PAR OS automatically reclaims snapshot space when the Virtual Copy, Remote Copy, or Thin Provisioning license is enabled.

- In an SAP environment, snapshots are frequently taken for faster backups and database refreshes from production to testing, QA or development. In large environments, several snapshots are scheduled, with some of them being incremental or differential snapshots; in these environments, it is a challenge for the storage administrator to keep the storage thin. Thin Reclamation seizes this opportunity and works with other thin technologies to maintain thin storage.

- In many traditional implementations, snapshot space is reserved upfront and as snaps get deleted the space reservation continues to lock up storage for snapshot use and not release the space if it is not needed. Thin Copy Reclamation helps to reclaim this deleted snapshot space.

Autonomic groups

HP 3PAR OS offers the ability to create autonomic groups also known as host sets and virtual volumes sets. Virtual volume sets can be exported to hosts sets. This function makes it very easy to provision storage to clusters and it ensures that all the hosts in the cluster see the same set of VLUNs; it also eliminates the likely human errors that the administrators may commit while manually configuring a path for each host and virtual volume. Autonomic groups save time and money while increasing efficiency and reducing risk. Figure 5, elaborates the Autonomic groups concept by showing two clusters of hosts in the two boxes on the left and two sets of LUNs on the right, host clusters are represented by host sets and sets of LUNs are represented by virtual volume sets.

- A typical SAP landscape has multiple instances running on a cluster of server nodes. With HP 3PAR Storage, a host set for all the nodes in the host cluster is created. Also all the virtual volumes that need to be visible to a host cluster can be added in a virtual volume set. At this point, the virtual volume set can be easily exported to a host set, which ensures that all the VLUNs are visible to all the nodes in the host set. These sets also make it very easy to maintain the storage environment. For example, an extra LUN can be added to any cluster by adding it to the virtual volume set that is exported to that cluster. In another example, to add a node to a cluster, all that is needed on the storage side is to add the node to the existing host set and it will start seeing all the VLUNs visible to all other nodes in the same cluster. This process reduces the time administrators spend provisioning storage and avoids situations that can easily lead to error.
Figure 5. Autonomic groups

Virtual domains

HP 3PAR Virtual Domains software is virtual machine software that delivers secure access and robust storage services for different and diverse applications/user groups, or virtual private arrays. By providing secure, administrative segregation of users and hosts within a consolidated HP 3PAR Storage, Virtual Domains allows individual user groups and applications to affordably achieve greater storage service levels (performance, availability, and functionality) than previously possible. This functionality is highly leveraged by hosting providers to deliver virtual private array services and enterprise IT organizations to deliver “self-service” storage that is both secure and capable of high quality-of-service levels.

- Additionally, HP 3PAR OS provides a functionality to create consistency groups for a set of VLUNs. These are very helpful in taking a consistent snapshot of all the LUNs belonging to a database. These snapshots can be further used for backups or database refresh of production data into testing or QA instances.

- All SAP landscapes consist of multiple SAP instances running different SAP applications like ERP, CRM, SRM, BW, etc. These applications run on more than one instance for production, quality assurance, testing, and development. Each instance also runs over a cluster of nodes, thereby adding further complexity. In this scenario, it is challenging for a storage administrator to keep track of which LUNs and paths belong to which hosts. There is also a chance of accidentally provisioning a LUN to a wrong host or cluster.

- HP 3PAR OS provides a domain functionality that can help overcome this challenge by organizing the storage objects in a way that makes it easier to track LUNs, hosts, host sets, paths, and storage users by segregating them into virtual domains. For example, if a CPG is attached to a domain, any LUNs created within that CPG cannot be assigned to any host outside the domain.

- Figure 7 shows how a virtual domain would look in an SAP Landscape, with separate domains created for development, production, QA, and testing environments. Separate CPGs can be created for each of these domains, ensuring that any LUNs created in those CPGs can be exported only to hosts within that domain.
Figure 6. Virtual domain and virtual domains sets

Figure 7. Virtual domain and its member objects
Virtual domain sets

Virtual domain sets extend autonomic groups by offering a functionality to create a domain set by adding a group of virtual domains, as shown in figure 6. HP 3PAR Storage offers a capacity that can scale up to 1.6PB; it is therefore imperative that all of this capacity not be used for just one application and that there may be other applications that will share the same storage array. For such scenarios, HP 3PAR OS provides a layer of segregation over and above the virtual domains by providing a possibility of creating domain sets to organize domains.

