Easy Tier for z/OS
Deep Dive

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Agenda

• Tiering Functionality for z/OS
• Easy Tier review
• New Easy Tier functionality
  – Easy Tier Policy and Controls
  – Easy Tier z/OS integration
• Tiered storage configurations for z/OS
• Easy Tier reporting
• Summary

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Tiering Functionality for z/OS

• DFSMS
  – Storage groups provide ability to assign a dataset to a group of volumes
  – Policy based criteria control allocation and management
  – Now available for distributed storage with Spectrum Scale functionality

• DFHSM
  – DFHSM provides ability to migrate and recall data from offline storage
  – Migrated data is not accessible by user until recalled to primary storage
  – Storage Tiers functionality provides transition between multiple online tiers

• Disk Subsystem based tiering
  – Volume based tiering assigns volumes to distinct classes of storage
  – SubLUN based tiering (Easy Tier) allows a volume to reside on multiple tiers
Easy Tier automated tiering

- Optimisation of backend storage resources based on historical performance data
- SubLUN granularity using native DS8000 extents for any volume type
- Flexible configurations with any combination of drives of any size and speed
- Easy Tier Application provides APIs for policy and proactive actions
- Easy Tier HeatMap transfer enables workload history to be transferred for replication scenarios (DR, migration etc)

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Easy Tier Processing Cycle

Performance data collected every 5 minutes and incorporated into history.

Data collected is for backend activity, not IO from hosts.

Workload analysis performed at various intervals – 5 minutes, ~6 hours, and ~24 hours.

Extent “heat” is categorised based on small and large IO activity.

Movement of extents scheduled.

Cost benefit analysis to ensure excessive movement is avoided.

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Easy Tier Terminology - Heat and Skew

- **Hot data**
  - Hot data is simply extents that have more I/O workload, relatively speaking, when compared to other extents within the pool and tier

- **Cold data**
  - Cold data either has low (or no) I/O workload. Cold data would not benefit from a higher tier and thus is not promoted and is considered for demotion

- **Warm data**
  - Warm data is the rest of the workload that is not considered hot or cold. Warm data could be promoted – but that would depend on the workload level and available resources
  - Hot and Warm data will reside on Flash/SSD to maximize capacity

- **Skew**
  - Highly skewed workload has a small number of hot extents
  - Low skewed workload has a more even distribution of workload to extents
Workload skew drives Easy Tier benefits

60% of the extents do 5% of the MB and virtually no random IOPS!

63% of the random IOPS and 20% of the MB from about 5% of the extents!

z/OS data from banking environment
Easy Tier Policies

- New Exclude Nearline tier assignment policy
- Prevents the extents of a volume from being demoted to Nearline arrays
- If data is already on Nearline it will be promoted to Enterprise drives
- Three common use cases for Easy Tier Application policies
  - Default – optimise use of all tiers
  - Exclude Nearline – avoid potential low performance
  - Assign Flash – high performance guaranteed
- Also possible to assign to Enterprise or assign to Nearline but less common use cases

Storage Pool

- Flash drives
- Enterprise drives
- Nearline drives

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Easy Tier Controls

- In the majority of environments Easy Tier is able to successfully use the history of workload performance to predict the future requirements
  - There are however cases where this is not true

- Easy Tier Controls provide mechanisms for proactively and reactively modifying Easy Tier behaviour to handle these situations

- Controls include
  - Pause and Resume Easy Tier learning for volume or pool
  - Reset Easy Tier learning for volume or pool
  - Pause and Resume Easy Tier migration for a pool
Easy Tier Application
Integration with DFSMS and DB2

- Easy Tier currently optimises data placement and tiering based on workload history and this does not always reflect the future performance requirements of the data.

- Easy Tier provides interfaces to enable software such as DFSMS and DB2 to provide hints when data has been created, moved or deleted.

- This will avoid performance degradation following maintenance activities such as database reorganisation.

- DB2 integration PTFs not yet available.

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Storage Tiers and Easy Tier

**Primary Storage Hierarchy**

- **Tier 0**: ‘Hot’ data is moved to SSD, but ‘Cold’ data is never allowed below Enterprise Class storage.

- **Tier 1**: ‘Hot’ data is not allowed higher than Enterprise Class, and ‘Cold’ data is allowed to reside on NL.

