Abstract

The Symmetrix® VMAX® is an ideal consolidation platform designed to be simple, cost effective and reliable for many applications. EMC VMAX has new Host I/O Limits Enginuity feature which allows customers to satisfy the service level agreement (SLA) for multi-tier/multi-tenant application environments with ease.

February 2013
# TABLE OF CONTENTS

**Executive summary** .......................................................................................................................... 5  
Audience ................................................................................................................................................. 6  

**Introduction** ....................................................................................................................................... 7  

**Products and Features overview** ..................................................................................................... 7  
  VMAX Auto-provisioning Groups .................................................................................................. 7  
  VMAX Host I/O Limits .................................................................................................................. 8  
  Host I/O Limits on cascaded storage group .................................................................................. 10  
  Limitations on Cascaded Storage Groups ..................................................................................... 11  
  Application Considerations for using VMAX Host I/O Limits ..................................................... 12  
  Setup of Host I/O Limits ................................................................................................................ 12  
    SYMCLI syntax to setup Host I/O Limits .................................................................................... 12  
    EMC Unisphere for VMAX ......................................................................................................... 13  

**Use case scenarios of Host I/O Limits with SQL Server** ............................................................... 14  
  Test environment .......................................................................................................................... 14  
  Test Case 1: Two databases servicing Tier 1 and Tier 2 applications ......................................... 16  
  Test Case 2: Multiple databases servicing Tier 1-EFD, Tier 2-FC, and Tier 3-FC applications on a single host .................................................................................................................. 18  
  Test Case 3: Independent databases servicing Tier 2-FC, and Tier 3-FC applications on separate hosts ........................................................................................................................................... 21  
  Test Case 4: Minimizing the impact of Tier 3 database backup, on Tier 2 production application, using Host I/O bandwidth limits ........................................................................................................... 24  
  Test Case 5: Understanding the EMC PowerPath load balancing and maintaining Host I/O Limits after FA port group update ......................................................................................................... 27  

**Conclusion** ........................................................................................................................................ 30  

**Appendixes** ...................................................................................................................................... 31  
  Configuration Layout Snapshots ................................................................................................. 31  
    Snapshot of SQL Storage Layout on VMAX 10K ....................................................................... 31  
    Snapshot of a Symmetrix VMAX-Port Group ........................................................................... 31  
    Snapshot of a Symmetrix VMAX-Cascaded Storage Group ..................................................... 32  
  SYMCLI Examples ......................................................................................................................... 33  
    Listing all the storage groups ................................................................................................... 33  
    Storage group without Host I/O limit defined ............................................................................ 33  
    A parent storage group without Host I/O limit defined ............................................................ 33  
    Child storage group without Host I/O limit defined ................................................................. 35  
    Setting IOPS Host I/O Limit on storage group .......................................................................... 35  
    Setting Bandwidth Host I/O Limit on storage group ................................................................. 35  
    Setting IOPS and Bandwidth Host I/O Limit on parent storage group ...................................... 37  
    Setting of a child storage group that shares Bandwidth and IOPS Host I/O Limits with the parent storage group .................................................................................................................. 37
Storage group list by port demand report
Storage group list by port demand report in verbose
Storage group list by port group demand report
Storage group list by portgroup demand report in verbose
Collection of Statistics
Symstat for FE Stats
Symstat for BE Stats
Symstat for Device Group Stats
**Executive summary**

The EMC® Symmetrix VMAX® with Enginuity delivers a multi-controller, multi-engine, scale-out architecture for enterprise reliability, availability, and serviceability at an affordable price. Built on the strategy of simple, intelligent, modular storage, it incorporates a scalable Virtual Matrix™ interconnect that connects all shared resources across all VMAX engines, allowing the storage array to grow seamlessly from an entry-level one engine configuration to up to eight engines. Each VMAX engine contains two directors and redundant interface to the Virtual Matrix™ interconnect for increased performance and availability.

VMAX arrays support multiple drive technologies that include Enterprise Flash Drives (EFDs), Fibre Channel (FC) drives, and SATA drives. Symmetrix VMAX with FAST VP technology provides automatic policy-driven storage tiering allocation, based on the actual application workload.

With all these enhanced capabilities, VMAX systems have successfully facilitated the consolidation of multiple applications on a single storage array from mission critical to test and development environments. However, with multiple applications comes the importance of ensuring that each application has adequate storage resources to meet performance needs and resource distribution is aligned with the desired service levels of the applications. To aid this alignment, Enginuity 5876 Q4 2012 Service Release (5876 SR), the latest Enginuity release supporting the VMAX Family, provides support for the setting of the Host I/O Limits.

**Implementing Host I/O Limits:**

- Ensures that applications cannot exceed their set IOPS or bandwidth limits on storage group basis, reducing the potential of impacting other applications.
- Provides greater levels of control on performance allocation in multi-tenant environments.
- Applies performance control for individual applications (storage groups) so critical workloads are given more bandwidth or IOPS than others.
- Enables predictability needed to service more customers on the same array.
- Simplifies quality-of-service management for applications serviced by VMAX by presenting controls in industry-standard terms of IOPS and bandwidth.
**Audience**

This white paper is intended for application administrators, storage administrators and architects, customers, and EMC field personnel who want to understand the management of application SLAs in multi-tenant environments using VMAX Host I/O Limits.
Introduction

This white paper demonstrates various use cases of Microsoft SQL Server databases servicing multi-tier applications in VMAX. It covers the impact of application workload profiles on shared VMAX storage resources and performance of other applications. The paper then covers newly introduced Host I/O Limits feature to control IOPS and bandwidth available to an application allowing user control of shared resources available to other applications and achieving desired service levels in a multi-tenant/multi-application environment. The paper addresses the workload profile of OLTP and DSS/backup applications and the use of Host I/O Limits to minimize their impact on mission critical applications.

Products and Features overview

VMAX Auto-provisioning Groups

VMAX Auto-provisioning Groups provides faster and easier mapping of devices for any application environments. Auto-provisioning groups provide simple constructs of host initiator groups, Symmetrix FA port groups and Symmetrix devices storage groups, and allow binding all of them in a masking view to automatically create relationship between host LUNs, Symmetrix FA ports and host initiators. Any component in the masking view can be dynamically modified and the changes will automatically propagate throughout the Auto-provisioning Group, thus improving and simplifying complex storage provisioning activities.

Figure 1 depicts Symmetrix storage provisioned to two SQL Server databases using Auto-Provisioning Groups.