By using virtual domains, storage administration activities can be decentralized by creating a separate User ID for each DBA, with user rights specific to provisioning storage for their respective applications within their domain. HP 3PAR OS ensures that these users can only see and use the storage objects within the domain where they have access.

Domains can also help implement service guarantees. For example, SSD and FC drives can be assigned in the domain where the production instances are running, with Nearline drives assigned to the test, QA, and development domains. This provides better performance for production instances, and also reduces the storage cost by running non-production instances on Nearline (SATA) drives. This is done by creating separate CPGs and then adding them to the domains.

Using the virtual domain sets feature, a domain set can be created for each of SAP, Microsoft®, Fileservers, and others. Since 3PAR systems support a mixed workload, all of these can co-exist in the same array using a converged infrastructure vs. islands of infrastructure. This can also be helpful in generating key reporting details like number of virtual volumes, hosts, and total space used in a snapshot.

Figure 8 shows domain sets for SAP and Microsoft applications, as well as the domains that are part of the SAP domain set, for example, DEV, PROD, QA, and TEST.
Dynamic Optimization

HP 3PAR Dynamic Optimization (DO) software is an optional product that allows the underlying characteristics of a volume to be changed transparently and without disruption of service. Using this software ensures that drive type, RAID level and configuration, and high availability options can all be changed simply, easily, and non-disruptively. Unlike traditional arrays, where a poor initial choice can be difficult and/or costly to change, dynamic optimization allows changes to be made easily.

Figure 9. Dynamic optimization allows changes to be made easily

<table>
<thead>
<tr>
<th>RAID 10</th>
<th>RAID 50</th>
<th>RAID 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid State Drive (SSD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibre Channel (FC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nearline Drives (SATA)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- DO also makes it easy for a storage administrator to adapt to the changing needs of a modern, dynamic computing environment. For example, a previously high-priority project that used RAID 1 on high-performance FC disks could be moved to more cost-effective RAID 6 storage on SATA disks non-disruptively. This allows storage administrators to move volumes from RAID 5 (3+1) to RAID 5 (7+1) non-disruptively. Changing the RAID level can help in saving storage space.

- Another use of DO is to redistribute volumes after adding drives to HP 3PAR Storage. Using dynamic optimization, existing volumes are autonomically striped across existing and new drives for optimal volume performance after capacity expansions. The increase in the total number of disks for the provisioned volume contributes to higher performance.
Figure 10. Sample SAP configuration using Dynamic Optimization

HP 3PAR Adaptive Optimization (AO) software is a fine-grained, policy-driven, autonomic storage software solution that delivers service level optimization for enterprises and cloud datacenters at a low cost while increasing agility and minimizing risk. AO analyzes performance (access rates) for sub-volume regions, then selects the most active regions (those with the highest I/O rates) and uses the proven sub-volume data movement engine built in to HP 3PAR OS software to autonomically move those regions to the fastest storage tier. It also moves less active regions to slower tiers to ensure space availability for newly-active regions.

Traditional storage arrays require the storage administrator to choose between slow, inexpensive storage and fast, expensive storage for each volume — a process that depends on the storage administrator’s knowledge of the application’s storage access patterns. Moreover, volumes tend to have hot spots rather than evenly-distributed accesses, and these hot spots can move over time.

For SAP, if higher loads are anticipated during month-end or quarter-end, the ERP instance can be moved to a higher tier. Similarly, most organizations have a predictable monthly payroll cycle and these payroll processes generate high I/O load, so the movement of payroll related instance and volumes to a higher tier can be scheduled in anticipation of the higher load. Once the processing is done it can be pushed back to lower tiers — all this can be done non-disruptively using DO.

SAP Dialog processes require more system resources to operate than do SAP background processes. When the system is busiest, the DO program can move the volumes of SAP systems with active dialog processes volumes into higher tiered storage such as SSD or FC and move the SAP systems with mostly background processes into Nearline storage. Figure 10 shows how DO optimizes the performance of SAP Dialog processes by moving the SAP DATA and SAP LOG volumes to a higher tier storage and the DB ARCHIVE volume to a lower tier storage. When there are lesser transactions, the SAP DATA and SAP LOG volumes can stay in the middle tier or be moved to a lower tier if necessary. In this way, the top storage tiers are freed up for other applications to use.

Adaptive Optimization

For SAP, if higher loads are anticipated during month-end or quarter-end, the ERP instance can be moved to a higher tier. Similarly, most organizations have a predictable monthly payroll cycle and these payroll processes generate high I/O load, so the movement of payroll related instance and volumes to a higher tier can be scheduled in anticipation of the higher load. Once the processing is done it can be pushed back to lower tiers — all this can be done non-disruptively using DO.