**Migration Hierarchy**

- **32 Day Migration**
- **End-of-Year Transition**
- **Recall**
- **Allocate**

**Data “Temperature”**

- Hot
- Warm
- Luke-warm
- Cool
- Cold
- Frigid

**Smart Tier 0:**
- SSD / Enterprise ($x$)

**Smart Tier 1:**
- Enterprise / Nearline ($1/3x$)

**ML2 (VTS)**

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DS8870 Drive Technology

- **Flash – 1.8” in High Performance Flash Enclosure**
  - 400 GB drive

- **SSD – 2.5” Small Form Factor**
  - Latest generation with higher sequential bandwidth
  - 200/400/800/1600GB SSD

- **2.5” Enterprise Class 15K RPM**
  - Drive selection traditionally used for OLTP and z/OS
  - 146/300/600GB drives

- **2.5” Enterprise Class 10K RPM**
  - Large capacity, much faster than Nearline
  - 600GB and 1.2TB drives

- **3.5” Nearline – 7200RPM Native SAS**
  - Extremely high density, direct SAS interface
  - 4TB drives

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Drive Selection in an Easy Tier Environment

- 3-5% Flash/SSD, 95-97% Enterprise
  - Provides improved performance compared to single tier solution and enables use of larger Enterprise drives
  - All data guaranteed to have at least enterprise performance

- 10-20% (or more) Flash/SSD, 80-90% Enterprise
  - Provides Flash IOPS and Latency
  - Can be combined with selective pinning of data to Flash if required

- 3-5% Flash/SSD, 25-53% Enterprise, 40-70% NL SAS
  - Provides improved performance and density to a single tier solution
  - Significant reduction in environmental costs

- 20-60% Enterprise, 40-80% NL SAS
  - Provides reduced costs and comparable overall performance to a single tier Enterprise solution

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Example Easy Tier implementations (1)

- Mainframe Easy Tier implementation on DS8870
- Two tier Easy Tier for production with separate pool of 900GB drives for low performance workloads
  - 75% of random workload on SSD
- Three tier Easy Tier for development

**Production**
- 9% 400GB SSD
- 69% 300GB 15K
- 22% 900GB 10K

**Test/Development**
- 2% 400GB SSD
- 78% 900GB 10K
- 20% 3TB 7.2K

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Example Easy Tier implementations (2)

- Mainframe Easy Tier implementation on DS8870
- Two tier Easy Tier for production with separate pool of Enterprise/Nearline drives for low performance workloads
  - ~99% of random workload on SSD
- Two tier Easy Tier with Enterprise/Nearline for development

![Graph showing disk usage](image)

**Production**
- 10% 400GB SSD
- 65% 600GB 10K
- 5% 600GB 10K
- 20% 3TB 7.2K

**Test/Development**
- 60% 600GB 10K
- 40% 3TB 7.2K

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Easy Tier – Modeling Tools

• Storage Tier Advisor Tool (STAT)
  – Extracts heat data collected by Easy Tier for volumes that are being monitored

• Disk Magic
  – Supports 5 predefined skew levels for prediction with Easy Tier
  – Can utilize detailed Easy Tier data to generate actual client skew chart
  – Utilizes either predefined or actual skew to predict the number of I/Os
    • Higher skew results in a more aggressive sizing

• FLASHDA (z/OS only)
  – Identifies what datasets and devices have the highest accumulated read-only disconnect time

• IBM Tivoli Storage Productivity Center (TPC)
STAT reports review(1)

**System Summary**

This report is based on data from Thu Oct 30 11:15:20 2014. Easy Tier has been running continuously since Wed May 21 10:38:34 2014.

**Storage Tier Advisor Tool version: 9.3.0.0**

<table>
<thead>
<tr>
<th>Storage facility</th>
<th>IBM.2107-SF75CFN60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total storage pools monitored</td>
<td>2</td>
</tr>
<tr>
<td>Total volumes monitored</td>
<td>10452</td>
</tr>
<tr>
<td>Total capacity monitored</td>
<td>177156 GiB</td>
</tr>
<tr>
<td>Hot data capacity (% of total)</td>
<td>322 GiB (0%)</td>
</tr>
<tr>
<td>Data validity</td>
<td>Valid</td>
</tr>
<tr>
<td>System state</td>
<td>Latest Warmstart: No Warmstart Latest Failback: No Failback</td>
</tr>
</tbody>
</table>

**Summary Report**

<table>
<thead>
<tr>
<th>Storage Pool ID</th>
<th>Capacity (GiB)</th>
<th>Configuration</th>
<th>Tier Status</th>
<th>Data Management Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>90434</td>
<td>SSD + Enterprise</td>
<td>*Enterprise is IOPS skewed</td>
<td>89932 GiB/100.00%</td>
</tr>
<tr>
<td>P1</td>
<td>90434</td>
<td>SSD + Enterprise</td>
<td></td>
<td>87224 GiB/100.00%</td>
</tr>
</tbody>
</table>

Complete your session evaluations online at www.SHARE.org/Seattle-Eval
STAT reports review(2)

Storage Pool 0001 Performance Statistics and Improvement Recommendation

Existing Tier Data Management Status

SSD Tier
- Easy Tier Managed: 9493 GB/40.04%
- Unallocated: 11 GB

Enterprise Tier
- Easy Tier Managed: 77731 GB/59.96%
- Unallocated: 3199 GB

*1. Tier Data Management Status displays how data is managed in this tier of the extent pool. For assigned, the dark purple portion of the bar represents data managed by the Easy Tier Application and the status displays Assigned. For assign in progress, the light purple portion of the bar represents data managed by the Easy Tier Application and the status displays Assign In-progress. For easy tier managed, the green portion of the bar represents data managed by Easy Tier. For unallocated, the black portion of the bar represents unallocated data. Each portion of the bar displays both capacity and I/O percentage of the extent pool (except that the black portion of the bar only displays capacity of the unallocated data) by following the "Capacity/I0 Percentage" format.