![Figure 1 Symmetrix VMAX Auto-Provisioning Groups](image-url)
**VMAX Host I/O Limits**

VMAX can service multiple applications and workload profiles simultaneously. Hence VMAX can support a multi-tenant environment running multi-tier applications. For ease of management Symmetrix resources including physical disks, thin pools, storage groups and FA ports can be effectively shared across these applications.

With Auto-Provisioning Groups multiple applications can easily share the storage and SAN objects in very flexible manner. This allows effective use of storage resources by sharing them across the application boundaries. When resources are shared this way, the workload profiles of any application may impact the performance of other applications. To minimize such impact and allow user control over the allocation of shared resources, the VMAX offers the Host I/O Limits feature that allows IOPS and bandwidth setting at the storage group level to control the VMAX resource consumption by the associated applications.

Host I/O Limits is a feature that can be used to limit the amount of front-end (FE) bandwidth (MB/s) and I/Os per second (IOPS) that can be consumed by a set of VMAX devices over a set of director ports. The bandwidth and IOPS are monitored by the Symmetrix system to ensure that they do not exceed the user-specified maximum. This feature allows the user to place limits on the FE bandwidth and IOPS consumed by applications on the VMAX system. To configure the Host I/O Limits feature on a set of devices, a Host I/O Limit is placed on a storage group having those devices. A provisioning view is then created using that storage group to limit the host IOs for the associated devices through the VMAX FA ports.

Host I/O Limits are defined as storage group attributes: The maximum bandwidth is displayed in MB/s and the maximum operations in IOPS. A Host I/O Limit can be added, removed, and modified dynamically and non-disruptively for a storage group. For a cascaded storage group, a Host I/O Limit can be added for either the parent or the child storage group, but not for both. If a parent storage group has a limit, the limit is shared among all its child storage groups when a provisioning view is created using the parent storage group. In addition, if a parent storage group has a limit, the user is not allowed to create provisioning views using the child storage groups.

The Host I/O Limit for a storage group can be either active or inactive, and only the active Host I/O Limit can limit the FE bandwidth and IOPS of the devices in a storage group. The Host I/O Limit becomes active when a provisioning view is created using the storage group, and it becomes inactive when the view is deleted. When a view is created on a parent storage group with a Host I/O Limit, the Host I/O Limit is shared among all the devices in all child storage groups. When a view is created on a parent storage group, if a child storage group has a limit, that limit is only applied to the devices on that child storage group.
The Host I/O Limit of the storage group applies to all the director ports of the port group in the provisioning view. The Host I/O Limit is divided equally among all the directors in the port group, independent of the number of ports on each director. Due to related redundancy considerations, it is recommended that the user configures only one of the ports (either port 0 or port 1, but not both) of a director in the port group.

Figure 1 depicts two SQL server storage groups – one used for an OLTP application (SQL OLTP SG) and one for backup (SQL Backup SG). The Host I/O Limits can be set for one or more of the storage groups – SQL OLTP SG or SQL Backup SG and that will result in limiting the I/O through the Symmetrix FA ports 1E:0 and 2E:0 for the storage group to the defined limits. This example is a simplified configuration, typical configurations have multiple initiators and FA ports for both performance and availability.

**Note:** Host I/O Limits are enforced, only if an associated Storage group is used within a provisioning view. Although the Host I/O Limits are applied at the storage group level, it is controlled at the front-end directors that are specified in the port group of the associated provisioning view. A storage group with defined Host I/O Limits can only appear with at most one port group in any provisioning view. The number of FA directors involved in the Host I/O Limits will share the workload evenly so if the I/O limit of 500 IOPS is set among 2 directors each will contribute 250 IOPS.
**Host I/O Limits on cascaded storage group**

When a provisioning view is created on a parent storage group with Host I/O Limits, the limit is shared among all the devices in all child storage groups. Excess I/O capacity resulting from less active children will be available to other children SGs.

**Note:** For a cascaded storage group, a Host I/O Limit can be added for either the parent or the child storage groups, but not for both.

---

**Figure 2 Cascaded storage group with three active children**

**Figure 3 Cascaded storage group with Host I/O Limit and inactive children**
When only one Child Storage Group is active, it can drive maximum possible IOPS based on activity. If an attempt is made to place a limit on a child where a limit was already present on the parent, an error "The operation cannot be performed because the child storage group or the parent storage group has a Host I/O Limit defined" is generated.

Figure 4 Error when setting Host I/O Limit on a child storage group

Limitations on Cascaded Storage Groups

There can be a maximum of 1024 Host I/O Limits configurable using Solutions Enabler (CLI or Unisphere) on a Symmetrix VMAX. A VMAX can have 8192 storage groups. In cascaded SG configuration each parent storage group can have a maximum of 32 child storage groups that will share the parent Host I/O Limits.
Application Considerations for using VMAX Host I/O Limits

Most businesses run multiple applications and tasks to support normal operations some of which may include including ERP, CRM, messaging, backups, and development and test environments. Some applications support transactional workload and others support decision support systems. There may also be some inter-dependencies across the applications. These applications might be running on scheduled or adhoc basis. In 24x7 global business environments it is not always possible to schedule the jobs/applications so that they do not interfere with each other.

The transactional applications have smaller I/O sizes for large numbers of transactions per second and they are IOPS sensitive whereas decision support systems or batch processing jobs have large I/O sizes (64 K or sometimes higher) and they are consumers of higher bandwidth. Also multi-tenant, multi-app environments will have many such applications running simultaneously that are competing for the I/O resources.

Even different database objects have workload profile that exhibits both random and sequential I/O patterns during normal operations. For example, data files may have smaller I/O sizes whereas log files have sequential writes followed by reads and writes as part of the log archival process.

All these aspects of application environments require careful planning, scheduling, and re-adjustment of available resources on periodic basis to ensure effective utilization of the resources and to provide a desired level of performance for mission critical applications. Consolidated storage environments like VMAX have to address mixed workloads like this and provide the right level of performance to the applications. To minimize administrative overhead required for desired performance and maintain SLAs, VMAX offers several solutions including Fully Automated Storage Tiering (FAST) for dynamic policy driven storage tier allocation and also Host I/O Limits for managing the application workloads through Symmetrix FA ports.