SAP Dialog processes require more system resources to operate than do SAP background processes. When the system is busiest, the DO program can move the volumes of SAP systems with active dialog processes volumes into higher tiered storage such as SSD or FC and move the SAP systems with mostly background processes into Nearline storage. Figure 10 shows how DO optimizes the performance of SAP Dialog processes by moving the SAP DATA and SAP LOG volumes to a higher tier storage and the DB ARCHIVE volume to a lower tier storage. When there are lesser transactions, the SAP DATA and SAP LOG volumes can stay in the middle tier or be moved to a lower tier if necessary. In this way, the top storage tiers are freed up for other applications to use.

Adaptive Optimization

HP 3PAR Adaptive Optimization (AO) software is a fine-grained, policy-driven, autonomic storage software solution that delivers service level optimization for enterprises and cloud datacenters at a low cost while increasing agility and minimizing risk. AO analyzes performance (access rates) for sub-volume regions, then selects the most active regions (those with the highest I/O rates) and uses the proven sub-volume data movement engine built in to HP 3PAR OS software to autonomically move those regions to the fastest storage tier. It also moves less active regions to slower tiers to ensure space availability for newly-active regions.

Traditional storage arrays require the storage administrator to choose between slow, inexpensive storage and fast, expensive storage for each volume — a process that depends on the storage administrator’s knowledge of the application’s storage access patterns. Moreover, volumes tend to have hot spots rather than evenly-distributed accesses, and these hot spots can move over time.
HP 3PAR AO software increases the use of higher tier storage, such as SSDs for an SAP system, by moving sub-volumes instead of full volumes as in DO. At a minimum, AO is applied into the SAP DATA volumes and the SAP LOG and DB ARCHIVE are left on FC. If the storage array is sufficiently sized, AO can be applied to DB BINARY and SAP DATA as shown in Figure 11. This will spread the 3PAR virtual volumes into all three tiers of storage, depending on the algorithm to segregate hot, warm, and cold regions on the volume.

In SAP environments, AO can significantly reduce storage cost by moving all dormant data to a lower tier residing on the less expensive Nearline drives, while using SSD and FC drives for active data. This also helps to increase the total storage space available since NL drives bring with them a much higher storage capacity of 1-2TB as compared to FC 300-600GB and SSD 50-100GB.
Tested configuration based on HP 3PAR Storage

As shown in Figure 12, the setup used for testing HP 3PAR Storage for this white paper consisted of an HP BladeSystem c7000 enclosure with three HP ProLiant BL460c server blades, connected to HP 3PAR F400 Storage over an 8Gbps SAN consisting of HP B-series switches.

Figure 12. Test setup
The tested configuration consisted of the following components and devices:

- HP 3PAR OS v3.1.1
- HP 3PAR Management Console 4.2.0
- HP 3PAR CLI 3.1.1
- Controller nodes (4)
  - F-Class control cache 8GB, data cache 12GB per controller pair
  - Controller memory 16GB
  - Data memory 48GB
- Fibre host connectivity
- Host port speed 4Gb
- Host port used (4)
- Drive enclosure cages (6)
- Drive types used
  - 64 x 300GB 15K rpm FC
  - 16 x 2000GB 7k rpm NL (SATA)
  - 8 x 100GB SSDs
- Common Provisioning Group (CPG) and Virtual Volume Layout
  - RAID 1 using SSD with cage availability
  - RAID 5 (set size of 3+1) using Nearline with cage availability
  - RAID 6 (set size of 8) using 15K FC drive type with port availability

Client system configuration used in this verification

In the tested configuration based on HP ProLiant BL460c servers, the following system configuration and software was used on the clients using HP 3PAR Storage:

- ProLiant BL460c
- SUSE Linux Enterprise Server 11(x86_64)
- SAP BS2011 which includes ERP6.0, SRM, CRM, SCM and BW
- Oracle 11gR2 Database

HP 3PAR performance

Tests were conducted to evaluate HP 3PAR Storage performance at the OS level and at the OLTP database level. These tests generated I/O load that is representative of the I/O load of an SAP database in terms of achievable IOPS and achievable throughput in MB/s. The performance was measured by trending the result of running several tests in parallel on a variable number of storage devices. The testing was repeated for RAID10, RAID50 and RAID60 to observe the storage performance under an SAP-like load.

