

# Optimizing Oracle Database 11gR2 with Automatic Storage Management on Hitachi Virtual Storage Platform

Best Practices Guide

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## Feedback

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# Optimizing Oracle Database 11gR2 with Automatic Storage Management on Hitachi Virtual Storage Platform

## Best Practices Guide

Today's challenges faced by storage and database administrators are twofold: one deals with storage capacity planning and database storage utilization management, and the other with data life cycle management.

Storage capacity planning and database utilization management are complex tasks that are made even more difficult by the rapid increase in data storage demands and ever-increasing database sizes. Data center managers must control storage budgets and help storage and database administrators efficiently plan for storage demands and minimize administration complexity.

One approach used by database and storage administrators to meet the I/O performance needs of applications is to deploy faster, high-performance drives. This may be a solution in environments with smaller database sizes and environments with minimal movement in hot datasets. However, as databases grow, frequently accessed data sets change constantly. It becomes more difficult to identify data based on access frequency and redistribute it to the correct storage media.

The Hitachi Virtual Storage platform addresses these challenges with the Hitachi Dynamic Provisioning software and the Hitachi Dynamic Tiering software. Hitachi Dynamic Provisioning software provides efficient and cost effective mechanisms to address capacity planning and database utilization management challenges. Hitachi Dynamic Tiering software extends the mechanisms to maximize the utilization of high-cost, high-performance storage media and supports automatic migration of frequently accessed data to address the data life-cycle management challenge.

Using a Hitachi Virtual Storage Platform with Hitachi Dynamic Provisioning software and Hitachi Dynamic Tiering software for the Oracle Automatic Storage Management (ASM) data volumes can simplify capacity management and data migration tasks. The Hitachi Virtual Storage Platform provides significant benefits by reducing initial cost of storage ownership, improving capacity design and lowering management costs. While Hitachi Dynamic Provisioning software helps satisfy storage capacity needs of the database as they arise, it also allows provisioning for future needs avoiding the need to procure the entire forecasted storage requirements in advance. Hitachi Dynamic Tiering monitors data access in real time and makes decisions on moving data between the available storage tiers based on frequency of access, thereby, increasing operational productivity, maximizing utilization of storage capacity and improving application service times.

This white paper provides best practice guidelines for using Hitachi Dynamic Provisioning and Hitachi Dynamic Tiering with Oracle 11gR2 ASM databases. It is intended for storage and Oracle database administrators. It assumes familiarity with general storage concepts and Oracle Database and Oracle Automatic Storage Management features.

## Solution Components

This section describes the hardware and software components mentioned in this best practices guide.

### Hitachi Virtual Storage Platform

The Hitachi Virtual Storage Platform can help you leverage your information, which is the new currency in today's data-driven economy. Information exists in many forms and must be protected and readily accessible to ensure business survival and success. The Virtual Storage Platform maximizes cost efficiency and return on investment by creating an agile storage infrastructure that reduces costs and increases performance, availability, scalability and reliability.

The Hitachi Virtual Storage Platform is the industry's only 3D scaling storage platform. With the unique ability to concurrently scale up, scale out and scale deep in a single storage system, the Virtual Storage Platform flexibly adapts for performance, capacity, connectivity and virtualization. No other enterprise storage platform can dynamically scale in three dimensions. Scaling up allows you to increase virtual server consolidation, improve utilization of resources, and reduce costs. Scaling out allows you to meet increasing demands by combining multiple chassis into a single logical system with shared resources. Scaling deep extends the advanced functions of the Virtual Storage Platform to external multivendor storage.

### Hitachi Dynamic Provisioning Software

On the Virtual Storage Platform, Hitachi Dynamic Provisioning software provides wide striping and thin provisioning functionalities. Basically, Hitachi Dynamic Provisioning software is similar to the use of a host-based logical volume manager (LVM), but with several additional features available within the Hitachi Virtual Storage Platform, and without the need to install software on the host or incur host processing overhead. Hitachi Dynamic Provisioning software provides for one or more pools of wide striping across many RAID groups within a Virtual Storage Platform. One or more Dynamic Provisioning virtual volumes (DP-VOLs) of a user-specified logical size of up to 60TB (with no initial physical space allocated) are created against each pool.

Primarily, you deploy Hitachi Dynamic Provisioning software to avoid the routine issue of hot spots that occur on logical devices (LDEVs) from individual RAID groups when the host workload exceeds the IOPS or throughput capacity of that RAID group. By using many RAID groups as members of a striped Dynamic Provisioning pool underneath the virtual or logical volumes seen by the hosts, a host workload is distributed across many RAID groups, which provides a smoothing effect that dramatically reduces hot spots.

Hitachi Dynamic Provisioning software also carries the side benefit of thin provisioning, where physical space is only assigned from the pool to the DP-VOL as needed using 42MB pages, up to the logical size specified for each DP-VOL. A pool can also be dynamically expanded by adding more capacity or reduced by withdrawing pool capacity. Either operation is performed without disruption or requiring downtime. Upon expansion, a pool can be rebalanced so that the data and workload are wide striped evenly across the current and newly added RAID groups that make up the pool.

Hitachi Dynamic Provisioning software's thin provisioning and wide striping functionalities provide virtual storage capacity to eliminate application service interruptions, reduce costs and simplify administration, as follows:

- Optimizes or “right-sizes” storage performance and capacity based on business or application requirements.
- Supports deferring storage capacity upgrades to align with actual business usage.
- Simplifies the storage administration process.
- Provides performance improvements through automatic optimized wide striping of data across all available disks in a storage pool.
- Eliminates hot spots across the different RAID groups by smoothing the combined workload.
- Significantly improves capacity utilization.

For more information, see the Hitachi Dynamic Provisioning software datasheet.

## Hitachi Dynamic Tiering Software

Hitachi Dynamic Tiering is a revolutionary solution that eliminates the time-consuming manual processes of data classification and movement between storage tiers, thus, optimizing tiered storage usage while improving performance. It is only available on the Hitachi Virtual Storage Platform.

Most data is rarely accessed after it is created. As a result, it should not be stored on your most expensive tier of storage, but instead moved to a lower, less expensive storage tier. Defining where and for how long data should reside at any point in its life cycle can be complex and problematic.

Many organizations use a data tiering approach to manage application performance manually provisioning space from several storage technologies with different performance and cost characteristics. Using this approach, data specialists typically look to past usage patterns to determine how to manually configure tiering, making the storage infrastructure unable to effectively respond to dynamic application and data use. If usage patterns change rapidly, manually tiered storage systems produce less than optimal results.

Hitachi Dynamic Tiering takes the automation of tiered storage to a new level. It enables the management of multiple storage tiers as a single entity. By leveraging the existing features of Hitachi Dynamic Provisioning software, Hitachi Dynamic Tiering presents a new kind of virtual volume with embedded smart tiering that monitors access and moves data at the 42MB page level. Hitachi Dynamic Provisioning software breaks the volume into pages and Hitachi Dynamic Tiering automatically moves infrequently referenced pages to lower cost tiers of storage. Moving pages instead of entire data sets or files reduces the time and storage space required to migrate data. It allows you to ensure that the right data is in the right place at the right time.

Hitachi Dynamic Tiering automatically moves pages of data within virtual volumes configured on a Dynamic Provisioning pool to the most appropriate media according to workload. This maximizes service levels and minimizes total cost of storage ownership. After an initial setup process, Hitachi Dynamic Tiering monitors data access in real time and makes decisions on moving data between the available storage tiers based on actual use. If a page on a lower tier is accessed frequently, Hitachi Dynamic Tiering moves it a higher tier. Using this approach, Hitachi Dynamic Tiering improves the availability and performance of your storage systems and the applications using that storage.

Previously, each Dynamic Provisioning pool had to be created using one RAID level and one disk type. Hitachi Dynamic Tiering on the Virtual Storage Platform allows a single pool to contain tiers made up of multiple types of RAID groups and any type of disk. Hitachi Dynamic Tiering manages the various tiers within a Dynamic Provisioning pool automatically. This eliminates most user management of storage tiers within a storage system, and maintains peak performance under dynamic conditions without storage administrator intervention.

Hitachi Dynamic Tiering is ideal for database applications and can provide improved performance for databases stored in a file system by keeping the frequently referenced data, such as indices, on tier 1 storage while moving less frequently referenced pages to a lower tier of storage. Hitachi Dynamic Tiering is also ideal for file and content data that requires high performance up front but becomes inactive over time. The self-adjusting system can optimize performance based on demand, enabling content service providers to manage their storage infrastructure more effectively and allowing the use of less expensive, higher capacity disk drives such as SATA.

For more information, see the Hitachi Dynamic Tiering software datasheet.