Setup of Host I/O Limits

Host I/O Limits can be setup using Symmetrix Command Line Interface (SYMCLI) or EMC Unisphere for Symmetrix VMAX. Both examples are covered in this section

**SYMCLI syntax to setup Host I/O Limits**

(A) Creating the storage group with Host I/O Limits - IOPS or MB/s

```
symsg –sid 45 create SQL OLTP_SG [-iops_max 10000] [-bw_max 500]
```

(B) Setting required Host I/O Limits on a storage group

```
symsg –sid 45 –sg SQL OLTP_SG set [-iops_max 10000] [-bw_max 500]
```

(C) Re-setting required Host I/O Limits on a storage group

```
symsg –sid 45 –sg SQL OLTP_SG set [-iops_max NOLIMIT] [-bw_max NOLIMIT]
```

(D) Listing the current limits on SG

```
symsg –sid 45 –sg SQL OLTP_SG list –by_port –demand <= List by port
symsg –sid 45 –sg SQL OLTP_SG list –by_pg –demand <= List by port group
```
Note: Actual SYMCLI commands like symstat to capture Host I/O Limits statistics and symsg to query Host I/O Limits on Storage Groups are shown in the Appendixes.

**EMC Unisphere for VMAX**

![Setting VMAX Host I/O Limits](image)

*Figure 5 Setting VMAX Host I/O Limits*
Use case scenarios of Host I/O Limits with SQL Server

This section covers examples of using Microsoft SQL Server databases with Host I/O Limits. The five use cases are:

1. Supporting two databases servicing application-tier 1 (T1) on high performance EFD storage-tier and application-tier 2 (T2) on FC storage-tier on a single host to understand the effect of shared FA ports by a noisy neighbor and increasing IOPS of T1 by applying Host I/O Limits on T2.
2. Supporting multiple databases servicing application-tier 1 (T1) on EFD storage-tier, application-tier 2 (T2) and application-tier 3 (T3) on FC storage-tier on a single host to maintain the performance of T1 application by limiting IOPS for T2 and T3 applications, and to support additional users for Tier 1 application by limiting T2 and T3 applications.
3. Supporting multiple databases servicing two independent applications running on separate hosts on shared FC pool but sharing the same FA ports and to allocate more Symmetrix resources for other applications.
4. Minimizing impact of database backup on production application.
5. Understanding the interoperability of host load balancing mechanism like EMC PowerPath and Host I/O Limits.

Test environment

This section describes the hardware, software, and database configuration used for SQL Server databases and Host I/O Limits in Table 1.

Table 1 Test environment

<table>
<thead>
<tr>
<th>Configuration Aspect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage array</td>
<td>Symmetrix VMAX 10K</td>
</tr>
<tr>
<td>Enginuity</td>
<td>5876.159.102</td>
</tr>
<tr>
<td>SQL Server</td>
<td>Microsoft SQL Server 2012</td>
</tr>
<tr>
<td>EFD</td>
<td>8 x 200 GB EFD</td>
</tr>
<tr>
<td>FC</td>
<td>80 x FC 15k rpm 450 GB drives</td>
</tr>
<tr>
<td>SATA</td>
<td>16 x SATA 7,200 rpm 2 TB drives</td>
</tr>
<tr>
<td>Windows Server</td>
<td>Windows Server 2012</td>
</tr>
<tr>
<td>Multipathing</td>
<td>EMC PowerPath® 5.5 SP1</td>
</tr>
<tr>
<td>Host</td>
<td>Cisco C210 with 32 GB memory</td>
</tr>
</tbody>
</table>
Table 2 SQL Server Setup

<table>
<thead>
<tr>
<th>Databases</th>
<th>Business Importance (Application Tier)</th>
<th>Size</th>
<th>Storage Group</th>
<th>Thin Pool</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINDB</td>
<td>T1</td>
<td>1 TB</td>
<td>FINDB_SG</td>
<td>EFD</td>
</tr>
<tr>
<td>CRMDB</td>
<td>T2</td>
<td>1 TB</td>
<td>CRMDB_SG</td>
<td>FC</td>
</tr>
<tr>
<td>HRDB</td>
<td>T3</td>
<td>1 TB</td>
<td>HRDB_SG</td>
<td></td>
</tr>
<tr>
<td>CLONEDB</td>
<td>T3</td>
<td>1 TB</td>
<td>CLONEDB_SG</td>
<td></td>
</tr>
</tbody>
</table>

Production Host: FINDB, CRMDB, HRDB

Backup Host: CLONEDB

Figure 6 SQL Server SAN Layout
Test Case 1: Two databases servicing Tier 1 and Tier 2 applications

Test Case Scenario
Supporting two databases servicing application-tier 1 (T1) on high performance EFD storage-tier and application-tier 2 (T2) on FC storage-tier on a single host to understand the effect of shared FA ports by a noisy neighbor and increasing IOPS of T1 by applying Host I/O Limits on T2.

Objectives
Achieve higher transaction rate for high performance T1 application running on EFD storage-tier. The application shares the Symmetrix FA ports with T2 application running on a FC storage-tier. An example of the performance impact of multiple applications running on single server is shown below.

Configuration
The test configuration had two SQL Server databases — T1-EFD, T2-FC — running on single server but on separate storage groups and storage tiers as shown in Figure 7. The baseline performance test was run to get the workload profile of the databases.

![Figure 7 SQL Server SAN Layout for Test Case 1](image)

Test case execution

Steps
1. Run a baseline workload on both applications without any Host I/O Limits.
2. Apply Host I/O limit on the storage group associated with T2-FC application.
3. Review the Symmetrix IOPS and SQL server response times (RT) and Transactions per second (TPS) data.
Table 3 SQL database performance with and without Host I/O Limits

<table>
<thead>
<tr>
<th>Host I/O Limits</th>
<th>T1-EFD</th>
<th>T2-FC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Users</td>
<td>Symm IOPS</td>
</tr>
<tr>
<td>NOLIMIT</td>
<td>300</td>
<td>61,154</td>
</tr>
<tr>
<td>T2-FC - 10K IOPS</td>
<td></td>
<td>71,941</td>
</tr>
</tbody>
</table>

Note: SQL RT (ms) is Avg. SQL Disk sec/Transfer metric in Windows Performance Monitor (Perfmon).

Database and storage performance results

During the baseline run storage groups on EFD and FC storage-tier, they were both sharing the same Symmetrix FA ports, and without any Host I/O Limits, all requests to these ports were processed at the same priority as they arrived to the port. So even though, EFD based back-end can drive much more IOPS, the T1 application was constrained due to the shared resources with the T2 application. In this case EFD and FC drives drove a total of 76,151 IOPS through Symmetrix FE which was shared between T1-EFD and T2-FC. The T2-FC share was 14,997 IOPS. When the Host I/O Limits of 10K was applied to the T2-FC storage group, the T1-EFD storage group was able to drive more IOPS through the Symmetrix FE. The T1-EFD IOPS increased from 61,154 to 71,941 – an improvement of 17% while the SQL TPS improved by 37% without any degradation in SQL response times.
Test Case 2: Multiple databases servicing Tier 1-EFD, Tier 2-FC, and Tier 3-FC applications on a single host.