Low level I/O tests

We performed low-level random I/O tests to determine the maximum supportable I/O rates for these HP 3PAR devices in a SAN environment. The tests were performed using an HP internal low-level I/O load generation tool with the 8k-byte block size and the 80:20 read-write ratio that is typical of OLTP databases. Results, shown in Figure 13, clearly convey that depending upon the RAID level chosen, about 30-50k I/O operations per second (IOPS) could be achieved easily with FC disks. These tests were conducted on the VLUNs residing on FC disks on a 3PAR F400 which was used to store our database and the redo logs.

The tests were performed to record the IOPS and MB/s for 3PAR VLUNs configured for RAID10, RAID50 and RAID60. Within each of these categories, trending was also done to determine the effect of increasing the number of LUNs from 5 to 25 in increments of five.
The test results showed that while RAID10 comes with the highest IOPS and MB/s, Fast RAID50 is close to RAID10 and gives almost 80-85% of the performance given by RAID10 while delivering up to 25% better storage space efficiency.

In general, the trending revealed performance improvement for all RAID types as the number of LUNs was increased.

Figure 13. Low level I/O and throughput comparison
### Table 3. Low level I/O and throughput comparison

<table>
<thead>
<tr>
<th>LUNs</th>
<th>RAID10</th>
<th>RAID50</th>
<th>RAID60</th>
<th>RAID10</th>
<th>RAID50</th>
<th>RAID60</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>42508</td>
<td>34782</td>
<td>29433</td>
<td>348</td>
<td>285</td>
<td>241</td>
</tr>
<tr>
<td>10</td>
<td>48104</td>
<td>40223</td>
<td>31608</td>
<td>394</td>
<td>330</td>
<td>259</td>
</tr>
<tr>
<td>15</td>
<td>48860</td>
<td>40304</td>
<td>31773</td>
<td>400</td>
<td>330</td>
<td>260</td>
</tr>
<tr>
<td>20</td>
<td>49577</td>
<td>39849</td>
<td>31440</td>
<td>406</td>
<td>326</td>
<td>258</td>
</tr>
<tr>
<td>25</td>
<td>50738</td>
<td>39591</td>
<td>31283</td>
<td>416</td>
<td>324</td>
<td>256</td>
</tr>
</tbody>
</table>

**OLTP load I/O tests**

In addition to the low level I/O tests, the storage was stressed with OLTP load I/O tests that more closely represent a real database environment. These tests were conducted using an Oracle Orion tool to generate random I/O load and measure IOPS and throughput (MB/s). We simulated the I/O with a read-write ratio of 80:20, on 100GB LUNs running on 300GB 15k FC disks. The tool generates I/O load levels by taking into account the number of disk spindles being tested.

The advantage to using Orion is in its ability to increment the I/O arrival rate and use requests of varying block sizes to test the storage through the I/O stack. Orion is a very predictable workload that allows for making comparisons and gaining insight into storage behaviors.
Figure 14. OLTP load I/O and throughput comparison

**Note**

ORION (Oracle I/O Calibration Tool) is a standalone tool for calibrating the I/O performance for storage systems that are intended to be used for Oracle databases. The calibration results are useful for understanding the performance capabilities of a storage system, either to uncover issues that would impact the performance of an Oracle database or to size a new database installation.

Since ORION is a standalone tool, the user is not required to create and run an Oracle database.
<table>
<thead>
<tr>
<th>LUNs</th>
<th>RAID10</th>
<th>RAID50</th>
<th>RAID60</th>
<th>RAID10</th>
<th>RAID50</th>
<th>RAID60</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>47346</td>
<td>39013</td>
<td>33200</td>
<td>370</td>
<td>305</td>
<td>259</td>
</tr>
<tr>
<td>10</td>
<td>50572</td>
<td>42331</td>
<td>35270</td>
<td>395</td>
<td>331</td>
<td>276</td>
</tr>
<tr>
<td>15</td>
<td>51320</td>
<td>42860</td>
<td>34952</td>
<td>401</td>
<td>335</td>
<td>273</td>
</tr>
<tr>
<td>20</td>
<td>51791</td>
<td>43804</td>
<td>34495</td>
<td>405</td>
<td>342</td>
<td>269</td>
</tr>
<tr>
<td>25</td>
<td>52927</td>
<td>43564</td>
<td>33391</td>
<td>414</td>
<td>340</td>
<td>261</td>
</tr>
</tbody>
</table>

OLTP tests revealed these results:

- The HP 3PAR performed even better in these tests as compared to the low level I/O tests.
- The IOPS and MB/s achieved using Orion were slightly higher than that achieved in the low level I/O tests.
- RAID 1 was 17% higher on IOPS and throughput as compared to RAID 5.
- The IOPS and MB/s counters showed higher numbers as the number of LUNs was increased in multiples of five.
- Since these tests are representative of an actual SAP load, we can conclude that HP 3PAR Storage is well-equipped for an SAP load.
Wide striping effectiveness test