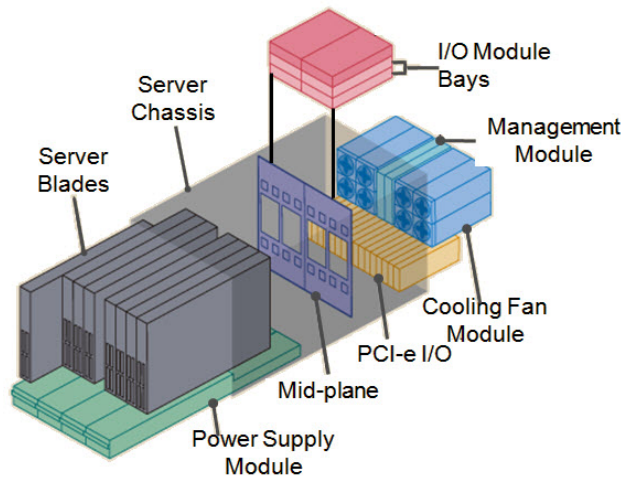
## Hitachi Compute Blade 2000

The Hitachi Compute Blade 2000 is an enterprise-class platform that offers the following features:

- Balanced system architecture that eliminates bottlenecks in performance and throughput
- Embedded Hitachi logical partitioning (LPAR) virtualization
- Unprecedented configuration flexibility
- Eco-friendly power-saving features and capabilities
- Fast recovery from server failures due to N+1 cold standby design that allows you to replace failed servers within minutes instead of hours or days

With its unique combination of power, efficiency and flexibility, you can now extend the benefits of virtualization to new areas of the enterprise data center — including mission-critical application servers and database servers — with minimal cost and maximum simplicity.

The Hitachi Compute Blade 2000 features a modular architecture that delivers unprecedented configuration flexibility, as shown in Figure 1.



**Figure 1**

The Hitachi Compute Blade 2000 combines all the benefits of virtualization with all the advantages of the blade server format: simplicity, flexibility, high compute density and power efficiency. This allows you to take advantage of the following benefits:

- Consolidate more resources
- Extend the benefits of virtualization solutions (whether Hitachi logical partitioning, VMware vSphere, Microsoft Hyper-V, or all three)
- Cut costs without sacrificing performance

The Hitachi Compute Blade 2000 enables you to use virtualization to consolidate application and database servers for backbone systems, areas where effective consolidation was difficult in the past. And by removing performance and I/O bottlenecks, the Hitachi Compute Blade 2000 opens new opportunities for increasing efficiency and utilization rates and reduces the administrative burden in your data center.

No blade system is more manageable or flexible than the Hitachi Compute Blade 2000. You can configure and administer the Hitachi Compute Blade 2000 using a web-based HTML browser that supports secure encrypted communications, or leverage the optional management suite to manage multiple chassis using a unified GUI-based interface.

## Oracle Database 11gR2 Automatic Storage Management

Oracle Database's Automatic Storage Management (ASM) system combines the features of a volume manager and an application-optimized general purpose file system. It is optimized for use with Oracle products. Oracle ASM makes it possible to stripe and mirror data automatically and to add and delete disks online; because data is reallocated automatically, ASM makes physical file management easy.

ASM Cluster File System (ACFS), which was introduced in Oracle 11gR2, is a general-purpose, single node and cluster-wide file system for non-Oracle database files. An ACFS file system is created on top of an ASM dynamic volume. Dynamic volumes are simply ASM files with an ASM volume type. They inherit -- and benefit from -- all ASM functionality as an integrated solution. The file system can store Oracle binaries, application executables, trace files, alert logs, image files and any general purpose files.

# Storage Configuration Best Practices

The following sections provide best practices for configuring storage for use with Oracle Database 11gR2 with ASM.

## Hitachi Dynamic Provisioning Software

Hitachi Data Systems recommends using Hitachi Dynamic Provisioning software in environments where its thin provisioning and wide striping features can improve performance and capacity utilization. The effectiveness of thin provisioning is dependent on how your operating system formats volumes and how applications allocate space. ASM is a thin-friendly application if you follow the best practices included in this paper for managing Oracle data.

With Hitachi Dynamic Provisioning software, storage allocation decisions need not be made at an early stage. Decisions can be delayed until capacity is actually required. This gives greater management flexibility and efficiency in the following ways:

- Newly purchased storage is not directly allocated to specific servers but instead is allocated to one of the configured storage pools.
- As application space is used, it is allocated directly from the pool only when needed.

Figure 2 shows how Hitachi Dynamic Provisioning software allows for efficient capacity planning and eases storage administration.

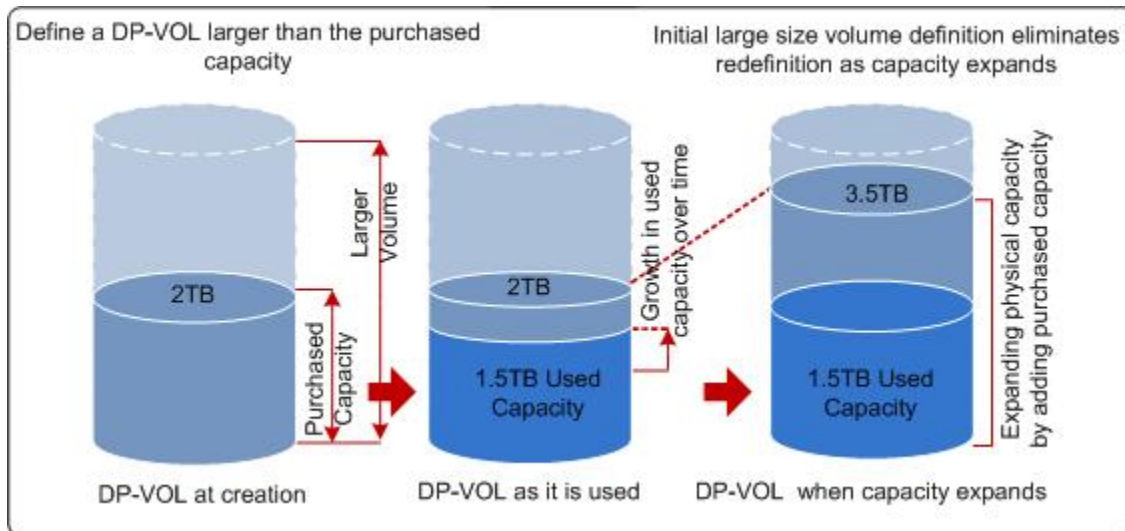


Figure 2

Deploying Oracle ASM disks using DP-VOLs from Hitachi Dynamic Provisioning pools on the Virtual Storage Platform brings the following benefits:

- Provides larger I/O buffer for peak usage times or intense maintenance activities like content indexing or database integrity checks
- Reduces the occurrence of hot spots across the different RAID groups, resulting in reduce data migration moves related to performance or capacity constraints
- Reduces management of the placement of heavy load databases
- Allows you to reclaim free space in ASM disks after deleting a large tablespace

Using Hitachi Dynamic Provisioning software does not mean you have to stop using static provisioning methods. Both are available simultaneously and most sites use both technologies. With static provisioning, physical location, reliability, performance and cost are fixed at the time the storage is made available to the server.

### *Storage Space Reclamation*

When Oracle database objects are deleted, the corresponding DP-VOL pages on the Hitachi Virtual Storage Platform remain allocated until they are marked for deallocation. Deallocation of these pages from a DP-VOL is called space reclamation. Reclamation of freed space is important because pages of storage space can be made available for reuse. For this purpose, Hitachi Dynamic Provisioning software provides a function called Reclaim Zero Pages. It is available in the virtual volumes management function in Hitachi Storage Navigator software. It returns all zeroed pages to available space for reuse. After releasing space for a DP-VOL, the Reclaim Zero Pages function performs a rebalance operation. Free space is not automatically released to the Dynamic Provisioning pool after operations like database deletion, tablespace deletion or triggering an ASM rebalance operation. Before free space can be reclaimed by Hitachi Dynamic Provisioning software, unused data blocks must be filled with zeroes. After any of these operations, you must use the ASRU utility provided by Oracle Database to identify and write zeros to unused data blocks. At this point, you can use the Reclaim Zero Pages reclaim function to detect and release page space. Schedule the Reclaim Zero Page operation during maintenance hours or low I/O activity periods. Do not run Zero Page Reclamation and ASM rebalance simultaneously. In some cases it has been found that it will lead to ASM disk header corruption.

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**Key Best Practice** —Hitachi Data Systems recommends running Hitachi Dynamic Provisioning software's Reclaim Zero Pages function after using the ASRU utility for DP-VOLS in a Dynamic Provisioning pool

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### *Performance Planning*

The Hitachi Dynamic Provisioning pool performance requirement, or the number of IOPS, is the aggregate of all applications using the same pool. Dynamic Provisioning pool design and use depends on the application performance requirements. You might need to evaluate more than one workload at the same time. This analysis provides data to inform your decisions about RAID level, minimum number of spindles necessary for performance and number of spindles required for anticipated capacity.

It is important to choose appropriate RAID levels in an ASM environment. Choose RAID levels based on your I/O performance and data availability requirements. When servicing a database workload, the difference between RAID-1+0 and RAID-5 for random writes is not pronounced when I/O is large or sequential. For example, for on-line transaction processing (OLTP) workloads with 30 percent random writes of 4K-32K, consider using RAID-1+0. However, if your workload consists of large writes (greater than 32K) or your database access is sequential in nature, for example in a data warehouse, consider using RAID-5.

