Abstract

This application note introduces the Storageflex Automated Storage Tiering function and the key information and benefits. Automated storage tiering is a smart data management service that prioritizes drive access based on data hotness and importance. Basically, it leverages the properties of different drives types by assigning frequently-accessed content to faster drives to boost storage performance, while also making better use of lower speed drives for infrequently-accessed content, such as archival data. Users can enjoy the boost in performance and capacity utilization by deploying storage tiering. The technology is especially helpful in tapping into the speed advantage offered by solid state drive (SSD), leading to better return on investment (ROI).
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Introduction

Different types of data in a storage system experience different lifecycles. Data is usually accessed more frequently at creation and the access frequency decreases as it ages. Businesses are growingly looking to manage their data more efficiently by utilizing different types of storage media for different types of data. However, assigning applications to different storage resources and migrating data when application requirements change can be a time consuming and inefficient process. To cope with the issue, Storageflex offers Automated Storage Tiering that automatically leverages the high throughput and low latency feature of solid state drives (SSDs) to deliver faster performance for frequently accessed data, while making better use of lower speed drives as data archiving media, thereby boosting system performance and reducing the cost of ownership.

What is Automated Storage Tiering?

Storage Tiering prioritizes storage blocks into different categories, referred to as storage tiers, which provide various levels of performance and capacity based on price/performance considerations, performance/bandwidth demands, frequency of use, and other criteria.

Storage Tiering enables users to flexibly assign applications to tiers with different drive types and RAID levels. Storageflex’s Automated Storage Tiering provides an architecture that fully consolidates the advantages of different storage media, including SSDs for high performance and near-line serial attach SCSI (NL-SAS) drives for storage capacity. It helps users more easily accommodate and meet different service level requirements via easy-to-use GUI-based management tools SANWatch (for DS platform) and EonOne (for GS platform).

DS Platforms and GS Platforms storage systems provide block-based storage tiering, which is implemented as a data service embedded into the hardware. Storageflex's Automated Storage Tiering provides up to 4 storage tiers, with the highest tier (tier 0) featuring the highest performance level. Although there are no restrictions for drive types when creating a tiered storage pool, we strongly recommend a topology of SSD for tier 0, SAS for tier 1, NL-SAS for tier 2, and SATA for tier 3. For RAID level configurations, we suggest RAID 1 (RAID 1+0) for high performance tiers and RAID 5 (RAID 5+0) or RAID 6 (RAID 6+0) for capacity tiers due to the performance characteristics of different RAID level protections. This way, Automated Storage Tiering can provide users an optimal balance of performance and capacity utilization, as well as maximum return on investment for each drive type purchased.
An Example of Storage Tiering Topology

Why Storageflex Automated Storage Tiering?

Traditionally, IT administrators may deploy various storage tiers based on different drive types to meet the requirements by different applications. To optimize utilization of storage media and system performance, they have to adjust the storage deployment dynamically according to the system use conditions. However, the manual tiering management cannot catch up with the rapidly evolving enterprise environments and has become an incredible burden for IT administrators and tremendous inefficiency for businesses. To offer a solution, Storageflex introduces Automated Storage Tiering that constantly monitors data access frequency (hotness) and intelligently dispatches the data to their appropriate storage tier. Users can trigger re-allocation of data by executing a tier migration operation to proper tier levels manually or automatically through their pre-defined scheduled tasks. With the automated operations, Automated Storage Tiering provides IT veterans a reliable and efficient storage deployment with outstanding performance.
To sum up, Automated Storage Tiering has the following advantages:

1. **Optimized storage performance and enhanced ROI**

   Automated storage tiering helps users significantly optimize storage performance and increase ROI. Performance is optimized by efficiently integrating SSDs, which deliver performance levels far beyond which SAS or near line drives are capable of offering. Adopting SSDs in a tiered architecture enables users to meet the stringent demands of mission-critical applications in a cost effective way.

2. **Simplified storage management**

   Storage tiering simplifies and reduces the management operations of storage systems. With traditional storage systems, IT administrators have to manually configure data migration operations and assign applications to specific media. By using Automated Storage Tiering, Storageflex’s intelligent firmware automatically analyzes data access behavior and recognizes the distribution of hot and cold data. These operations are done automatically, simplifying the processes, reducing the time administrators have to spend on storage management, and lowering the costs.

   Automated storage tiering can be managed via the software suites, SANWatch (for DS Platform) and EonOne (for GS Platform). Tiering configurations are fully integrated into the user interface, enabling users to set up and maintain tiering operations quickly and efficiently.