Wide striping was tested by varying the I/O load on the 3PAR F400 Storage system using HP internal I/O generation tools, which provided randomized I/O in the ratio of 80:20 read:write. Figure 15 shows near equal I/O distribution on all of the 64 physical FC disks that were installed on the storage; moreover, with some FC disks frequently higher than 200 IOPS. It is also noteworthy that these 64 FC disks were dedicated to two controller nodes. Each controller owned 32 disks, yet the I/O was uniform over all the disks.

Figure 15. Wide striping effectiveness test

Each bar in the horizontal axis indicates a physical drive in the CPG and the vertical axis indicates IOPS. This example shows about 200 IOPS per physical drive of which about 75% is read and 25% write.

Wide striping effectiveness test revealed these results.

- Both the controller nodes were active handling I/O requests.
- The LUN was spread across all 64 FC disks and all the disks were actively handling the I/O requests. The I/O count observed on all the disks is almost equal as shown in Figure 15.
- This shows that HP 3PAR is truly active-active storage. This is a direct outcome of chunklet based RAID and mesh connected architecture, which can improve SAP performance far beyond any other monolithic array.

Dynamic Optimization effectiveness test

The effectiveness of DO software was tested in the lab by artificially generating high I/O load on an SAP database and then, from the backend, changing the RAID type of the relevant volumes. All the volumes were migrated from one RAID type to another non-disruptively and the SAP instance was up and running all throughout the virtual volume migration phase. While this migration can be done at any time, it does have an overhead of 5-10% on the storage response times; therefore, it is advisable to plan the virtual volume tuning activities when the I/O load on the database is relatively low. The considerations before migrating virtual volumes would be the RAID type, disk type and volume size of the source and target volumes.
Adaptive Optimization effectiveness test

On a hardware level, the F400 was altered using SSD, FC and Nearline drives, and CPG tiers were created as per the details shown in Table 5. Table 6 shows additional Systems Reporter options to tune policy advisor. These options can be set to change the number of hours of I/O statistics to consider for moving the regions and the optimization mode to select, such as Performance, Balanced or Cost.

Table 5. CPG tiers

<table>
<thead>
<tr>
<th>Tier 0</th>
<th>Tier 1</th>
<th>Tier 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD</td>
<td>8 * 100GB</td>
<td>SSD</td>
</tr>
<tr>
<td>FC</td>
<td>24 * 300GB</td>
<td>FC</td>
</tr>
<tr>
<td>NL</td>
<td>32 * 1TB</td>
<td>NL</td>
</tr>
</tbody>
</table>

Table 6. Policy advisor

<table>
<thead>
<tr>
<th>Measurement hours</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Performance</td>
</tr>
</tbody>
</table>

The Adaptive Optimization software was tested by artificially generating I/O load on 3PAR LUNs using Oracle Orion. The load was random I/O with a read:write ratio of 80:20 that is typical of OLTP databases. Figure 16 shows that while most of the data that was cold was residing on tier 2 (NL), only the hot regions were moved to tier 0 (SSD) drives. It is further seen on the adjacent graph that most of the I/O was happening only on SSD tier, that is, tier 0.

Figure 16. Adaptive Optimization effectiveness test
The region move for LUNs that were cold was tested by shutting down all I/O on those LUNs. After several hours, all of those LUNs were moved to tier 2, that is, Nearline drives. A rerun of the I/O load tests again started moving regions to higher tiers. Figure 17 shows a System Reporter output of region moves for the selected duration. It is seen that much of the data has moved from tier 0 to tier 2 and freed up space on the SSD drives.

Figure 17. Region Move report

Space moved by Adaptive Optimization from 2012-03-13 13:13:26 to 2012-03-13 16:04:47

SAP configuration on HP 3PAR

A typical SAP environment consists of multiple production, quality assurance, and development systems. Multiple tiered SAP systems can be configured on a robust disk array such as the HP 3PAR Storage system without compromising reliability, performance, and availability.

SAP system layout

All SAP databases consist of data containers that hold actual data and transaction logs that maintain a record of all changes that have been made to the database. In the event of system failure, successful recovery of the database depends on the availability of the transaction logs. It is therefore recommended that the log files and data files be stored on different virtual volumes to simplify overall manageability.