When servicing large streaming sequential I/Os, an entire stripe set can be rewritten in one operation. However, in online transaction processing (OLTP) database applications, this happens comparatively infrequently due to the relatively large stripe width.

An OLTP application might only require the storage capacity of one RAID group, but might have a peak IOPS load that requires four RAID groups in a RAID-1+0 (2D+2D) configuration.

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**Key Best Practice** — Base your storage configuration decisions on performance requirements first, then capacity requirements.

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For multiple, large or performance-intensive databases, your performance requirements might justify creating a separate pool or pools for each database.

Hitachi Dynamic Link Manager software provides active-active dynamic multipaths from the Virtual Storage Platform system's storage ports to the HBA ports. You can improve I/O performance with the load balancing feature of Hitachi Dynamic Link Manager software under conditions where there is an I/O bottleneck due to saturation of existing paths. If you use Hitachi Dynamic Link Manager software for multipathing with ASM, you must change the value of ORACLEASM\_SCANORDER parameter to `ORACLEASM_SCANORDER="sddl m"` in the `/etc/sysconfig/oracleasm` file. It improves accessibility and availability of data storage.

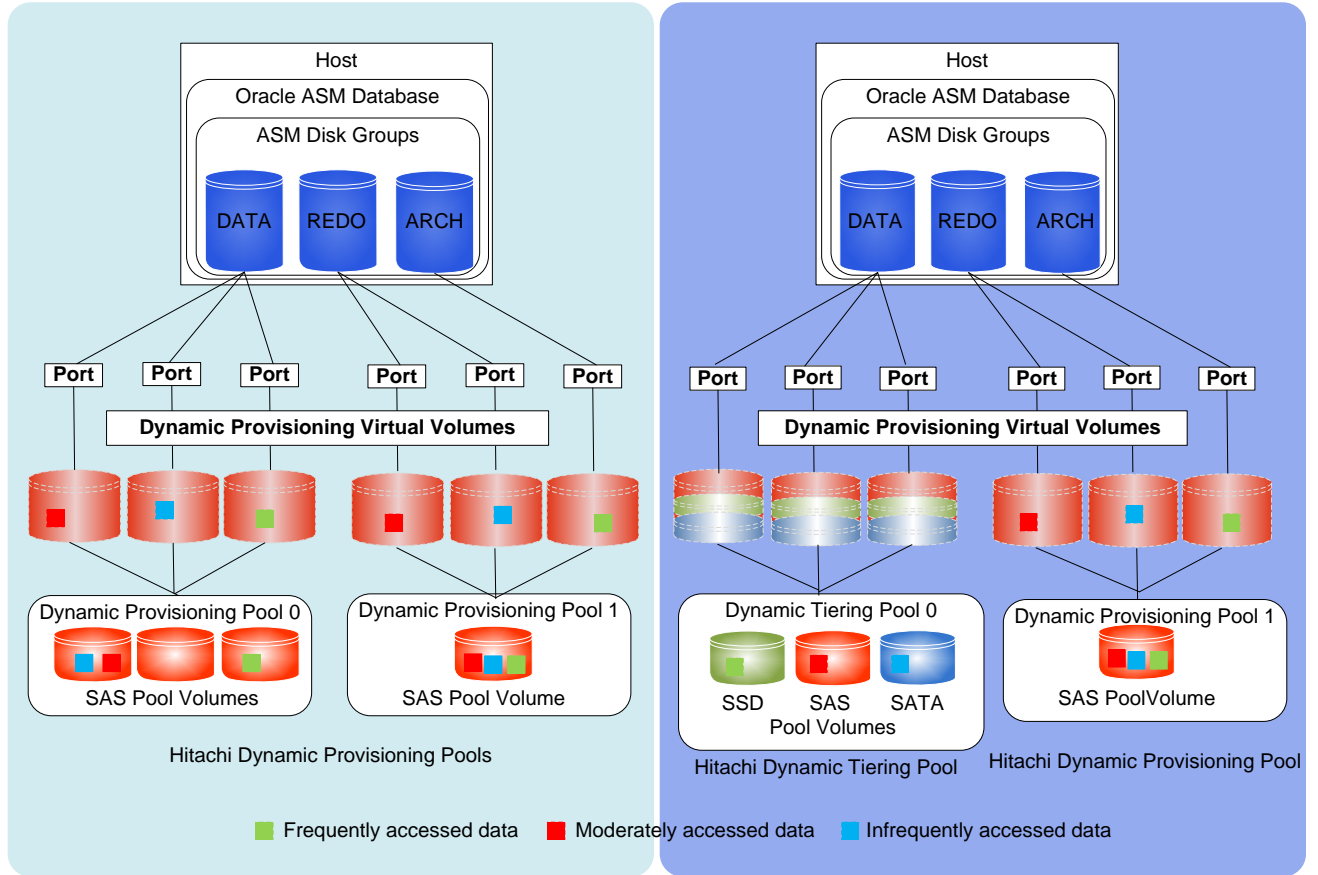
## Hitachi Dynamic Tiering Software

Hitachi Data Systems recommends using Hitachi Dynamic Tiering software in database environments where storage tiering can improve application I/O throughput, response time or storage space allocation efficiency. The effectiveness of Hitachi Dynamic Tiering on database workloads depends on the I/O characteristics of the workload.

With Hitachi Dynamic Tiering software, DP-VOL pages are automatically classified and relocated to appropriate tiers in the pool. This automatic data classification and placement gives greater management flexibility and efficiency in the following ways:

- Improves database I/O performance by adding a fast storage tier, such as SSD, for most frequently accessed database objects.
- Ensures most frequently accessed Oracle data resides in the highest tier.
- Reduces the occurrence of hot spots across the different RAID groups within the tiers of the Hitachi Dynamic Tiering pool.
- Reduces storage cost by adding a low cost storage tier, such as SATA, for rarely accessed database objects.
- Allows more granular control of database object placement among storage tiers.
- Lowers operational costs through automatic data movement among storage tiers based on the frequency of access.
- Reclaims zeroed pages automatically through automatic space reclamation during page relocation.
- Allows enabling and disabling of tier relocation management at DP-VOL and LDEV levels.
- Eliminates the operational overhead involved in manual placement of partitioned Oracle data objects between different storage media
- Eliminates the need of monitoring the I/O performance of Oracle data objects for data migration purposes.
- Eliminates the need of ASM Rebalancing.

Figure 3 shows an Oracle ASM database layout on a Hitachi Dynamic Provisioning pool and a Hitachi Dynamic Tiering pool. In the Dynamic Tiering pool, there are SSD, SAS and SATA tiers configured. The Dynamic Provisioning virtual volumes (DP-VOL) will have pages allocated from the tiers in the pool based on the Dynamic Tiering allocation policy. The Oracle online redo log and archive redo log files are not stored in the Hitachi Dynamic Tiering pool.



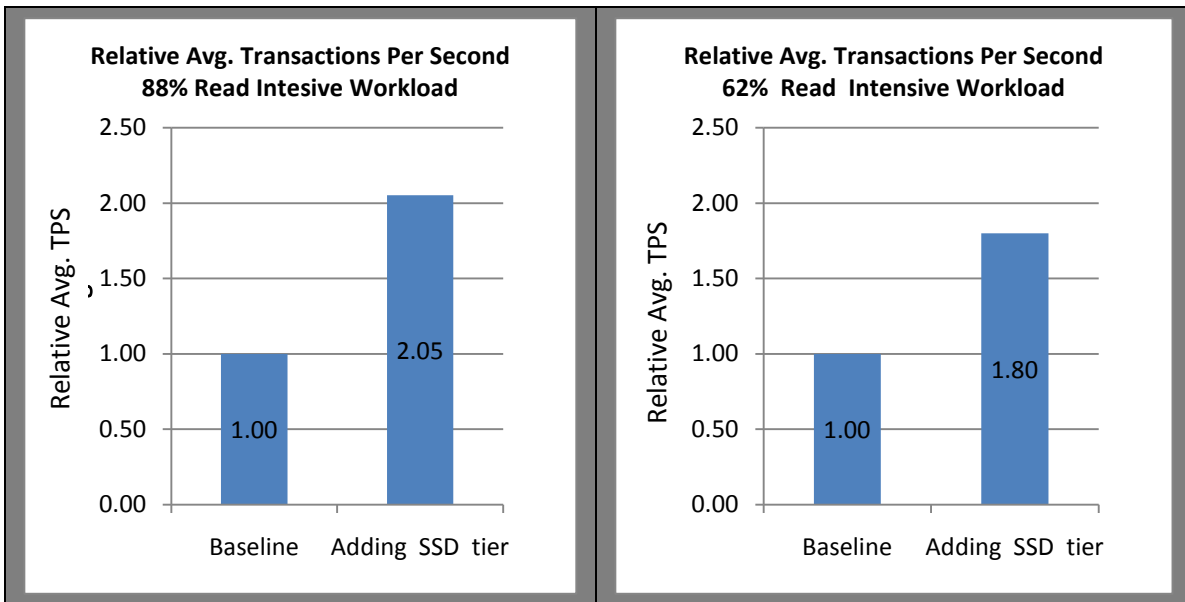
**Figure 3**

A Hitachi Dynamic Tiering pool can have a maximum of three storage tiers in one Dynamic Tiering pool. A tier is defined by I/O throughput and response performance of the media. Media with shorter response times are positioned as higher tiers and media with longer response times are positioned as lower tiers. Tier order is based on media type and rotational speed (rpm) only. Differences in performance due to RAID levels are not factored in when determining order of tiers.