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**Automated Storage Tiering Architecture**

**How Storageflex Automated Storage Tiering works**

Basically, Automated Storage Tiering operates by moving the most active data to the highest available tier to optimize the utilization of the best performance disks. To ensure there is sufficient space for new incoming hot data from the host, the system reserves 10% free space in higher tier storage and flushes relatively cold data to lower tier storage when tier migration is executed. Generally, when Automated Storage Tiering is enabled, the intelligent firmware constantly records statistical information of each data block, i.e. the metadata, and immediately updates the hotness record into the controller memory cache. However, for a thin-provisioned tier volume, the system starts to record data hotness when it is created, regardless of whether the setting is switched to full-provisioning. Working at a granularity of 8 MB on GS Platform and 2 MB on DS Platform, Storageflex Automated Storage Tiering provides an accurate sub-volume tiering by moving data blocks to their suitable tiers. Data hotness, which is referred to as the accessed frequency or temperature of the data, is determined by the number of I/Os and the latest
accessed time. Based on the hotness record, Automated Storage Tiering performs a proprietary algorithm which migrates the data blocks to the most appropriate tiers, leading to improvement on the performance and capacity usage.

![Automated Storage Tiering Architecture](image)

*Data is placed in the highest available tier initially and the reserve capacity for higher tier(s) before migration*

### Relocation Algorithm

Automated Storage Tiering employs three different procedures to ensure the tiering mechanism moves the correct data blocks to the correct tiers. Since the operations work at a fine granularity, these techniques play an important role of identifying hot and cold data and relocating them based on their temperature, i.e. generating the status of data blocks and determining which ones should be promoted (moved to a higher tier) or demoted (moved to a lower tier).

#### Setup and pre-scanning

As mentioned, the system starts to scan the hotness of each data block as Automated Storage Tiering is activated. The statistics of hotness for each data block are recorded in the cache instantly. When tiering migration is triggered, the system will start preparing resources, e.g. memory, for relocation purposes. To distinguish newly received hot data from those that are ready to be relocated, the firmware will pre-scan the records and add extra status tags into the hotness records to lock all the migrating data.

#### Scanning and planning

After the pre-scanning procedure, the firmware will then scan the locked records to get detailed information for data relocation, e.g. which tier to put the data block in. Based on the hotness records, the firmware automatically ranks the data blocks that are assigned to be migrated, from hot to cold. Once all of the locked records are scanned, the system will prepare for data migration.

#### Data moving

The system then performs the actual data migration among storage tiers. During the data relocation, the firmware prioritizes the relocation of the data blocks starting with moving high-ranking hotness records to higher tiers. By using the scheme, Automated Storage Tiering ensures the utility of high performance drives...
and accurate data distribution. The following figure depicts the results after data relocation.

Results after applying Automated Storage Tiering

Tiering Policy

Since Automated Storage Tiering is done automatically, it offers a couple of user-defined tiering policies to provide the best solution for various business needs. These policies define what new data placement rules should be followed within a tiered storage pool.

**Higher Tier First**

Generally, we recommend users select “Higher Tier First” when rapid response time is the top priority. The reason is that this policy ensures the usage of the high performance drives. The typical behavior of tiering and migration involves data passing logical volumes through the highest tier first, and users can trigger tier migration to move data between different tiers to re-arrange data blocks to the most suitable tier.

**Use Selected Tiers by Ratio Calculation**

For low latency and high performance, users may allocate hot data in higher storage tiers. However, users may not be able to create another tiered volume within the same storage pool due to a critical issue since the highest tier may have been occupied by the original one. Thus, the only way to solve the issue is to extend the capacity of the highest tier which may lead to extra burden and deployment time.

To prevent such circumstances, Storageflex Automated Storage Tiering sets a new policy by default that allocates storage space by the ratio of different drive types, e.g. SSDs and HDDs. By applying the policy, the system can reserve the high performance storage tier for other tiered volumes within the same storage pool. As an example, the figure below demonstrates the case that when drive type ratio between SSDs and HDDs is 20% to 80%.
Using Selected Tiers according to the Ratio Calculation policy reserves storage space for other tiered volume(s)

Requirements

1. Automated Storage Tiering License

Automated Storage Tiering is a licensed feature. Storageflex also provides a 30-day trial license. For the detailed procedure to obtain a license via SANWatch for DS family and EonOne for GS family, please refer to the provided software user manual.

2. SSD requirement

If you wish to use SSDs with the Automated Storage Tiering function, only SSD products in our QVL are supported to enhance performance as described in this document.
Deploy the solution

In this section, we will demonstrate the procedures to configure automated storage tiering with 2 tiers step-by-step. Based on the aforementioned architecture overview, here we will configure the solution top-down from storage tier 0.