Test Case Scenario
Supporting multiple databases servicing, application-tier 1 (T1) on EFD storage-tier, application-tier 2 (T2) and application-tier 3 (T3) on FC storage-tier on a single host to maintain the performance of T1 application by limiting IOPS for T2 and T3 applications, and to support additional users for T1 application by limiting T2 and T3 applications.

Objectives
Achieve higher transaction rate, and higher user count for a high performance T1 application running on EFD storage-tier, in a multi-tier application environment all running on single host. The applications share the Symmetrix FA ports with T2 and T3 application running on FC tier.

This section shows an example of the performance impact running multi-tier applications on a single server, and the corresponding increase in T1 users by using Host I/O Limits on the lower tier applications.

Configuration
The test configuration had three SQL Server databases — T1-EFD, T2-FC, and T3-FC running on single server but in separate storage groups and storage tiers as shown in Figure 8. The baseline performance test was run to get the workload profile of the databases. The baseline test consisted of running with 200 and 250 users on T1 application without Host I/O Limits. T2 and T3 applications were also running at the same time as shown in Figure 8 below. After the baseline test was run, the Host I/O Limits were applied to the T2-FC and T3-FC and SQL TPS, IOPS, and response times (RT) for the T1-EFD were noted. See Table 4 and Table 5 for results.

Figure 8 SQL Server SAN Layout for Test Case 2
Test case execution

Steps
1. Run a baseline workload on the three applications without any Host I/O Limits. The workload comprises of 200 and 250 users for T1-EFD and 100 users for T2-FC and T3-FC.
2. Apply 10,000 IOPS Host I/O Limits on the storage group associated with the T2-FC application. Similarly apply 5,000 IOPS Host I/O Limits on the storage group associated with the T3-FC application.
3. Review the Symmetrix IOPS and SQL server response times (RT) and Transactions per second (TPS) data.

Table 4. SQL multi-tier (T1-EFD, T2-FC, T3-FC) database performances with and without Host I/O Limits, single host with 200 T1-EFD users.

<table>
<thead>
<tr>
<th>Host I/O Limits</th>
<th>T1-EFD</th>
<th>T2-FC</th>
<th>T3-FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>Symm IOPS</td>
<td>SQL RT (ms)</td>
<td>SQL TPS</td>
</tr>
<tr>
<td>NOLIMIT</td>
<td>53,250</td>
<td>3</td>
<td>1,973</td>
</tr>
<tr>
<td>T2-FC: 10K IOPS</td>
<td>59,724</td>
<td>3</td>
<td>2,357</td>
</tr>
<tr>
<td>T3-FC: 5K IOPS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. SQL multi-tier (T1-EFD, T2-FC, T3-FC) database performances with and without Host I/O Limits, single host with 250 T1-EFD users.

<table>
<thead>
<tr>
<th>Host I/O Limits</th>
<th>T1-EFD</th>
<th>T2-FC</th>
<th>T3-FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>Symm IOPS</td>
<td>SQL RT (ms)</td>
<td>SQL TPS</td>
</tr>
<tr>
<td>NOLIMIT</td>
<td>51,818</td>
<td>3</td>
<td>1,970</td>
</tr>
<tr>
<td>T2-FC: 10K IOPS</td>
<td>64,664</td>
<td>3</td>
<td>2,881</td>
</tr>
<tr>
<td>T3-FC: 5K IOPS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SQL RT (ms) is Avg. SQL Disk sec/Transfer metric in Windows Performance Monitor (Perfmon).
Database and storage performance results

During the baseline run with 200 T1-EFD users, storage groups on the EFD and FC tiers were both sharing the same Symmetrix FA port and without any Host I/O Limits all requests to these ports are processed at the same priority as they arrive to the port. T1-EFD had 53,250 IOPS, while T2-FC and T3-FC both drove 11,459 IOPS and 11,276 IOPS respectively. Applying Host I/O Limits of 10,000 IOPS and 5,000 IOPS on T2-FC and T3-FC respectively allowed both the T1-EFD SQL TPS and T1-EFD IOPS to increase.

After applying the above limits, T1-EFD hit 59,724 IOPS and 2357 SQL TPS, an improvement of 12% and 20% respectively. Applying Host I/O and increasing the number of T1-EFD users to 250 from the previous value of 200 users generated 25% improvement in IOPS and 46% improvement in TPS, without any degradation in SQL response times (RT).
Test Case 3: Independent databases servicing Tier 2-FC, and Tier 3-FC applications on separate hosts.

Test Case Scenario
Support multiple databases servicing two, independent applications, running on separate hosts on a shared FC tier; but share the same FA ports and allocate more Symmetrix resources for other applications.

Objectives
Achieve lower backend CPU usage, but maintain bandwidth and response times (RT) for T2-FC application, by applying Host I/O Limits on the less critical T3-FC application. The applications share the VMAX FA ports and also reside on the FC tier. This test deals with an example of two independent applications T2-FC and T3-FC running on separate hosts but sharing the same FA ports and storage-tiers (FC). It shows how, Host I/O Limits can be used, to free up BE Symmetrix resources for other applications while improving performance for other critical applications. Because separate hosts were used in this test, the contention for resources was only Symmetrix shared resources.

Configuration
The test configuration had 2 SQL Server databases on a FC storage tier — T2-FC, T3-FC— running on separate servers and on separate storage groups as shown in Figure 9. The baseline performance test without the Host I/O Limits was run to get the workload profile of the databases and the Symmetrix backend CPU usage was noted.

Figure 9 SQL Server SAN Layout for Test Case 3
Test case execution

Steps
1. Run a baseline workload on both T2-FC and T3-FC applications without any Host I/O Limits.
2. Apply Host I/O Limits on the storage group associated with the T3 application – T3-FC.
3. Review the Symmetrix IOPS, Symmetrix Backend CPU usage, SQL server response times (RT) and Transactions per second (TPS) data.