### *Improving Database I/O Performance by Adding an SSD Tier*

Most Online Transaction Processing (OLTP) Oracle databases employ random I/O patterns and can benefit from adding an SSD tier to an existing Hitachi Dynamic Provisioning pool. Our lab testing results show that the database with a higher percentage of random reads benefit more from adding an SSD tier than one with less random reads because more pages are promoted into the SSD tier with the more read intensive workload.

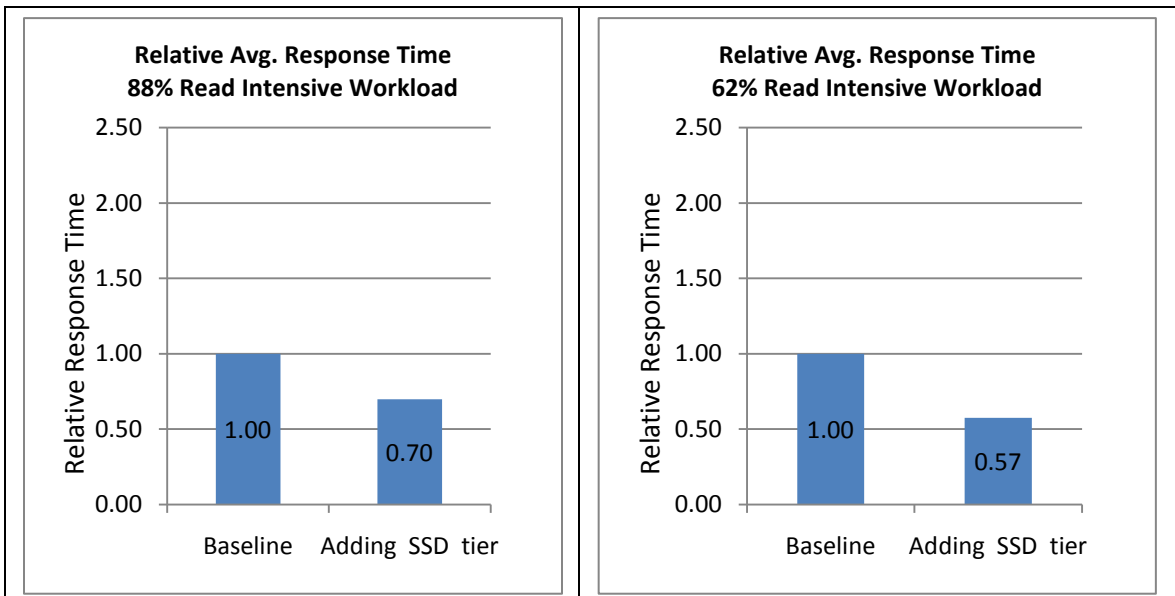
Figure 4 shows the average transactions per second increases after adding an SSD tier to an existing SAS tier pool. The chart on the left is for an OLTP database with 88% reads in all datafile I/Os. The chart on right is for the same database with 62% reads in all datafile I/Os.



**Figure 4**

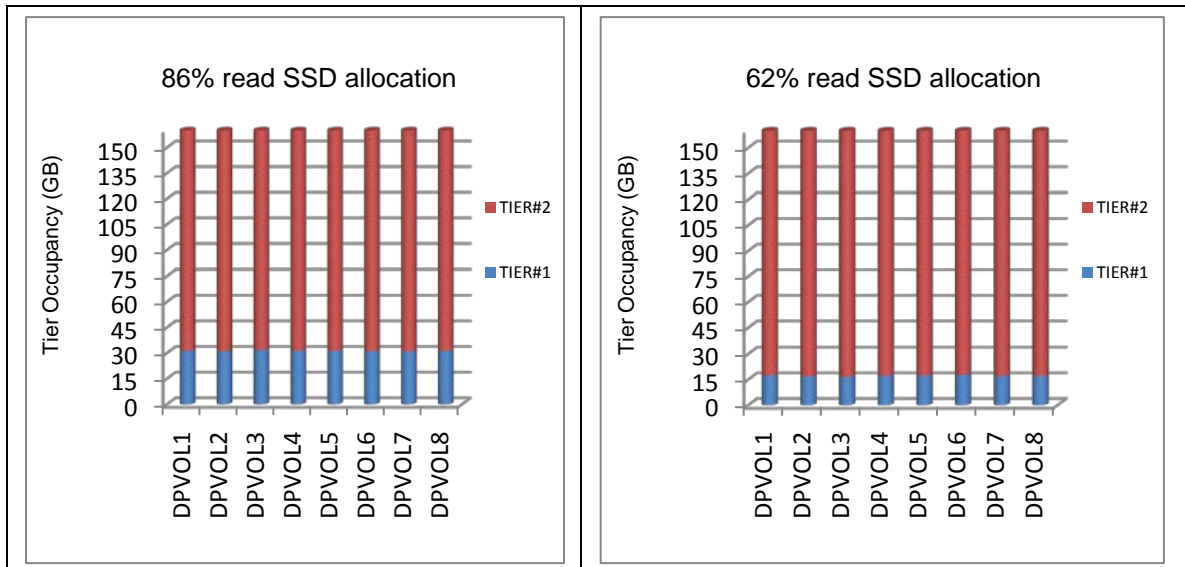
As shown in the graphs below one can also add the SSD tier to improve response times. With the workload described above the average response times improved after adding an SSD tier.

Figure 5 shows the improvement in average response time.



**Figure 5**

The different performance gains of the two workloads are because the SSD media has a higher I/O throughput capacity with a more read intensive I/O pattern. The Hitachi Dynamic Storage Tiering software intelligently adjusts the SSD tier performance capacity and right sizes the number of DP-VOL pages for the SSD tier based on the application I/O pattern. Figure 6 shows the amount of SSD tier space allocated after relocation for these two workloads. It shows that more DP-VOL pages were relocated to the SSD tier for the 88% read intensive workload as compared to the 62% read intensive workload.



**Figure 6**

The first pool volume of a Hitachi Dynamic Tiering pool cannot be removed from the pool because it contains the Dynamic Mapping Table (DMT). Therefore do not use an SSD as the first pool volume. Instead, add an SSD tier to the existing pool to improve I/O throughput or response time after determining that the workload can benefit from an SSD tier.

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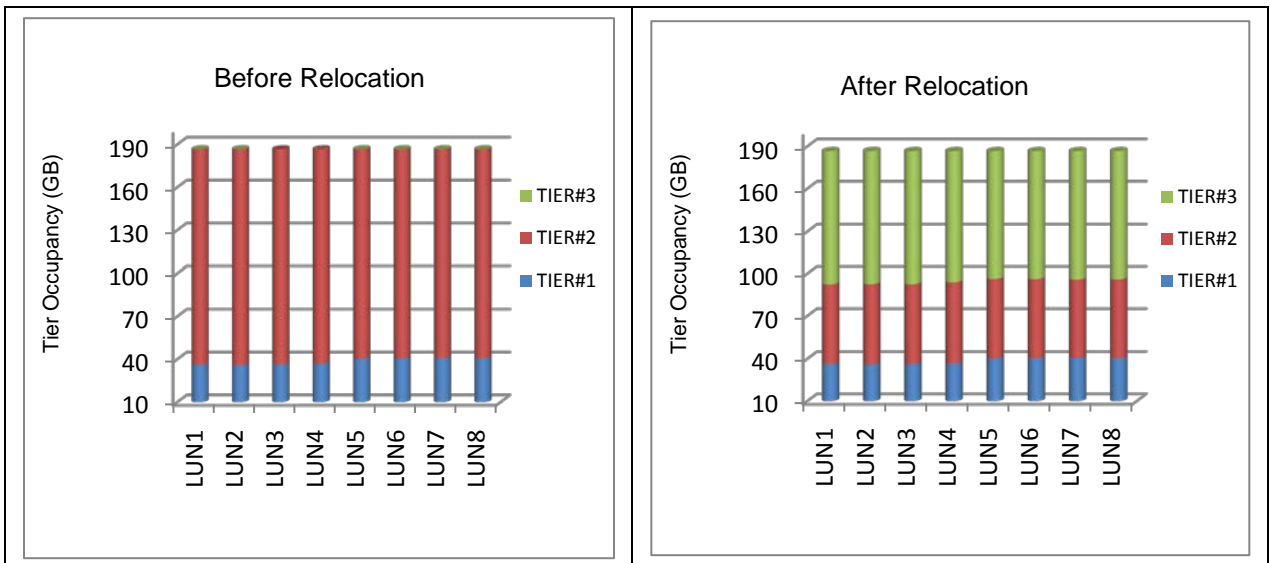
**Key Best Practice** — Hitachi Data Systems recommends using a SAS volume as the first pool volume in a Hitachi Dynamic Tiering pool.