Table 7 illustrates a sample of how SAP and database components can be distributed on different virtual volumes and RAID levels for Oracle. Except for a few common folders like /oracle, the same structure can be repeated for each SAP instance. Traditionally, one SAP instance is installed on five LUNs and each LUN is home to SAPbin, ORACLEbin, ORACLElog, ORACLEarch and SAPdata. On each LUN, a logical volume manager (LVM) volume group is created and multiple logical volumes are created as needed by the binaries and data file.

The I/O testing revealed that having a higher number of LUNs gives better IOPS and MB/s. Hence, increasing the number of LUNs would be beneficial. This increase, however, would not have any impact on the total storage space consumption because all the virtual volumes will be thin provisioned.
<table>
<thead>
<tr>
<th>3PAR Virtual Volume</th>
<th>Size (GB)</th>
<th>LVM volume group</th>
<th>LVM LVOL</th>
<th>Mount point</th>
<th>RAID level</th>
</tr>
</thead>
<tbody>
<tr>
<td>sapvvol01bin1</td>
<td>50</td>
<td>vg_sap_bin1</td>
<td>lv_sapbin1</td>
<td>/sapmnt/$SAPSID$</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol01bin2</td>
<td>50</td>
<td>vg_sap_bin2</td>
<td>lv_sapbin2</td>
<td>/usr/sap/trans</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol01bin3</td>
<td>50</td>
<td>vg_sap_bin3</td>
<td>lv_sapbin3</td>
<td>/usr/sap/$SAPSID$</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol02bin1</td>
<td>50</td>
<td>vg_oracle_bin1</td>
<td>lv_orabin1</td>
<td>/oracle</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol02bin2</td>
<td>50</td>
<td>vg_oracle_bin2</td>
<td>lv_orabin2</td>
<td>/oracle/client</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol02bin3</td>
<td>50</td>
<td>vg_oracle_bin3</td>
<td>lv_orabin3</td>
<td>/oracle/stage/112_64</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol02bin4</td>
<td>50</td>
<td>vg_oracle_bin4</td>
<td>lv_orabin4</td>
<td>/oracle/$SAPSID$</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol02bin5</td>
<td>50</td>
<td>vg_oracle_bin5</td>
<td>lv_orabin5</td>
<td>/oracle/$SAPSID$/112_64</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log1</td>
<td>50</td>
<td>vg_oracle_log1</td>
<td>lv_oralog1</td>
<td>/oracle/$SAPSID$/origlogA</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log2</td>
<td>50</td>
<td>vg_oracle_log2</td>
<td>lv_oralog2</td>
<td>/oracle/$SAPSID$/origlogB</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log3</td>
<td>50</td>
<td>vg_oracle_log3</td>
<td>lv_oralog3</td>
<td>/oracle/$SAPSID$/mirrlogA</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log4</td>
<td>50</td>
<td>vg_oracle_log4</td>
<td>lv_oralog4</td>
<td>/oracle/$SAPSID$/mirrlogB</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log5</td>
<td>50</td>
<td>vg_oracle_log5</td>
<td>lv_oralog5</td>
<td>/oracle/$SAPSID$/sapreorg</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol03log6</td>
<td>50</td>
<td>vg_oracle_log6</td>
<td>lv_oralog6</td>
<td>/oracle/$SAPSID$/saptrace</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol04arch1</td>
<td>250</td>
<td>vg_oracle_arch</td>
<td>lv_orarch</td>
<td>/oracle/$SAPSID$/orarch</td>
<td>10</td>
</tr>
<tr>
<td>sapvvol05data1</td>
<td>500</td>
<td>vg_sapdata1</td>
<td>lv_sapdata1</td>
<td>/oracle/$SAPSID$/sapdata1</td>
<td>50 or 60</td>
</tr>
<tr>
<td>sapvvol05data2</td>
<td>500</td>
<td>vg_sapdata2</td>
<td>lv_sapdata2</td>
<td>/oracle/$SAPSID$/sapdata2</td>
<td>50 or 60</td>
</tr>
<tr>
<td>sapvvol05data3</td>
<td>500</td>
<td>vg_sapdata3</td>
<td>lv_sapdata3</td>
<td>/oracle/$SAPSID$/sapdata3</td>
<td>50 or 60</td>
</tr>
<tr>
<td>sapvvol05data4</td>
<td>500</td>
<td>vg_sapdata4</td>
<td>lv_sapdata4</td>
<td>/oracle/$SAPSID$/sapdata4</td>
<td>50 or 60</td>
</tr>
</tbody>
</table>
Reference architectures

An SAP landscape can be implemented in many ways depending upon the size of the SAP data, number of users, and acceptable response times. SAP installations are broadly defined as Small, Medium and Large ERP.