Table 6. Independent T2 and T3 databases running on separate hosts and the role of Host I/O Limits in curtailing Backend CPU usage

<table>
<thead>
<tr>
<th>Host I/O Limits</th>
<th>T2-FC-Host 1</th>
<th>T3-FC-Host 2</th>
<th>VMAX Backend CPU %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Users</td>
<td>Symm IOPS</td>
<td>SQL RT (ms)</td>
</tr>
<tr>
<td>NOLIMIT</td>
<td>200</td>
<td>25,462</td>
<td>13</td>
</tr>
<tr>
<td>T2-FC - 10K IOPS</td>
<td>34,066</td>
<td>34,066</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: SQL RT (ms) is Avg. SQL Disk sec/Transfer metric in Windows Performance Monitor (Perfmon).
Database and storage performance results

During the baseline run, the storage groups on T2-FC and T3-FC were both sharing the same Symmetrix FA ports and had identical IOPS, SQL TPS and response times (RT), which contributed to 72% Backend CPU usage. When T3-FC had 10,000 IOPS Host I/O limit, the SQL response times for the T2-FC application changed from 13 ms to 10 ms and the corresponding SQL TPS numbers went up from 1,124 to 1,569. At the same time the VMAX IOPS jumped up from 25,000 to 34,000. The backend CPU usage lowered from 72% to 57%, thereby freeing up VMAX resources for other critical application workloads.
**Test Case 4: Minimizing the impact of Tier 3 database backup, on Tier 2 production application, using Host I/O bandwidth limits**

**Test Case Scenario**
Minimizing impact of database backup on a production application

**Objectives**
Leverage Host I/O Limits for bandwidth, to reduce backend and frontend bandwidth limits for large I/O activities like backup (T3-FC) which are time-consuming and improve performance and response times of time sensitive applications T2-FC.

This user scenario deals with one application running an OLTP workload while a backup is run on the other. Host I/O Limits (bandwidth) is used to constrain the backup workload in order to get higher IOPS for the OLTP workload.

SQL Backup and Restore operations issue large I/O transfers by default. They tend to have higher latency, and issue scan-intensive operations that access large portions of data at a time, unlike OLTP workloads. This makes the bandwidth or MB/s the metric to watch and constrain.

**Configuration**
The test configuration had two SQL Server databases - Host 1 (T2-FC) Production Application database and Host 2 (T3-FC) Clone Backup database — running on separate servers and on separate storage groups but using the same storage-tiers(FC) as shown in Figure 10.

The baseline performance test was run to get the workload profile of the databases, the database backup doing large I/O on the backup host (Host 2 T3-FC), and the OLTP database doing random I/O (TPCE) on the production host (T2-FC).
Test case execution

Steps
1. Run a baseline workload on both applications without any host I/O bandwidth limits enforced on Host 2(T3-FC).
2. Apply host I/O bandwidth limits (100 MB/s) on the storage group associated with backup application Host 2(T3-FC).
3. Review the Symmetrix frontend and backend bandwidth numbers, SQL server response times (RT) and Transactions per second (TPS) data.

Table 7. Production DB (T2-FC) on Host1 and Backup DB (Host 2 T3-FC) on Host2 metrics with and without Host I/O bandwidth limits

<table>
<thead>
<tr>
<th>Host I/O Limits</th>
<th>T2-FC Host1</th>
<th>T3-FC Host2</th>
<th>VMAX Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Users</td>
<td>Symm IOPS</td>
<td>SQL RT (ms)</td>
</tr>
<tr>
<td>NOLIMIT</td>
<td>200</td>
<td>38,877</td>
<td>8</td>
</tr>
<tr>
<td>Host 2 T3-FC: 100 MB/s IOPS</td>
<td>42,994</td>
<td>7</td>
<td>1,944</td>
</tr>
</tbody>
</table>

Note: SQL RT (ms) is Avg. SQL Disk sec/Transfer metric in Windows Performance Monitor (Perfmon).
Database and storage performance results

**Figure 11** Enforcing Host I/O bandwidth limits to ease backend contention

T2-FC, increased to 42,994 IOPS, an improvement of 10%. This was because of the Host I/O bandwidth limit enforced on Host2 (T3-FC). The response times improved to 7ms from 8ms. The SQL TPS increased from 1768 to 1944, a 10% improvement. The Symmetrix backend and frontend resources had reduced bandwidth, during the backup window (100 MB/s), thereby enabling T2-FC Host1 to perform better.

This example shows how Host I/O bandwidth limits can help reduce the impact large I/O backup windows have on critical applications (T2-FC). With Host I/O Limits we maintained the SLA for T2-FC application by controlling bandwidth consumed by backup job on T3-FC and freed up Symmetrix resources to drive other applications.
Test Case 5: Understanding the EMC PowerPath load balancing and maintaining Host I/O Limits after FA port group update

Test Case Scenario

Understanding the interoperability of a host load balancing mechanism like EMC PowerPath and Host I/O Limits, and how these two features complement each other.

Objectives

Show the effect of PowerPath load balancing and its interaction with FE Host I/O Limits after removing ports from the port group.

Configuration

The test configuration had T1-EFD SQL Server database, running on a single server. The host had EMC PowerPath and a 4 port HBA initiator group to drive I/O across 8 FE VMAX ports. The VMAX Port group for this host was gradually changed from 8 ports, to 4 ports to 2 ports, creating path failures.

Figure 12 Path failures from port removal as shown in EMC PowerPath
Test case execution

Steps
1. Start workload with Host I/O Limits applied on the storage group associated with T1-EFD application and note down IOPS as baseline.
2. Simulate incremental removal of FA ports while the test is running. Port can be removed from the VMAX port group associated with a host provisioning view as shown by the SYMCLI command.

   SYMCLI Command: symaccess -sid 45 -name DSIB1134_IG_PG -type port -dirport 2e:0,2f:0,2g:0,2h:0 remove

3. Note down the Symmetrix FE IOPS.

Table 8. FA port IOPS with Host I/O Limits and PowerPath load balancing

<table>
<thead>
<tr>
<th>Number of FA ports active</th>
<th>Total FA port IOPS</th>
<th>FA port IOPS breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01e</td>
<td>01f</td>
</tr>
<tr>
<td>8</td>
<td>26417</td>
<td>3319</td>
</tr>
<tr>
<td>4</td>
<td>26407</td>
<td>6620</td>
</tr>
<tr>
<td>2</td>
<td>25908</td>
<td>12775</td>
</tr>
</tbody>
</table>

H O S T I/O Limits – T1-EFD SG - 24K IOPS

a. The total FA port IOPS of 26,000+ beyond the user defined Host I/O Limits (24k) are contributed by Unisphere for VMAX stats and performance data collection policies.
Database and storage performance results

In cases where there are multiple paths to the same set of FA ports in the port group, and there is a path failure, host multi-pathing and load balancing software like EMC PowerPath will help re-distribute the load between surviving paths thus meeting the SLAs. Host I/O Limits is statically distributed among all the directors. When there are eight front-end ports/directors with 24,000 Host I/O Limit sets, each director/port will contribute around 3,000+ IOPS because of static allocation. When any FA port is removed from port group, the masking view is refreshed, that allows the Host I/O Limits to be redistributed and enforced across surviving FA ports, as shown in Figure 13.