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### *Effective Use of Low Cost Storage Media*

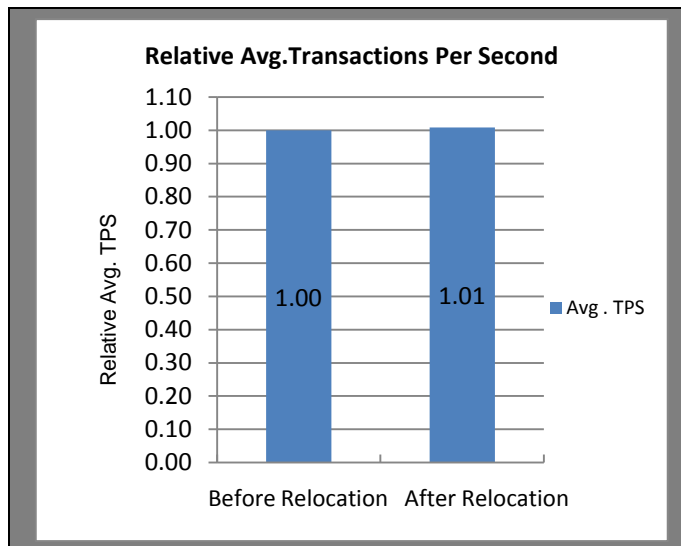
Many Oracle databases contain infrequently accessed data which is suitable for low cost storage media such as SATA. With the Hitachi Dynamic Tiering software, it is possible to add a SATA tier and have the infrequently accessed data relocated to the SATA tier. This frees up pool pages in the SAS tier.

Figure 7 shows infrequently used Oracle data has been automatically moved down to the SATA tier. The lowest tier is effectively utilized while premium capacity becomes available in the upper tier to house more data.



**Figure 7**

Our lab test results show that relocating the infrequently accessed data to the SATA tier improves effective utilization of all tiers while maintaining the performance of the application. Figure8 shows the performance was not affected after the less frequently accessed data was moved to the SATA tier.



**Figure8**

## *Reduced Operational Costs*

The manual process involved in data life-cycle management and data migration across media tiers for performance improvements are costly, cumbersome, time consuming and prone to errors. The process of monitoring data constantly for I/O performance bottlenecks, although automated is still time consuming and resource intensive. Once the data set is identified, it has to be extracted and prepared for transfer to a faster media tier. Storage required to house the extracted data set needs to be provisioned, setup and configured. The dataset has to be loaded and verified against SLAs for application performance goals. These steps constitute one monitoring and migration cycle. The cycle has to be repeated at regular intervals and at certain other trigger points, since data constantly changes impacting application service times.

With Hitachi Dynamic Tiering data management is automatic. Once the storage tiers are configured and monitoring and relocations cycles are established Hitachi Dynamic Tiering handles the rest automatically and without disruption. The database administrators can thus realize reduced operational costs, reduced risk of errors and benefit from utilizing the resources to increase operational productivity.

## *Storage Space Reclamation*

While you continue to have the option in Hitachi Dynamic Provisioning software for space reclamation and continue to reclaim zero pages as per the best practice suggested in the Hitachi Dynamic Provisioning section, Hitachi Dynamic Tiering provides further operational efficiency. Hitachi Dynamic Tiering automatically performs zero page reclamation during the relocation process. The zero page reclamation is applied to pages selected for relocation. After executing the ASRU utility provided by Oracle Database to identify and write zeros to unused data blocks, the next scheduled relocation cycle will perform the Reclaim Zero Pages function to detect and release zeroed pages back to the pool. However, if the space is required before the next relocation schedule you can use the Reclaim Zero Page operation during maintenance hours or low I/O activity periods.

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**Key Best Practice** — Hitachi Data Systems recommends running the ASRU utility after deleting a large database object and let Hitachi Dynamic Tiering software perform the Reclaim Zero Pages during the relocation cycle.

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## *Performance Planning*

Recommendations for configuring Hitachi Dynamic Tiering pools for performance include the following:

- Choose RAID-5 for SSD and SAS, and RAID-6 for SATA.
- It is recommended that the array groups used in a tier be of the same size.
- Do not place high performance media type as the first pool volume in a Dynamic Tiering pool.
- Create only one pool volume per array group. For large array groups containing multiple LDEVs place all pool volumes from an array group in the same pool.

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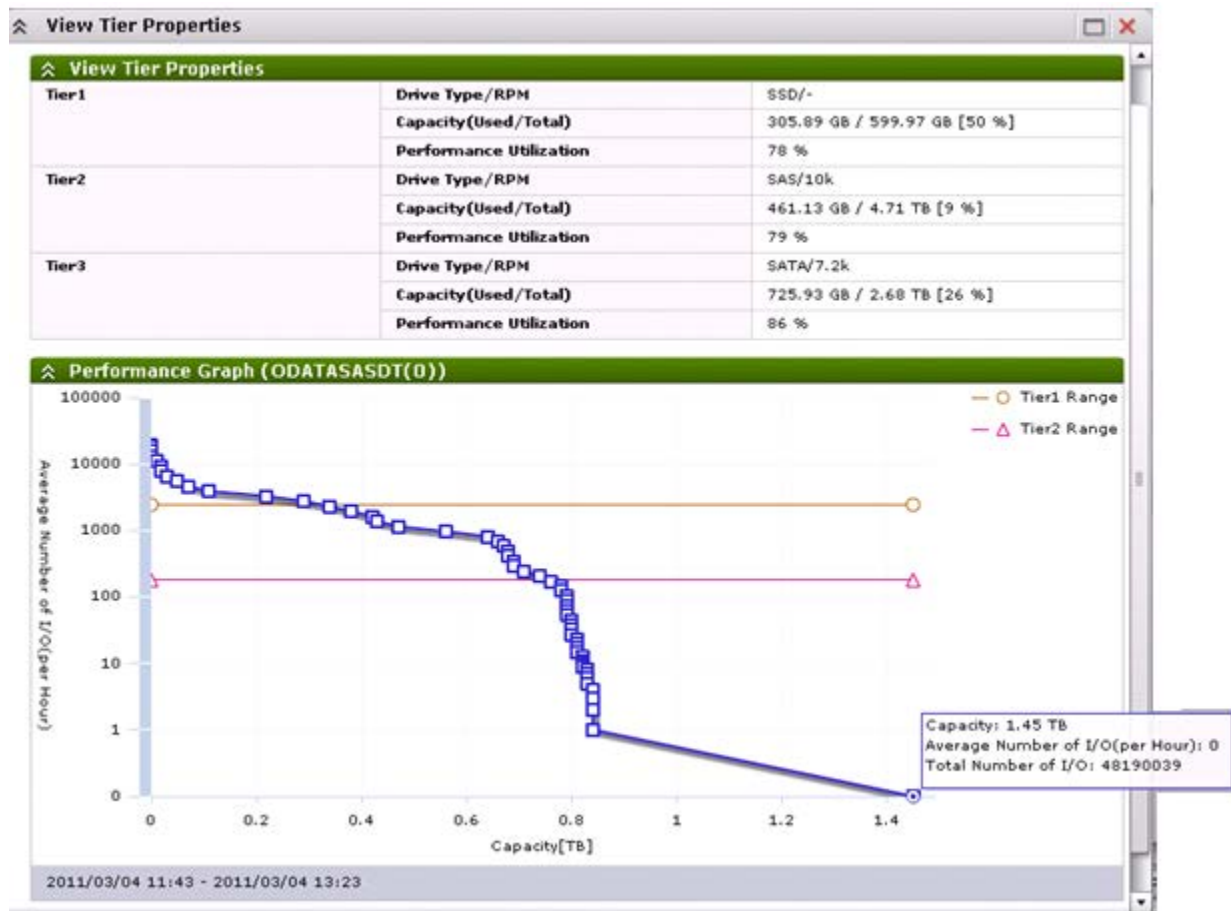
**Key Best Practice** — Hitachi Data Systems recommends using RAID-5 for SSD and SAS tiers and RAID-6 for SATA tiers.

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Maximum throughput of a Dynamic Tiering pool is the sum of the throughput of each tier in the pool.

The Hitachi Dynamic Tiering pool performance graph can be obtained from the **View Tier Properties** option at the pool and DP-VOL level in the Hitachi Storage Navigator. This graph provides the total cumulative I/O. It provides information on capacity and performance utilization of the tiers.

Figure 9 shows a screen shot of the **View Tier Properties** window of a Hitachi Dynamic Provisioning pool with the **Multi-Tier** option enabled.