Step 1. Create a storage pool

After inserting different types of media drives into the storage system, login to EonOne and go to Settings → Storage → Pool → Add pool button.

Add a storage pool

After clicking the Add pool button, please select your preferred pool mode in the Create pool page. We will go over the following instructions in asymmetric active/active mode.

Select the pool mode

In the pool configuration page, we will start creating tier 0 with SSD drives. First, select the SSD drives in the drive’s list on the top of the page. Then, configure the pool name and RAID protection level in the following section. To optimize the system performance, we suggest selecting RAID 1 for tier 0. Second, click the enable Storage tiering checkbox to enable the feature and specify the tier index in the drop-down list. Finally, press Apply to complete the settings.
Step 2. Add a logical drive

After creating the first tier - tier 0 in the storage pool, we will create the second storage tier via adding an extra logical drive in the pool. As aforementioned architecture, since the storage tier is configured in a storage pool and each storage tier is created by logical drives, you can deploy different storage tiers in different RAID protection. Therefore, here we demonstrate how to create the second tier with different drive type and RAID level.

Select the existing storage pool from Step.1 in the pool list and press Add logical drive button.

The Add logical drive page will appear, select the drives on the left and choose the tier index and RAID level on the right-hand side. Note that you can select the drives from both RAID enclosure and expansion enclosure (JBOD) from the list. For storage tier in common performance level, we suggest
you select RAID 5 or 6 for better data protection. Press OK to finish the settings.

Step 3. Check tiered settings

After configuring the storage tiering, you can examine the settings by selecting the pool and clicking the Tiered settings button under More.

In the Tiered settings page, the system displays the current storage tier configuration with logical drives information. You can also rearrange the tier index in the Tier column by selecting the index number from the drop-down list.
Step 4. Add a tiered volume

Go to Settings → Storage → Volume and press Add volume button to proceed.

Add a storage volume

In the Create volume page, select the tiered pool created in the previous step. You can configure the tiered volume by either block-level or file-level base on your requirements. Then, specify the volume name and its size. Currently, the minimum capacity for a volume is 10 GB. Press Next to proceed.

In the next step, please select the space allocation policy we have mentioned in the Tiering Policy section and the volume you wish the data blocks to be resided in. “Use selected tiers by ratio
Deploy the solution

calculation” policy is selected by default. Click **Apply** to complete the settings.

After the tiered volume has created, you can check its information by clicking **Volume details** in the volume list. Scroll down to the bottom of the page, you can see the current space configuration in pie chart. You can also select the tiered volume and click **Tier ratio settings** button under **More** to change the volume residing tier.
Deploy the solution

## Volume tier ratio settings

Configure tiering parameters for the volume including the residing tier and ratio..

### Configure the residing tier

### Step 5. Apply tiered migration

Before applying tiered migration, you can examine the current tiered information by clicking the button under More. In the Information page, system shows the current detailed tier information and the space usage in the volume.
Deploy the solution

 Tiered information button

<table>
<thead>
<tr>
<th>Information</th>
<th>Tier 0</th>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of tier information</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>237.97 GB</td>
<td>837.86 GB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All volumes</td>
<td>Used</td>
<td>2.37 GB(1.0%)</td>
<td>7.6 GB(0.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data service</td>
<td>0 MB(0.0%)</td>
<td>0 MB(0.0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reserved</td>
<td>23.79 GB(10.0%)</td>
<td>0 MB(0.0%)</td>
<td></td>
</tr>
<tr>
<td>Volume details</td>
<td>Tier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used</td>
<td>2.38 GB(23.82%)</td>
<td>7.61 GB(76.18%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data service</td>
<td>0 MB(0.0%)</td>
<td>0 MB(0.0%)</td>
<td></td>
</tr>
</tbody>
</table>

Tiered information

We do not recommend performing tiered migration right after the tiered volume creation, since the result may turn out inaccurately. Due to the hotness record mechanism, the system needs a time period to collect these information to distinguish whether the data is hot or not, i.e. being frequently accessed. However, it is impossible to accurately predict the exact time to apply the data migration. The only way to approach the optimal solution is to create a schedule that constantly moves the data according to user’s behavior.

To tackle the issue, GS Platform/GSe storage system provides a few ways to perform data migration, by **schedule** and **manual**. We will go over these schemes in the following section.
Deploy the solution

Step 5.1 Tiered migration by scheduling

Go to Settings → Backup & Restore → Schedule and click Create schedule button. Select Create a tiered migration schedule from the list and click Next to proceed.