The Host I/O Limit is divided equally among all the directors in the port group, independent of the number of ports on each director. Due to related redundancy considerations, it is recommended that the user configure only one of the ports of a director in the port group. This example covers the scenario with EMC PowerPath; other multi-pathing software may exhibit different results.

Figure 13 Host I/O Limits with FA port removal and PowerPath load balancing


**Conclusion**

Host I/O Limits enables administrators to limit IOPS and/or bandwidth of individual applications (storage groups) to define and enforce service levels. It allows administrators to set thresholds or limits on how much bandwidth or IOPS allocated to each workload.

The benefits of implementing Host I/O Limits are:

- Ensures that applications cannot exceed their set limit or share, reducing the potential of impacting other applications.
- Provides deterministic service levels thus meeting application SLAs.
- Enforces performance ceilings on a per-storage-group basis.
- Provides greater levels of control on performance allocation in multi-tenant environments.
- Enables predictability needed to service more customers on the same array.
- Simplifies quality-of-service management by presenting controls in industry-standard terms of Tunable IOPS and bandwidth allocation.
- Provides the flexibility of setting either IOPS or bandwidth or both, based on application characteristics and business needs.
Appendixes

Configuration Layout Snapshots

Snapshot of SQL Storage Layout on VMAX 10K

Snapshot of a Symmetrix VMAX-Port Group
### Snapshot of a Symmetrix VMAX-Cascaded Storage Group

<table>
<thead>
<tr>
<th>Name</th>
<th>Parent</th>
<th>FAST Policy</th>
<th>Capacity (GB)</th>
<th>Volumes</th>
<th>Masking Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSIB1134_SQL2</td>
<td>N/A</td>
<td>N/A</td>
<td>3126.24</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>DSIB1134_SQL3</td>
<td>N/A</td>
<td>N/A</td>
<td>2404.8</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>DSIB1134_SQL4</td>
<td>N/A</td>
<td>N/A</td>
<td>2404.8</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
SYMCLI Examples

Listing all the storage groups
Command: symsg list

STORAGE GROUPS

Symmetrix ID: 000198700045

<table>
<thead>
<tr>
<th>Storage Group Name</th>
<th>FMSL</th>
<th>Devices</th>
<th>SGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSIB1134_cascade</td>
<td>.PD</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>DSIB1134_GKs</td>
<td>.</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>DSIB1134_SQL1</td>
<td>.D</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>FINDB_SG</td>
<td>.CS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CRMDB_SG</td>
<td>.XCS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>HRDB_SG</td>
<td>.XCS</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>DSIB1135_GKs</td>
<td>.</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>CLONEDB_SG</td>
<td>.</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>DSIB1135_SQL5</td>
<td>..</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Ora_006_SG</td>
<td>..</td>
<td>43</td>
<td>0</td>
</tr>
</tbody>
</table>

Legend:
Flags:
(F)ast Policy, X = Associated with Fast Policy, . = N/A
(M)asking View, X = Contained in Mask View(s), . = N/A
(C)ascade (S)tatus, P = Parent SG, C = Child SG, . = N/A
Host IO (L)imit, D = Host IO Limit Defined, S = Host IO Limit Shared, . = N/A

Storage group without Host I/O limit defined
Command: symsg -sid 45 show DSIB1134_SQL1

Name: DSIB1134_SQL1

<table>
<thead>
<tr>
<th>Symmetrix ID</th>
<th>000198700045</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last updated at</td>
<td>Mon Nov 12 15:38:31 2012</td>
</tr>
<tr>
<td>Masking Views</td>
<td>Yes</td>
</tr>
<tr>
<td>FAST Policy</td>
<td>No</td>
</tr>
<tr>
<td>Host I/O Limit MB/Sec</td>
<td>N/A</td>
</tr>
<tr>
<td>Host I/O Limit IO/Sec</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of Storage Groups</td>
<td>0</td>
</tr>
<tr>
<td>Storage Group Names</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Devices (2):

<table>
<thead>
<tr>
<th>Sym</th>
<th>Device</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev</td>
<td>Pdev Name</td>
<td>Config</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>01E</td>
<td>\\PHYSICALDRIVE13</td>
<td>TDEV</td>
</tr>
<tr>
<td>01A3</td>
<td>\\PHYSICALDRIVE14</td>
<td>TDEV</td>
</tr>
</tbody>
</table>

A parent storage group without Host I/O limit defined

Command: symsg -sid 45 show DSIB1134_cascade

Name: DSIB1134_cascade
Symmetrix ID             : 000198700045
Last updated at          : Mon Dec 24 08:10:30 2012
Masking Views            : Yes
FAST Policy              : No
Host I/O Limit           : None
Host I/O Limit MB/Sec    : N/A
Host I/O Limit IO/Sec    : N/A
Number of Storage Groups : 3
Storage Group Names      : HRDB_SG  (IsChild)
                         : CRMDB_SG  (IsChild)
                         : FINDB_SG  (IsChild)

Devices (7):
{ 
  ---------------------------------------------------------
  Sym   Dev    Pdev Name                Device               Cap
  Sts    (MB)  ---------------------------------------------------------
  01AC   \\.\PHYSICALDRIVE15 \\.\PHYSICALDRIVE15 TDEV           RW  985005
  01B0   \\.\PHYSICALDRIVE16 \\.\PHYSICALDRIVE16 TDEV           RW  985005
  01B4   \\.\PHYSICALDRIVE10 \\.\PHYSICALDRIVE10 TDEV           RW  1231256
  01B9   \\.\PHYSICALDRIVE17 \\.\PHYSICALDRIVE17 TDEV           RW  1231256
  01BE   \\.\PHYSICALDRIVE11 \\.\PHYSICALDRIVE11 TDEV           RW  1231256
  01C3   \\.\PHYSICALDRIVE18 \\.\PHYSICALDRIVE18 TDEV           RW  1231256
  01CB   \\.\PHYSICALDRIVE12 \\.\PHYSICALDRIVE12 TDEV           RW  1231256
  }
**Child storage group without Host I/O limit defined**

**Command:** symsg -sid 45 show FINDB_SG

**Name:** FINDB_SG

<table>
<thead>
<tr>
<th>Symmetrix ID</th>
<th>Last updated at</th>
<th>Masking Views</th>
<th>FAST Policy</th>
<th>Host I/O Limit</th>
<th>Host I/O Limit MB/Sec</th>
<th>Host I/O Limit IO/Sec</th>
<th>Number of Storage Groups</th>
<th>Storage Group Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>000198700045</td>
<td>Fri Dec 21 13:37:14 2012</td>
<td>Yes</td>
<td>No</td>
<td>None</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>DSIB1134_cascade</td>
</tr>
</tbody>
</table>