**Figure 9**

### *Hitachi Dynamic Tiering Monitoring and Relocation Cycles*

The Hitachi Dynamic Tiering monitors the backend I/O per hour (IOPH) during the monitoring cycle. The monitoring and relocation cycle can be set to auto monitoring and relocation mode in the Hitachi Storage Navigator. Manual monitoring and relocation can be started and stopped from the Hitachi Command Control Interface provisioning and reporting command line interface tool.

Monitoring does not include management I/Os in the IOPH calculation. Management I/Os are the I/Os from page relocation, rebalancing and failure processing. During the relocation cycle, page migration, rebalancing and space reclamation tasks are performed.

If there are DP-VOLs in the pool for which relocation is disabled, pages from those DP-VOLs will not be relocated.

In the auto monitoring and relocation mode, Hitachi Dynamic Tiering software performs monitoring and page relocation automatically. If the database activity consists of intermittent lull periods then a longer monitoring period should be used so that monitoring covers both the active and lull periods. If the monitoring is performed during lull periods the inactive data will be moved down to the lower tiers, which may not be desirable.

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**Key Best Practice** — Hitachi Data Systems recommends determining the manual monitoring cycle period based on sustained periods of application data traffic and performance requirements. Monitoring should be scheduled during busy business hours and relocation during off hours.

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## ASM Configuration Best Practices

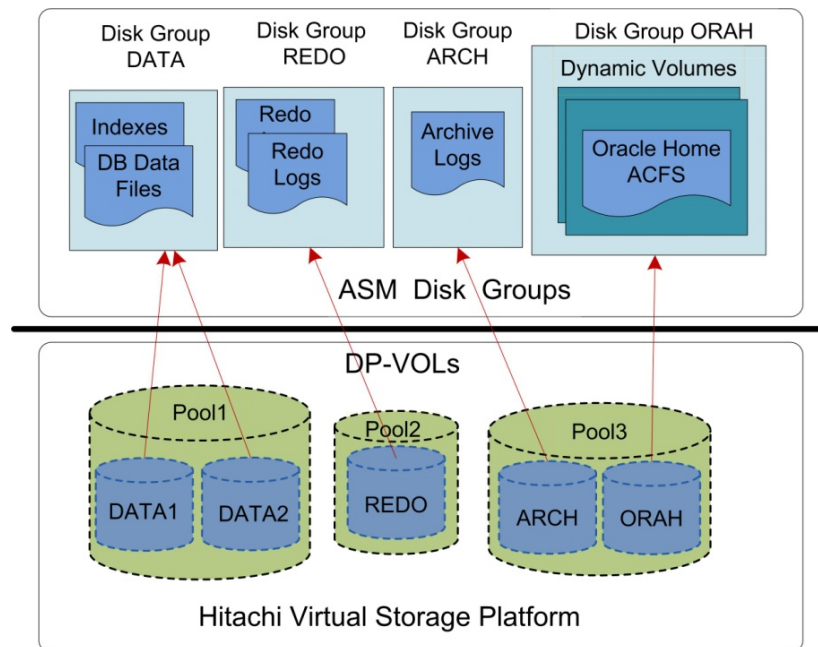
This section describes the Hitachi Dynamic Provisioning and Hitachi Dynamic Tiering software configuration best practice recommendations for Oracle ASM database configuration.

### Hitachi Dynamic Provisioning Software

It is critical to understand how Hitachi Dynamic Provisioning software interacts with ASM and Oracle storage objects.

#### Oracle ASM

An ASM disk group is created from one or more disk devices to form one logical storage container. When it is deployed with Hitachi Dynamic Provisioning software, an ASM disk group acquires and stamps ASM labels on DP-VOLs presented by the operating systems as disk devices. Various database files like the control files, data files, temporary files, redo files and archive logs, Oracle binaries, trace logs, and so on are created in the disk group and distributed or striped through it. Figure 10 shows how ASM disk groups and an ACFS file system map to DP-VOLs.



**Figure 10**

Because the space required by metadata can grow quickly, you must carefully evaluate metadata space allocation and management to make efficient use of Hitachi Dynamic Provisioning pool space. This is a function of the volume and file system management software you use. ASM allocates only a few pages of initial metadata and remains efficient.

Hitachi Data Systems testing shows that the ASM metadata allocation process works efficiently with Hitachi Dynamic Provisioning software. Table 1 lists the amount of space allocated in a Dynamic Provisioning pool after various ASM operations during the creation of a tablespace on a new disk.

**Table 1. Metadata Space Allocation with ASM and Hitachi Dynamic Provisioning Software**

<i>Action</i>	<i>Pool Allocated for Metadata (cumulative total in MB)</i>
Label and partition disk	42
ASM create disk	84
ASM create disk group	126
Create 42MB tablespace	168

At this point, a tablespace with capacity for 42MB of data blocks is initialized. You can expand this tablespace manually or with AUTOEXTEND when you need more capacity. The disk group also has free space for other data objects. Less than 126MB is used for metadata, this compares well with other volume managers. Also, the metadata remains fixed, no matter how large the disk or Oracle objects become; general purpose systems often allocate increasing quantities of metadata as the objects become larger.

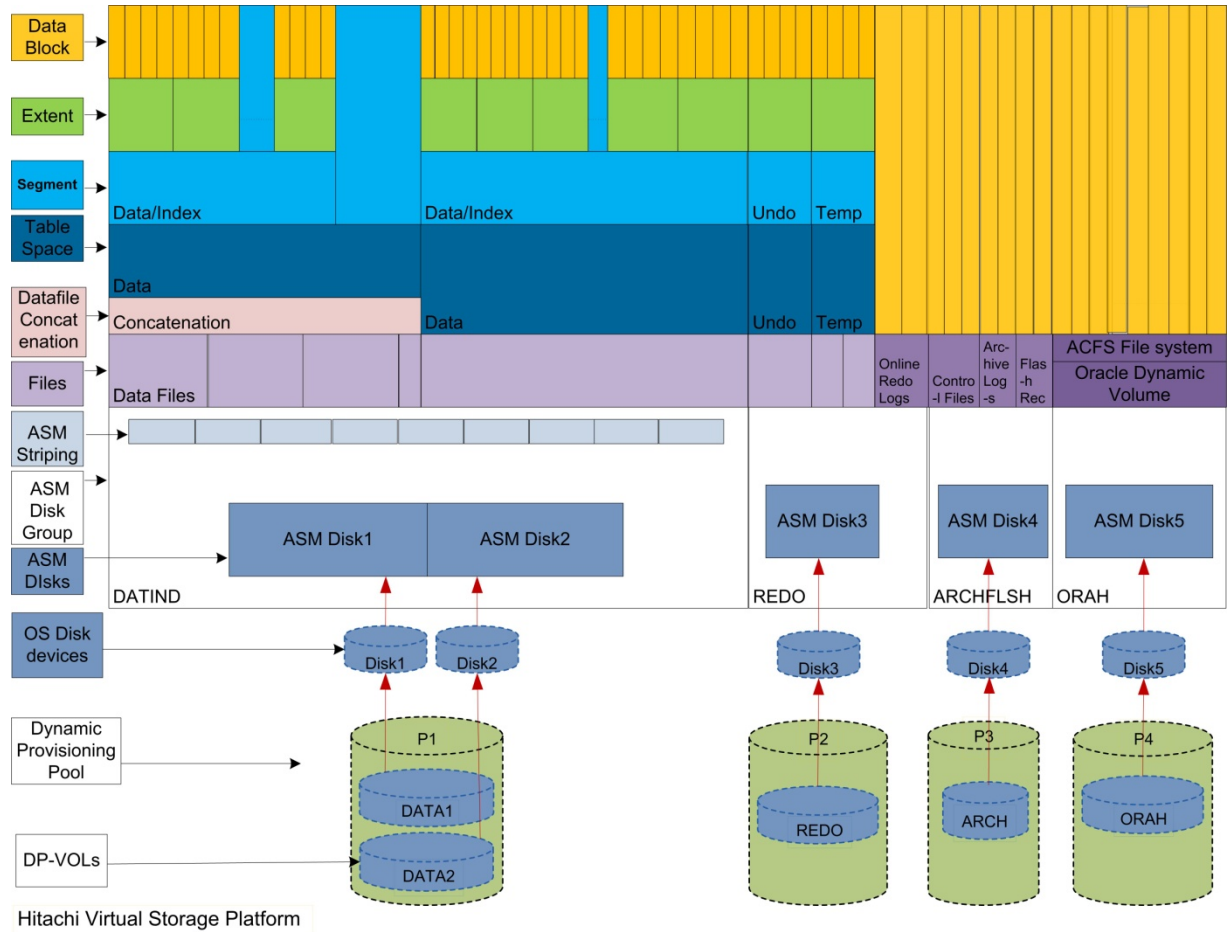
### *Data Storage Objects*

Oracle Database stores data in physical and logical data structures. These data storage objects are grouped in several ways by Oracle Database depending on the type of data usage. Table 2 lists the data storage objects.