Next, select the tiered pool from the list and press Next. The schedule configuration page will appear. Fill in the scheduling parameters required in the page and select the priority level at the bottom of the page. Press Next as you complete the settings.

Note:
The priority level settings may affect the overall performance. If the priority is set to “High”, then the system will apply the tiered migration immediately no matter any processing I/O tasks; If the priority is set to “Normal” or “Low”, then the system will apply the tiered migration process at an appropriate time (usually off-peak hours).
Deploy the solution

Select the tiered pool

Configure schedule parameters

Finally, you can confirm your scheduling settings in the Summary page, press OK to exit. After the schedule is successfully created, you can find it on the schedule list.
### Step 5.2 Tiered migration by manual

Besides scheduling, you can also apply the tiered migration manually on EonOne. Go to **Settings → Storage → Pool**, select the tiered pool from the list and click **Tiered migration** button under **More**.
Deploy the solution

In the tiered migration page, you can select the priority level same as we mentioned in Step 5.1 to determine the priority between the storage workload and tiered migration. Press Start button to enable the data migration. You can check the migration status from event log in the EonOne main page. Time consumption for the tiered migration depends on the storage capacity and user’s behavior.
Performance Illustration

In this section we will demonstrate the performance improvement through SPC-1 benchmark. Storage configurations follow the SPC-1, including the portions of the application storage units (ASUs) which are 45%, 45%, and 10%. In the performance results, only I/O rates within 10ms latency are listed.

Topology

The topology of Automated Storage Tiering test

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>RAID Level</th>
<th>Capacity</th>
<th>Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 0</td>
<td>SAS SSD</td>
<td>RAID 10</td>
<td>744 GB</td>
</tr>
<tr>
<td>Tier 1</td>
<td>SAS HDD</td>
<td>RAID 10</td>
<td>4167 GB</td>
</tr>
</tbody>
</table>

Storage tier configurations

<table>
<thead>
<tr>
<th>Controller Assignment</th>
<th>Volume</th>
<th>ASU</th>
<th>Channel Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool 1</td>
<td>Volume 1, 2, 3</td>
<td>1</td>
<td>Volume Number: Odd → Channel 4A</td>
</tr>
<tr>
<td></td>
<td>Volume 4, 5, 6</td>
<td>2</td>
<td>Even → Channel 8A</td>
</tr>
<tr>
<td></td>
<td>Volume 7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Pool 2</td>
<td>Volume 8, 9, 10</td>
<td>1</td>
<td>Volume Number: Odd → Channel 4B</td>
</tr>
<tr>
<td></td>
<td>Volume 11, 12, 13</td>
<td>2</td>
<td>Even → Channel 8B</td>
</tr>
<tr>
<td></td>
<td>Volume 14</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Configuration of storage pools
Performance Results

- Benchmark Tool: SPC-1
- SSD Type: SAS 400GB (Speed: 12G)
- HDD Type: SAS 300GB (Speed: 12G; 10K rpm)

<table>
<thead>
<tr>
<th></th>
<th>SPC-1 Performance</th>
<th>GS Platform 3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC 16b/s</td>
<td>Before Migration</td>
<td>After Migration</td>
</tr>
<tr>
<td>I/O rate (IOPS)</td>
<td>17505</td>
<td>40006</td>
</tr>
<tr>
<td>Enhancement</td>
<td></td>
<td>228.5%</td>
</tr>
<tr>
<td>Response time</td>
<td>10 ms</td>
<td>9.9 ms</td>
</tr>
<tr>
<td>Business Scaling Units (BSUs)</td>
<td>350</td>
<td>800</td>
</tr>
</tbody>
</table>

Note: Technically, the higher the BSUs are set, the higher I/O rate (IOPS) of the storage system can be improved. However, the response time may increase dramatically as well. As a standard for storage areas, we use its response time within 10ms of performance.

Conclusion

Storageflex Automated Storage Tiering is an intelligent solution that dramatically optimizes storage performance and increase ROI by leveraging high speed SSD for expedited access to hot data while using affordable drives such as NL-SAS for archiving purposes. Storage tiering management is simplified via Storageflex's intuitive GUIs. It is highly recommended for use with IOPS-focused applications accompanied by large capacity archival storage.

With Storageflex Automated Storage Tiering, users can eliminate the complexity and management overhead from their IT environments. It utilizes SSD, SAS, NL-SAS and SATA drives within a storage pool. By leveraging the advantages of each drive type at the 2 / 8 MB slice granularity, users can enjoy the performance boost and cost reduction.