**Small ERP**

Typically, small ERP systems are in the range of 200 to 500 medium-weighted Sales and Distribution (SD) users. Modular compute is based on the ProLiant BL460c G7. In SAP central server form, this platform achieves SD benchmark performance of more than 26,000 SAPs. In native or virtualized operating environment, this capacity is sufficient for a small ERP implementation. Two blades would be required for production instances and the database.

Two additional blades provide compute capabilities for quality assurance and development; as well as support for testing in either native or virtual operating environments. The c3000 enclosure would still have enough free slots to accommodate blades for applications outside the SAP landscape.

Storage resources are served by HP 3PAR F200 Storage. Capacity requirements can vary; however, small production ERP systems are typically well-served with 2 TB of storage requirement. Suggesting 6-8 TB of usable capacity allows sufficient space for growth and for two non-productive copies. An HP 3PAR F200 can be scaled up for potential storage capacity to 128TB, giving enough room to also accommodate applications outside of the SAP landscape.

SAN connectivity will be provided by installing FlexFabric modules directly in the c3000 enclosure.

**Medium ERP**

The medium ERP category is in the range of 500 to 1500 medium-weighted SD users. Modular compute can be ProLiant BL460c G7, which is suitable for x86 Linux. The SAP environment can be three-tier and OE-homogenous. With a minimum of six productive blades, a medium ERP requirement can be met with a scalable and highly available solution.
Productive SAP system distribution across a six blade minimum

SAP database and central services run together on one blade with a failover target representing a second blade. Blades three through six represent an application tier where all remaining SAP application processes run.

Both platforms offer 40-50% additional scale-up capacity for the SAP database and central services. The n+1 distribution of the application tier provides 50-60% additional scale-out capacity within the minimum of four blades.

Note
One node is used as a spare node.

The number of non-productive SAP landscapes supporting a medium ERP system can vary. A minimum of two additional blades provide sufficient compute for quality assurance and development with operational testing in either native or virtual operating environments. Since there are enough free slots in the c7000 enclosure, this setup can be used to converge other running applications like Microsoft Exchange and SharePoint outside of the SAP landscape.

Storage resources are served by HP 3PAR F400 Storage. Capacity requirements can vary, however, medium productive ERP systems are typically well-served with between 4 and 5 TB of storage. Suggesting 12 to 15 TB of usable capacity is sufficient space for growth and accounts for at least two non-productive copies. FC is a suitable SAN protocol for this size implementation. The storage sizing and planning here should also include applications outside the SAP landscape to facilitate the convergence of the whole IT landscape.

Large ERP

The large ERP category is generally beyond 1500 medium-weighted SD users. Modular compute for the SAP application is based on the ProLiant BL460c G7. One ProLiant BL685c G7 can be used for the database. With ten to twelve production servers, a large ERP requirement can be met with a scalable and highly available solution.

The number of non-productive SAP landscapes supporting a large ERP system can vary. A minimum of four additional blades provides sufficient compute capability for quality assurance and development with operational testing in either native or virtual operating environments.

Storage resources are served by HP 3PAR F400 Storage or HP 3PAR T400 Storage or HP 3PAR P10000 V400 Storage. Capacity requirements for large ERP systems are far too variable to form a reference value. However, HP 3PAR Storage offers the scalability in storage space and the storage controllers so that the storage space can grow from 16 to 800TB (V-Class) and the storage nodes can grow from two to four, thereby adding storage space and processing power. FC is a suitable SAN protocol for this size implementation.

SPC-1 benchmark

SPC-1 benchmark is designed for business-critical applications that process large and multiple complex transactions such as SAP or any other online transactional processing application.

The HP 3PAR P10000 V800, T800 and F400 Storage systems have set individual performance records by achieving SPC-1 benchmark results of 450,212 IOPS for the V800; 224,989 IOPS for the T800; and 93,050 IOPS for the F400. The storage performance council website may be referred to for further details on these records and tests performed by SPC at http://www.storageperformance.org/results/benchmark_results_spc1.