**Table 2. ASM and Oracle Database Data Storage Objects**

<i>Object</i>	<i>Description</i>
<b>ASM Disk Objects</b>	
DISK	The storage LUN presented to the OS as a physical device. ASM controls disk objects by writing a disk label.
DISKGROUP	A number of disks grouped together logically. Data is automatically striped across all disks in the disk group.
DYNAMIC VOLUME	A logical disk created from the disk group. The volume is an ASM file of type <code>asmvol</code> .
FILE SYSTEM	An ACFS file system built on an ASM dynamic volume. It can be the database home file system or a general purpose file system.
<b>ORACLE Data Objects</b>	
DATAFILE	An ASM file stored in an ASM disk group.
TABLESPACE	Data, such as tables, indexes and other user data are stored in tablespaces. In ASM configuration, a table space is a collection of one or more ASM files. Table spaces contain one or more segments.
SEGMENT	A group of one or more extents within a tablespace used to store one logical object. Specialized segment types also exist for <code>rollback</code> , <code>undo</code> and <code>temp</code> .
EXTENT	A contiguous set of data blocks within a single data file. The fact that these are contiguous is very important to how Hitachi Dynamic Provisioning software operates.
BLOCK	The basic unit of storage. Block size can vary between tablespaces.

Figure 11 shows how ASM and Oracle Database data storage objects are structured in a typical database.



**Figure 11**

Figure 11 also shows the ASM disk layout mapping to DP-VOLs, including details of data files and redo files. It is important to note that the data blocks in each extent are contiguous and pre-reserved. This means that if the extent size is too large, space can be wasted. With 11gR2, you can assign a block size to online redo logs. The ACFS file system block size is fixed at 4K.

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**Key Best Practice** — Manage extent size and block size to avoid wasting storage capacity.

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### *ASM Disk Group Configuration*

An Oracle database can be stored in a single disk group or across many disk groups. When used with Hitachi Dynamic Provisioning software, any disk group layout is acceptable. Hitachi Data Systems recommends spreading data across multiple disk groups when using Hitachi Dynamic Provisioning software.

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**Key Best Practice** — To achieve additional flexibility and performance, place data into different disk groups based on the Oracle Database file type.

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While using ASM with Hitachi Dynamic Provisioning software, you can back up Oracle Database using Hitachi software, which enables disk mirroring of the Hitachi Virtual Storage Platform. For backup and mirroring, Hitachi Data Systems recommends creating at least three ASM disk groups. Create a separate disk group for the ACFS `oracl e home` file system.

Dividing the data this way permits implementation of a replication backup solution using products such as Hitachi TrueCopy® Synchronous software, Hitachi TrueCopy Asynchronous software, Hitachi Universal Replicator software, Hitachi ShadowImage® Heterogeneous Replication software or Hitachi Copy-on-Write Snapshot software. For more information about these products, see the Hitachi Data Systems [Storage Software web site](#).

Table 3 lists a suggested disk group layout for a database.

**Table 3. Sample Oracle Database Disk Group Layout**

<i>Disk Group</i>	<i>Use</i>	<i>Notes</i>
DATIND	One or more tablespaces, indexes, UNDO segments	N/A
REDO	Online redo log files, control files	Separating redo from data and indexes makes it easier for tablespaces to be backed up independently from online redo logs. Oracle requires that you never back up online redo logs as its restore might corrupt the database. If separated, it is possible to place this I/O onto different storage and improve performance. Although redo logs are never backed up; however, in disaster recovery scenarios, redo logs can be replicated because replication minimizes recovery time.
TEMP	Temporary tablespaces	It is not critical to separate this data. However, if you replicate the database to another site, separation is beneficial, as temporary tablespaces do not need to be replicated. In some scenarios, temporary tablespaces receive large amounts of I/O, and removing this can save valuable inter-site bandwidth. TEMP I/O is also subject to traffic patterns in bursts; in asynchronous environments replicating this might affect the RPO. Scenarios with high TEMP I/O, for example, decision support environments, involve large complex queries.
ARCHFLSH	Control files, archive REDO log files, RMAN backup files, flash recovery files	Like REDO, you can restore this independently from the DATA tablespaces. In addition, archive files have a lower and much less critical data rate than DATA. You might consider placing this on lower-cost storage, but it can only be considered if on a different disk group. Backup can be replicated between sites if all resources necessary to perform restore and recovery are also replicated.
ORAH	Oracle Database binaries, log and diagnostics files.	This is the Oracle ACFS; it is built on an Oracle dynamic volume. Hitachi Data Systems recommends using a separate disk group because it holds the Oracle binaries and any other diagnostics files. It is helpful for backup, restore and replication purposes.

These recommendations are designed to deliver flexibility and choice, but are not hard rules. For example, although placing REDO, ARCHFLSH and DATAIND on different disk groups and different pools might be ideal, other factors might require a different design. For example, in a demanding OLTP environment with limited disk capacity, the LDEVs for the data and index area might not result in enough disk spindles to meet the IOPS requirement. In this case, Hitachi Data Systems still recommends using separate disk groups with separate DP-VOLs, but these can all share a single Hitachi Dynamic Provisioning pool.

The online redo log files can be placed on either a regular static provisioning volume or a Dynamic Provisioning volume. Since the I/O is sequential writes and file sizes fixed in size, there is no benefit to placing these in a Hitachi Dynamic Tiering pool. Sequential performance of SSD and SAS media is nearly the same.

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**Key Best Practice** —Hitachi Data Systems recommends using Hitachi Dynamic Provisioning pools for Oracle online redo logs.

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More than one database can be stored in an ASM disk group or disk group set. For example, if you have a limited number of spindles, you might choose to store more than one database in an ASM disk group. However, having only one database in a disk group or disk groups minimizes disruption during database maintenance tasks like resizing disks. For example, if a disk group has more than one database, and one of its databases needs a disk resize, that operation might involve disk group downtime and create disruption for all databases in that disk group. You can avoid this problem by having a single database in a disk group.

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**Key Best Practice** — For ease of management, Hitachi Data Systems recommends ensuring that ASM disk groups contain data belonging to only one database.

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### *Configuring Tablespace Space Management*

In Oracle Database, three keywords control most disk space use: INITIAL SIZE, NEXT SIZE and MAXIMUM SIZE. These control how disk space is allocated initially and as the database grows. This allocation directly controls how much Hitachi Dynamic Provisioning pool space is used.

When a tablespace is created or when a table is created inside a tablespace, it is created with an initial size that is controlled by the INITIAL SIZE keyword. This initial allocation is guaranteed to be contiguous. Oracle Database initializes this space. This initialization causes an equivalent amount of Dynamic Provisioning pool space to be allocated.

The NEXT SIZE keyword defines how much a table or tablespace grows if the currently allocated space is exhausted. Many alternatives exist. Growth by fixed sizes is supported. You can also have Oracle Database tune each allocation automatically, depending on how much data is inserted.

Use the MAXIMUM SIZE keyword to limit the size to which an object can grow. This can be especially valuable in an environment that uses Hitachi Dynamic Provisioning software to avoid running out of space in a Dynamic Provisioning pool when it is over provisioned.

Use the AUTOEXTEND keyword option to allow tablespaces to automatically grow past the size they were initially allocated. Oracle uses the free space available on volumes, and as a result, applications will not fail because free space is available and another extent to a segment can be allocated automatically. The AUTOEXTEND feature specified for data files and listed in the DBA\_DATA\_FILES view, tells Oracle to automatically grow to a certain limit or UNLIMITED in which case all available space on the volume will be used.

Hitachi Data Systems recommends using the smallest increment that allows you to balance locality of reference against the amount of unused capacity. With Hitachi Dynamic Provisioning software, use an increment of at least 42MB because of the way it allocates space. The tablespace is automatically extended as the application's space requirements grow. This initial allocation and each extension results in equivalent pool space being allocated.

## *Data Files and BIGFILE Tablespaces*

ASM restripes existing data across all new disks. Adding disks to an ASM disk group can improve performance of that disk group, depending on your workload. Because of this it is now more common to use a single data file for each tablespace. The BIGFILE tablespace type only supports one data file. Designed for implementing very large databases (VLDB), a BIGFILE tablespace can store up to 32TB for a tablespace with 8K blocks. Hitachi Dynamic Provisioning software works well with all tablespace types. When a Dynamic Provisioning pool has sufficient spindles, Hitachi Dynamic Provisioning software's wide striping feature provides the performance benefit. Having few over provisioned DP-VOLs reduces storage system workload for needed for rebalancing. Hitachi Data Systems recommends using the BIGFILE tablespace type with few over provisioned DP-VOLs in environments with very large tablespaces.

## *ASM Striping and Mirroring*

ASM distributes data on all the ASM disks in the disk group. Striping options are COARSE and FINE. COARSE striping is laid out in allocation units (AU) of 1MB and FINE striping is laid out in finer units of 128KB. ASM mirrors at the file level, files are partitioned in allocation units (AU) of 1MB, and are laid out on different disks to implement mirroring. ASM provides two levels of mirroring through NORMAL and HIGH redundancy options. In NORMAL REDUNDANCY, data is duplicated. In HIGH REDUNDANCY, data is in triplicate. ASM also provides the ability to create disk groups without mirroring, using EXTERNAL REDUNDANCY. This feature allows you to leverage the storage's RAID implementation.