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## STAT reports review (3)

### Intra-tier Status

#### SSD Tier (Average Utilization of Rank IOPS is 8%)

<table>
<thead>
<tr>
<th>Rank ID</th>
<th>Storage Pool ID</th>
<th>Rank Type</th>
<th>Number of IOPS Threshold Exceeded</th>
<th>Utilization of Rank IOPS</th>
<th>Projected Utilization of Rank IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0001</td>
<td>SSD</td>
<td>0</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>19</td>
<td>0001</td>
<td>SSD</td>
<td>0</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>33</td>
<td>0001</td>
<td>SSD</td>
<td>0</td>
<td>8% 1%</td>
<td>8% 1%</td>
</tr>
<tr>
<td>47</td>
<td>0001</td>
<td>SSD</td>
<td>0</td>
<td>8% 2%</td>
<td>8% 2%</td>
</tr>
</tbody>
</table>

#### Enterprise Tier (Average Utilization of Rank IOPS is 42%)

<table>
<thead>
<tr>
<th>Rank ID</th>
<th>Storage Pool ID</th>
<th>Rank Type</th>
<th>Number of IOPS Threshold Exceeded</th>
<th>Utilization of Rank IOPS</th>
<th>Projected Utilization of Rank IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 6%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>3</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 6%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>7</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 6%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>9</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>11</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>13</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>15</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>21</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>23</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>25</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>29</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>31</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
<tr>
<td>35</td>
<td>0001</td>
<td>Enterprise</td>
<td>0</td>
<td>42% 3%</td>
<td>42% 2%</td>
</tr>
</tbody>
</table>
IBM System Storage DS8000

IBM System Storage DS8000

Projected Workload Distribution on Top Tier on Secondary Storage Device

- Read Only IO Percentage: 52%
- Without Easy Tier heat map transfer: 20%
- Easy Tier heat map transfer is enabled: 100%

Summary Report
- Systemwide
- Recommendation

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**Volume Heat Distribution**

<table>
<thead>
<tr>
<th>Volume ID</th>
<th>Learning Strategy</th>
<th>Configured Size</th>
<th>IO Percentage of Extent Pool</th>
<th>Tier</th>
<th>Capacity on Tier</th>
<th>Heat Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0100</td>
<td>N/A</td>
<td>1 GB</td>
<td>0.00%</td>
<td>SSD Tier</td>
<td>0 GB</td>
<td>1 GB</td>
</tr>
<tr>
<td>0x0101</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.01%</td>
<td>Enterprise Tier</td>
<td>1 GB</td>
<td>1 GB</td>
</tr>
<tr>
<td>0x0102</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.00%</td>
<td>SSD Tier</td>
<td>0 GB</td>
<td>8 GB</td>
</tr>
<tr>
<td>0x0103</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.01%</td>
<td>Enterprise Tier</td>
<td>9 GB</td>
<td>1 GB</td>
</tr>
<tr>
<td>0x0104</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.00%</td>
<td>SSD Tier</td>
<td>0 GB</td>
<td>8 GB</td>
</tr>
<tr>
<td>0x0105</td>
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<td>0.02%</td>
<td>Enterprise Tier</td>
<td>8 GB</td>
<td>5 GB</td>
</tr>
<tr>
<td>0x0106</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.01%</td>
<td>SSD Tier</td>
<td>1 GB</td>
<td>5 GB</td>
</tr>
<tr>
<td>0x0107</td>
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<td>0.00%</td>
<td>Enterprise Tier</td>
<td>4 GB</td>
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<tr>
<td>0x0108</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.00%</td>
<td>SSD Tier</td>
<td>5 GB</td>
<td>3 GB</td>
</tr>
<tr>
<td>0x0109</td>
<td>N/A</td>
<td>9 GB</td>
<td>0.00%</td>
<td>Enterprise Tier</td>
<td>9 GB</td>
<td>9 GB</td>
</tr>
</tbody>
</table>

*1. Volume ID represents the DS8000 volume ID, which is generated when the volume is created.
*2. Configured Size displays the configured capacity of the volume.
*3. Heat Distribution displays the specific heat distribution used by this volume.
*4. N/A indicates that the volume applies learning data based on its own learning results.
*5. Based on remote indicates that the volume applies learning data transferred from a remote storage device.

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csv file output from STAT
Data movement
Workload categorisation

![Bar chart showing the distribution of workload based on different categories (Sum of active_cap, Sum of active_large_cap, Sum of low_activity_cap, Sum of inactive_cap). The chart is divided into Extent Pool & Tier with values for pool_id and tier. Extents are measured from 0 to 120,000.](image)}

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Summary

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