**Devices (3):**

<table>
<thead>
<tr>
<th>Sym</th>
<th>Device</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AC</td>
<td>.\PHYSICALDRIVE15</td>
<td>TDEV</td>
</tr>
<tr>
<td>01B0</td>
<td>.\PHYSICALDRIVE16</td>
<td>TDEV</td>
</tr>
<tr>
<td>01EB</td>
<td>.\PHYSICALDRIVE12</td>
<td>TDEV</td>
</tr>
</tbody>
</table>

---

**Setting IOPS Host I/O Limit on storage group**

**Command:** symsg -sg DSIB1134_SQL1 -sid 45 set -iops_max 10000

**Command:** symsg -sid 45 show DSIB1134_SQL1

**Name:** DSIB1134_SQL1

<table>
<thead>
<tr>
<th>Symmetrix ID</th>
<th>Last updated at</th>
<th>Masking Views</th>
<th>FAST Policy</th>
<th>Host I/O Limit</th>
<th>Host I/O Limit MB/Sec</th>
<th>Host I/O Limit IO/Sec</th>
<th>Number of Storage Groups</th>
<th>Storage Group Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>000198700045</td>
<td>Mon Nov 12 15:38:31 2012</td>
<td>Yes</td>
<td>No</td>
<td>Defined</td>
<td>NoLimit</td>
<td>10000</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Devices (2):**

<table>
<thead>
<tr>
<th>Sym</th>
<th>Device</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>019E</td>
<td>.\PHYSICALDRIVE13</td>
<td>TDEV</td>
</tr>
<tr>
<td>01A3</td>
<td>.\PHYSICALDRIVE14</td>
<td>TDEV</td>
</tr>
</tbody>
</table>

---

**Setting Bandwidth Host I/O Limit on storage group**

**Command:** symsg -sg DSIB1134_SQL1 -sid 45 set -bw_max 100

**Command:** symsg -sid 45 show DSIB1134_SQL1

**Name:** DSIB1134_SQL1

<table>
<thead>
<tr>
<th>Symmetrix ID</th>
<th>Last updated at</th>
<th>Masking Views</th>
<th>FAST Policy</th>
<th>Host I/O Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>000198700045</td>
<td>Mon Nov 12 15:38:31 2012</td>
<td>Yes</td>
<td>No</td>
<td>Defined</td>
</tr>
</tbody>
</table>

---
Host I/O Limit MB/Sec  : 100  
Host I/O Limit IO/Sec  : 10000  
Number of Storage Groups : 0  
Storage Group Names     : N/A  

Devices (2):
{
  ------------------------------------------
  Sym  Device                  Config   Sts  Cap  (MB)
  ------------------------------------------
  019E  \\.\PHYSICALDRIVE13     TDEV    RW   1231256
  01A3  \\.\PHYSICALDRIVE14     TDEV    RW   1231256
  ------------------------------------------
Setting IOPS and Bandwidth Host I/O Limit on parent storage group

Command: symsg -sg DSIB1134_cascade -sid 45 set -iops_max 10000
Command: symsg -sg DSIB1134_cascade -sid 45 set -bw_max 100
Command: symsg -sid 45 show DSIB1134_cascade

Name: DSIB1134_cascade

Symmetrix ID : 000198700045
Last updated at : Mon Dec 24 08:10:30 2012
Masking Views : Yes
FAST Policy : No
Host I/O Limit : Defined
Host I/O Limit MB/Sec : 100
Host I/O Limit IO/Sec : 10000
Number of Storage Groups : 3
Storage Group Names : HRDB_SG (IsChild)
                      CRMDB_SG (IsChild)
                      FINDB_SG (IsChild)

Devices (7):

{| Sym | Device | Config | Sts | Cap |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01AC</td>
<td>\.PHYSICALDRIVE15</td>
<td>TDEV</td>
<td>RW</td>
<td>985005</td>
</tr>
<tr>
<td>01B0</td>
<td>\.PHYSICALDRIVE16</td>
<td>TDEV</td>
<td>RW</td>
<td>985005</td>
</tr>
<tr>
<td>01B4</td>
<td>\.PHYSICALDRIVE10</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td>01B9</td>
<td>\.PHYSICALDRIVE17</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td>01BE</td>
<td>\.PHYSICALDRIVE11</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td>01C3</td>
<td>\.PHYSICALDRIVE18</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td>01EB</td>
<td>\.PHYSICALDRIVE12</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Setting of a child storage group that shares Bandwidth and IOPS Host I/O Limits with the parent storage group

Command: symsg -sid 45 show FINDB_SG

Name: FINDB_SG

Symmetrix ID : 000198700045
Masking Views : Yes
FAST Policy : No
Host I/O Limit : Shared
Host I/O Limit MB/Sec : 100
Host I/O Limit IO/Sec : 10000
Number of Storage Groups : 1
Storage Group Names : DSIB1134_cascade (IsParent)

Devices (3):

{| Sym | Device | Config | Sts | Cap |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01AC</td>
<td>\.PHYSICALDRIVE15</td>
<td>TDEV</td>
<td>RW</td>
<td>985005</td>
</tr>
<tr>
<td>01B0</td>
<td>\.PHYSICALDRIVE16</td>
<td>TDEV</td>
<td>RW</td>
<td>985005</td>
</tr>
<tr>
<td>01EB</td>
<td>\.PHYSICALDRIVE12</td>
<td>TDEV</td>
<td>RW</td>
<td>1231256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Storage group list by port demand report
### Command: symsg list -by_port -demand

**Symmetrix ID:** 000198700045

<table>
<thead>
<tr>
<th>Director</th>
<th>IO Limit</th>
<th>Bandwidth Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Host Limit</th>
<th>Maximum Demand</th>
<th>Number NoLimit</th>
<th>Port Speed Limit</th>
<th>Maximum Demand</th>
<th>Number NoLimit</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>3</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DIR:F:0</td>
<td>2500</td>
<td>4</td>
<td>1000</td>
<td>24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>DIR:F:1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Storage group list by port demand report in verbose