HP 3PAR Storage offers unique mixed workload support so that transaction and throughput-intensive workloads run without contention on the same storage resources, alleviating performance concerns and dramatically cutting traditional array costs. HP 3PAR Storage is massively parallel and autonomically load balanced, making simplified storage administration, high performance and consolidation easily achievable by any organization. HP 3PAR Storage is suitable for a mission-critical enterprise software application such as SAP that relies on top storage array performance.
Table 8. HP 3PAR SPC-1 performance

<table>
<thead>
<tr>
<th>Tested storage configuration</th>
<th>HP 3PAR P10000 V800</th>
<th>HP 3PAR T800</th>
<th>HP 3PAR F400</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 IOPS</td>
<td>450,212.66</td>
<td>224,989.65</td>
<td>93,050.06</td>
</tr>
<tr>
<td>Total ASU* capacity (GBs)</td>
<td>230,400GB</td>
<td>77,824GB</td>
<td>27,046GB</td>
</tr>
<tr>
<td>SPC-1 Price/performance $/SPC-1 IOPS</td>
<td>$6.59</td>
<td>$9.30</td>
<td>$5.89</td>
</tr>
<tr>
<td>Data protection level</td>
<td>Mirroring</td>
<td>Mirroring</td>
<td>Mirroring</td>
</tr>
<tr>
<td>Identifier</td>
<td>A00109</td>
<td>A00069</td>
<td>A00079</td>
</tr>
<tr>
<td>Version</td>
<td>1.12</td>
<td>1.10.1</td>
<td>1.10.1</td>
</tr>
</tbody>
</table>

General recommendations

While the prior sections have discussed 3PAR features in the context of how they add value in an SAP landscape, these are additional general recommendations:

- Create separate virtual domains for production, QA, testing and development environments.
- Create separate virtual domain sets for SAP, Microsoft, virtual server environments, etc.
- Use separate CPGs based on disk type and RAID types. Do not try to cover all permutations and combinations of disk and RAID types; only create as many CPGs as are required by the application.
- Consider the I/O pattern of the application before deciding on the RAID level.
- Use thin virtual volumes to keep storage space utilization in control. Ensure proper alerting is in place while using thin volumes. Enable zero detect to further save on storage space.
- Schedule routine tuning of virtual volumes during periods of low activity.
- Schedule routine compacting of CPGs during periods of low activity.

Conclusion

Customers demand the highest efficiency and performance in their SAP environment, while keeping costs under control. SAP customers need a storage solution they can count on to increase total resource utilization and productivity, adapt quickly to changing business conditions and protect storage investments. HP provides a wide selection of reliable storage solutions that address such requirements. We validated that HP 3PAR Storage meets these demands by testing the performance (IOPS, MB/s), storage efficiency (thin technologies), ease of use, and reduced complexity (autonomic groups). For SAP customers, data availability and performance are critical. When SAP customers need a storage solution, HP 3PAR is what they can count on—it is the ideal storage solution for all SAP landscapes.

The HP 3PAR Storage system is designed to enable business success while driving down the cost of ownership through its key features—thin provisioning for efficient allocation and utilization of storage, autonomic storage tiers for self-tuning and self-management of storage tiers, and DR solutions such as remote copy and virtual copy. Combining the reliable performance of the HP 3PAR Storage system with SAP delivers the business solutions needed to drive return on investment that adds to profitability.
Appendix A: Bill of materials

The bill of materials for an SAP installation would include the equipment listed below.

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Small</th>
<th>Medium</th>
<th>Large (Option 1)</th>
<th>Large (Option 2)</th>
<th>Large (Option 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP BladeSystem c3000 Enclosure</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP BladeSystem c7000 Enclosure</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HP Virtual Connect Flex-10 Ethernet module</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>HP Virtual Connect FlexFabric module</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>HP ProLiant BL460c G7</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>HP ProLiant BL685c G7</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>HP Storage 3Par F200</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP Storage 3Par F400</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP Storage 3Par T400</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP Storage 3Par V400</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controller nodes</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Disk cages</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Disk Magazine</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>FC 15k 300GB Disk</td>
<td>32</td>
<td>64</td>
<td>128</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>SVP (Service Processor)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HP 3Par or EIA Standard 19” rack</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2*</td>
<td>2*</td>
</tr>
</tbody>
</table>

* Only HP 3Par rack option available for T400 and V400
For more information

HP ProLiant BL460c, http://www.hp.com/servers/bl460c
HP ProLiant BL685c, http://www.hp.com/servers/bl685c
HP Single point of connectivity knowledge (SPOCK), http://www.hp.com/storage/SPOCK


© Copyright 2012 Hewlett-Packard Development Company, L.P. The information contained herein is subject to change without notice. The only warranties for HP products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. HP shall not be liable for technical or editorial errors or omissions contained herein.

Oracle is a registered trademark of Oracle and/or its affiliates. Microsoft is a U.S. registered trademark of Microsoft Corporation.