AU sizes on the current versions of ASM go to 64MB. It is recommended that 4MB be used for OLTP workloads and 8MB for DSS and DW workloads.

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**Key Best Practice** — Hitachi Data Systems recommends using the EXTERNAL REDUNDANCY option, whether or not you use Hitachi Dynamic Provisioning software or Hitachi Dynamic Tiering software.

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If you use the HIGH or NORMAL REDUNDANCY options instead of the EXTERNAL REDUNDANCY option, the disk drive mirrors are likely to become fully allocated in the Dynamic Provisioning pool. This can lead to inefficient use of Fibre Channel bandwidth, host processing cycles and storage space due to redundant mirror data.

## *Adding Disks and ASM Rebalance Operations*

The rebalance operation cannot occur if the ASM disk group consists of only one disk. However, adding disks to an ASM disk group can lead to some degree of unwanted pre-allocation. For example, consider a disk group with three ASM disks, each with a 100GB capacity and each 80 percent full. 240GB [3 x (0.80 x 100)] of the Hitachi Dynamic Provisioning pool space is allocated. Adding a disk to the disk group causes ASM to rebalance the data across the existing disks and the new one. This puts 60GB of data onto each disk, including the new one. But the three original disks remain at 80 percent allocated. 300GB (240+60) of Dynamic Provisioning pool space is allocated and only 240GB of data is stored. This is only a temporary situation. After the data grows to 300GB, the disks return to an efficient state. To avoid this effect, Hitachi Data Systems recommends using larger, over provisioned DP-VOLs for the disks you add to an ASM disk group. This ensures that the addition of disks is rarely needed. Rather than adding disks to ASM disk groups to gain more capacity, consider alternatives such as expanding ASM disk objects into free space on the DP-VOL or dynamically resizing the underlying DP-VOLs and expanding the ASM disk objects. Be sure to consider your operating system's requirements when evaluating these options. This approach aligns with ASM's stripe and mirror everything (SAME) recommendation because a DP-VOL on RAID-1+0 groups is mirrored and wide striped over all available RAID groups allocated to the DP-VOL. Using wide striping techniques, Hitachi Dynamic Provisioning software automatically spreads the I/O load of all applications accessing the common Dynamic Provisioning pool across the available spindles. This process reduces the chance of hot spots and optimizes I/O response times. Using Hitachi Dynamic Provisioning software's rebalance feature instead of Oracle's native rebalance utility also reduces management effort and reduces the load on the Oracle Database server.

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**Key Best Practice** — Hitachi Data Systems recommends using Hitachi Dynamic Provisioning software's rebalancing feature instead of the Oracle ASM rebalance utility.

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## Hitachi Dynamic Tiering Software

All ASM configuration best practices applied to Hitachi Dynamic Provisioning apply to Hitachi Dynamic Tiering.

### *Oracle Database Partitioning*

Large Oracle tables and indexes are usually partitioned to improve query performance. With Oracle data partitioning, table records accessed by the most frequently used query are stored in the same or nearby Oracle data blocks. This increases the spatial locality of the Oracle database objects and makes Hitachi Dynamic Tiering more effective.

## Storage Monitoring Best Practices

Monitoring your environment is an important part of ensuring that the storage service remains available and reliable.

## Hitachi Dynamic Provisioning Software

To avoid running out of capacity on a Dynamic Provisioning pool, Hitachi Data Systems recommends monitoring pool volume capacity usage when using Oracle Database ASM with Hitachi Dynamic Provisioning software. Within Hitachi Dynamic Provisioning software, you can manage threshold values for free pool volume capacity for the pool. When a set threshold is exceeded, an alert is triggered. Regularly audit space used against space allocated. Reclaim space where appropriate.

Hitachi Tuning Manager software provides advanced storage resource management reporting and analysis to enable comprehensive performance monitoring, troubleshooting and capacity forecasting for Hitachi storage environments. Use Hitachi Tuning Manager software for reporting the trends of pool and LDEV and DP-VOL usage. Configure Tuning Manager software to generate alerts when usage exceeds pre-defined thresholds. For more information, see the [Hitachi Tuning Manager web site](#).

Use Hitachi Command Control Interface commands to generate Dynamic Provisioning pool, pool volume and DP-VOL level space usage reports. For more information, see the *Hitachi Command Control Interface (CCI) User and Reference Guide* that accompanies the software.

## Hitachi Dynamic Tiering Software

Even though Hitachi Dynamic Tiering automatically optimizes the page placement of your Oracle database objects in a Dynamic Tiering pool, Hitachi Data Systems recommends monitoring database I/O performance as well as the performance utilization of the tiers on a regular basis. This is because application loads can increase as business grows and fluctuate as demand varies. Hitachi Dynamic Tiering software provides the storage administrator the flexibility of adding more pool volumes to an existing tier on demand to handle an increased load or removing pool volumes from an existing tier when the application load decreases.

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**Key Best Practice** — Hitachi Data Systems recommends monitoring I/O performance and the performance utilization of the tiers on a regular basis and adjusting the number of pool volumes in a storage tier based on application loads.

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Hitachi Data System also recommends watching for changes in business critical hours and adjusting the Hitachi Dynamic Tiering software's monitoring window accordingly. This ensures the Hitachi Dynamic Tiering software optimize the page placement based on the most critical storage usage patterns.

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**Key Best Practice** — Hitachi Data Systems recommends matching Hitachi Dynamic Tiering software's monitoring window to the business critical hours.

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## Conclusion

This white paper provides best practices for deploying Oracle Database 11gR2 with ASM and Hitachi Virtual Storage Platform. Following these best practices helps to ensure that your infrastructure is well designed and scalable and offers ease of management, better resource utilization and increased uptime.

Table 4 lists the best practices provided in this white paper.

**Table 4. ASM Configuration Best Practices**

<i>Description</i>	<i>Best Practice</i>
Storage configuration	For Hitachi Dynamic Tiering configurations, use RAID-5 array groups for SSD and SAS drives and RAID-6 array groups for SATA drives for Dynamic tiering pool volumes.
	Do not use a Hitachi Dynamic Tiering pool for Oracle online redo logs.
	Use larger, over provisioned DP-VOLs for ASM disks.
Hitachi Dynamic Tiering monitoring cycle	Determine the manual monitoring cycle period based on sustained periods of application data traffic and performance requirements.
	Match Hitachi Dynamic Tiering software's monitoring window with the business critical hours and relocation during off hours.
Performance and capacity utilization	Use Hitachi Dynamic Provisioning software in environments where it's thin provisioning and wide striping features are beneficial.
	Use Hitachi Dynamic Tiering software in database environments where storage tiering can improve application I/O throughput and response time or storage space allocation efficiency.
Storage space reclamation	For Hitachi Dynamic Tiering configurations, run Hitachi Dynamic Provisioning software's Reclaim Zero Pages function after using the ASRU utility. Schedule the Reclaim Zero Page operation during maintenance hours or low I/O activity periods.
	For Hitachi Dynamic Tiering configurations, run ASRU utility after deleting a large database object and let Hitachi Dynamic Tiering software perform the Reclaim Zero Pages during the relocation cycle.
Performance planning	Base storage configuration decisions on performance requirements first, then capacity requirements.
Storage monitoring	Monitor pool volume capacity usage when using Oracle Database ASM with the Hitachi Dynamic Provisioning software.
	Monitor pool volume capacity usage and tier performance utilization when using Oracle Database ASM with the Hitachi Dynamic Tiering software.
	Configure Tuning Manager software to generate alerts when usage exceeds pre-defined thresholds.
Data storage objects	Manage extent size and block size to avoid wasting storage capacity.

<i>Description</i>	<i>Best Practice</i>
Disk group configuration	Spread Oracle File types across multiple disk groups when using Hitachi Dynamic Provisioning software.
	Place data into different disk groups based on the Oracle Database file type.
	Create at least three ASM disk groups for backup and mirroring.
	Create a separate disk group for the ACFS <code>oracle_home</code> file system.
	Ensure that ASM disk groups contain data belonging to only one database.
Tablespace space management	Use the smallest increment that allows you to balance locality of reference against the amount of unused capacity. With Hitachi Dynamic Provisioning software, use an increment of at least 42MB because of the way it allocates space.
BIGFILE tablespaces	Use the BIGFILE tablespace type with few over provisioned DP-VOLS in environments with very large tablespaces.
ASM rebalance operations	ASM rebalancing is not required with either Hitachi Dynamic Provisioning or Hitachi Dynamic Tiering.
ASM striping and mirroring	Use the EXTERNAL REDUNDANCY option.
Data loading into HDT pools	Before loading data into a HDT pool, determine the tables that are most frequently accessed. Load these tables first and then the moderately accessed tables. After that load the remaining tables.

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