**Command: symsg list -by_port -demand -v**

**Symmetrix ID:** 000198700045

**Director Identification:** FA-1E

**Director Port:** 0

**Port Total Demand (IO/Sec):** 2500

**Port Negotiated Speed (MB/Sec):** 1000

**Port Total Demand (MB/Sec):** 24

**Percent Port Capability (%):** 2

**Port Excess (MB/Sec):** +976

**Number of SGs without Limit (MB/Sec):** 4

#### Storage Groups

```plaintext
{  
    "Name": "Ora_006_SG", "MB/Sec": "NoLimit", "%": "NoLimit", "IO/Sec": "NoLimit"  
    "DSIB1135_GKs": {  "Name": "DSIB1135_GKs",  "MB/Sec": "NoLimit",  "%": "NoLimit",  "IO/Sec": "NoLimit"  },  
    "CLONEDB_SG": {  "Name": "CLONEDB_SG",  "MB/Sec": "NoLimit",  "%": "NoLimit",  "IO/Sec": "NoLimit"  },  
    "DSIB1134_GKs": {  "Name": "DSIB1134_GKs",  "MB/Sec": "NoLimit",  "%": "NoLimit",  "IO/Sec": "NoLimit"  },  
    "DSIB1134_cascade": {  "Name": "DSIB1134_cascade",  "MB/Sec": "12",  "%": "1",  "IO/Sec": "1250"  },  
    "HRDB_SG": {  "Name": "HRDB_SG",  "MB/Sec": "-",  "%": "-",  "IO/Sec": "-"  },  
    "CRMDB_SG": {  "Name": "CRMDB_SG",  "MB/Sec": "-",  "%": "-",  "IO/Sec": "-"  },  
    "FINDB_SG": {  "Name": "FINDB_SG",  "MB/Sec": "-",  "%": "-",  "IO/Sec": "-"  },  
    "DSIB1134_SQL1": {  "Name": "DSIB1134_SQL1",  "MB/Sec": "12",  "%": "1",  "IO/Sec": "1250"  }  
}
```

...
Storage group list by port group demand report

Command: symsg list -by_pg -demand

Symmetrix ID: 000198700045

<table>
<thead>
<tr>
<th>Port Group</th>
<th>IO Limit</th>
<th>Bandwidth Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Host Limit</td>
<td>Maximum Number</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>NoLimit</td>
</tr>
<tr>
<td>Name</td>
<td>Exist (IO/Sec)</td>
<td>SGs (MB/Sec)</td>
</tr>
<tr>
<td>Or_006_PG</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>DSIB1135_IG_PG</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>DSIB1134_IG_PG</td>
<td>Mixed</td>
<td>20000</td>
</tr>
</tbody>
</table>

Storage group list by portgroup demand report in verbose

Command: symsg list -by_pg -demand -v

Symmetrix ID: 000198700045

Port Group Name                     : DSIB1135_IG_PG
Port Group Total Demand (IO/Sec)    : 0
Number of SGs without Limit (IO/Sec): 2
Port Group Negotiated Speed (MB/Sec): 8000
Port Group Total Demand (MB/Sec)    : 0
Percent Port Group Capability (%)   : 0
Port Group Excess (MB/Sec)          : +8000
Number of SGs without Limit (MB/Sec): 2

Storage Groups (2)

{  
  -----------------------------
  Maximum Demand
  -----------------------------
  Name                     MB/Sec (%) IO/Sec
  -----------------------------  -------- --- --------
  DSIB1135_Gks  NoLimit 0 NoLimit
  CLONEDB_SG    NoLimit 0 NoLimit
}

Port Group Name                     : DSIB1134_IG_PG
Port Group Total Demand (IO/Sec)    : 20000
Number of SGs without Limit (IO/Sec): 1
Port Group Negotiated Speed (MB/Sec): 8000
Port Group Total Demand (MB/Sec)    : 200
Percent Port Group Capability (%)   : 2
Port Group Excess (MB/Sec)          : +7800
Number of SGs without Limit (MB/Sec): 1

Storage Groups (3)

{  
  -----------------------------
  Maximum Demand
  -----------------------------
  Name                     MB/Sec (%) IO/Sec
  -----------------------------  -------- --- --------
  DSIB1134_Gks  NoLimit 0 NoLimit
  DSIB1134_cascade 100 1 10000
  HRDB_SG        - - -
  CRMDB_SG        - - -
  FINDB_SG        - - -
  DSIB1134_SQL1   100 1 10000
}
Collection of Statistics

**Symstat for FE Stats**

Command: symstat -i 120 -type REQUESTS -SA ALL

**Symstat for BE Stats**

Command: symstat -i 120 -type PREFETCH -DA ALL

**Symstat for Device Group Stats**

Command: symstat -i 120 -type REQUESTS -g TPCE2_dg

Where TPCE2_dg is a device group as show below. Use EMC Unisphere for VMAX or EMC SYMCLI to create device groups.

Group Name: TPCE2_dg

<table>
<thead>
<tr>
<th>Group Type</th>
<th>REGULAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Group in GNS</td>
<td>No</td>
</tr>
<tr>
<td>Valid</td>
<td>Yes</td>
</tr>
<tr>
<td>Symmetrix ID</td>
<td>000198700045</td>
</tr>
<tr>
<td>Group Creation Time</td>
<td>Tue Oct 16 08:18:31 2012</td>
</tr>
<tr>
<td>Vendor ID</td>
<td>EMC Corp</td>
</tr>
<tr>
<td>Application ID</td>
<td>SYMCLI</td>
</tr>
<tr>
<td>Number of STD Devices in Group</td>
<td>1</td>
</tr>
<tr>
<td>Number of Associated GK's</td>
<td>0</td>
</tr>
<tr>
<td>Number of Locally-associated BCV's</td>
<td>0</td>
</tr>
<tr>
<td>Number of Locally-associated VDEV's</td>
<td>0</td>
</tr>
<tr>
<td>Number of Locally-associated TGT's</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-associated VDEV's (STD RDF)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-associated TGT's (TGT RDF)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-associated BCV's (BCV RDF)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-assoc'd RBCV's (RBCV RDF)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-assoc'd BCV's (Hop-2 BCV)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-assoc'd VDEV's (Hop-2 VDEV)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Remotely-assoc'd TGT's (Hop-2 TGT)</td>
<td>0</td>
</tr>
<tr>
<td>Number of Composite Groups</td>
<td>0</td>
</tr>
<tr>
<td>Composite Group Names</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Standard (STD) Devices (1):

<table>
<thead>
<tr>
<th>Sym</th>
<th>Device</th>
<th>Cap (MB)</th>
<th>LdevName</th>
<th>PdevName</th>
<th>Dev</th>
<th>Config</th>
<th>Att. Sts</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----</td>
<td>--------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>-----</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>985005</td>
<td>DEV001</td>
<td>\PHYSICALDRIVE15</td>
<td>01AC</td>
<td>TDEV</td>
<td>RW</td>
</tr>
</tbody>
</table>
