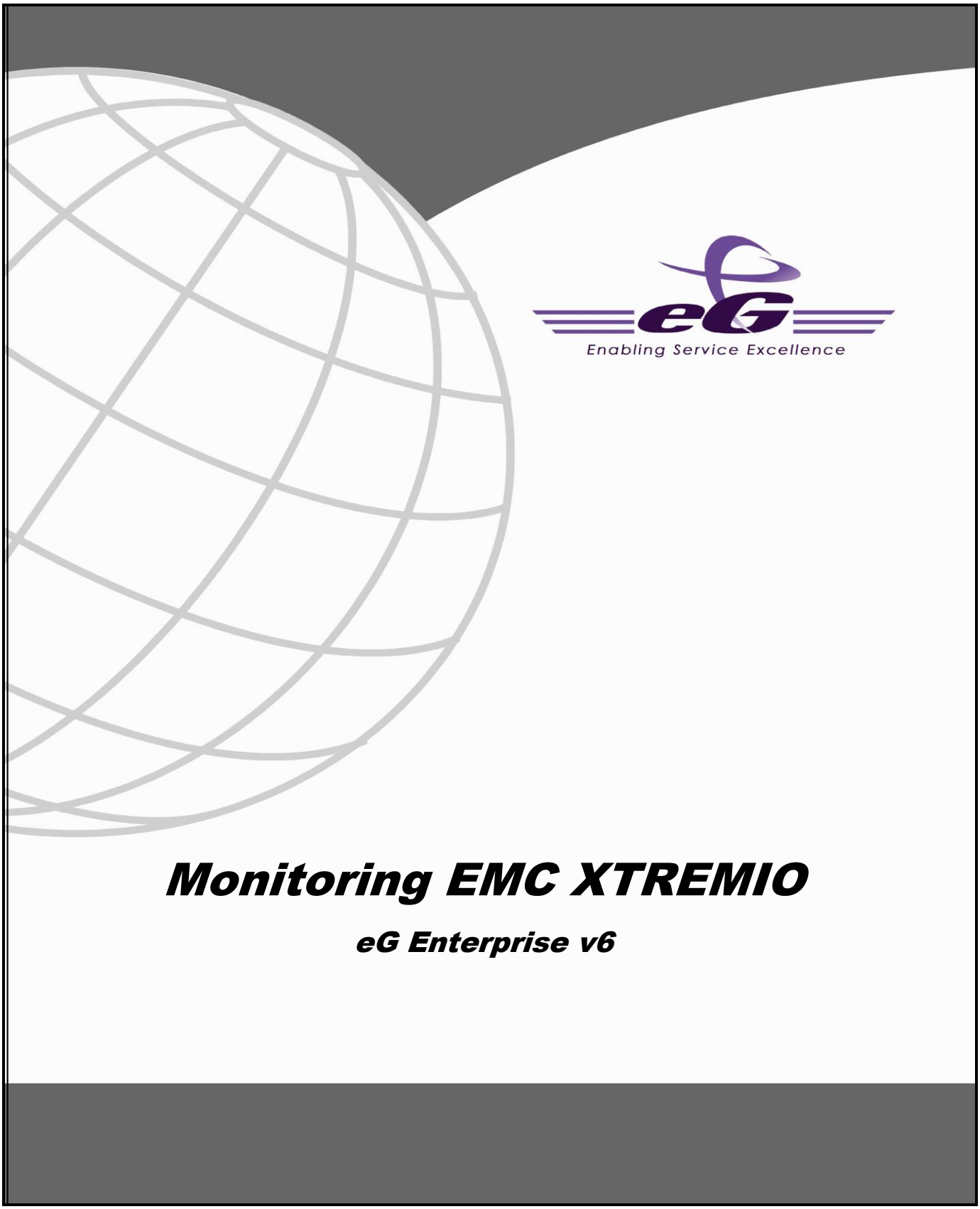

Monitoring EMC XTREMIO

eG Enterprise v6

Table of Contents

1

Introduction

The XtremIO Storage Array is an all-flash system, based on a scale-out architecture. The system uses building blocks, called X-Bricks, which can be clustered together, as shown in Figure 2.

The system operation is controlled via a stand-alone dedicated Linux-based server, called the XtremIO Management Server (XMS). Each XtremIO cluster requires its own XMS host, which can be either a physical or a virtual server. The array continues operating if it is disconnected from the XMS, but cannot be configured or monitored.

XtremIO's array architecture is specifically designed to deliver the full performance potential of flash, while linearly scaling all resources such as CPU, RAM, SSDs, and host ports in a balanced manner. This allows the array to achieve any desired performance level, while maintaining consistency of performance that is critical to predictable application behavior.

The XtremIO Storage Array provides a very high level of performance that is consistent over time, system conditions and access patterns. It is designed for high granularity true random I/O.

The cluster's performance level is not affected by its capacity utilization level, number of volumes, or aging effects. Moreover, performance is not based on a "shared cache" architecture and therefore it is not affected by the dataset size or data access pattern.

Due to its content-aware storage architecture, XtremIO provides:

- Even distribution of data blocks, inherently leading to maximum performance and
- minimal flash wear
- Even distribution of metadata
- No data or metadata hotspots
- Easy setup and no tuning
- Advanced storage functionality, including Inline Data Deduplication and Compression, thin provisioning, advanced data protection (XDP), snapshots, and more

eG Enterprise offers a specialized *EMC XtremIO* monitoring model that monitors each of the key indicators of the performance of EMC XtremIO - such as the SSDs, X-Bricks, volumes, target ports, initiators, etc. - and proactively alerts administrators to potential performance bottlenecks, so that administrators can resolve the issues well before end-users complain.

Figure 1: The layer model of EMC XtremIO

Each layer of Figure 1 above is mapped to a variety of tests, each of which report a wealth of performance information related to the EMC XtremIO storage array. Using these metrics, administrators can find quick and accurate answers to the following performance queries:

- How well the bandwidth is utilized in each Data Protection Group?
- How well read/write operations were performed on each Data Protection Group?
- How much of space is utilized in the SSDs of each Data Protection Group?
- How well read/write operations were performed on each SSD?
- What is the current state and CPU utilization of each X-Env?
- What is the current health of each cluster? Which cluster is too slow in processing I/O requests? What type of I/O requests does it process very slowly - read or write requests?
- How well each data block in a cluster is processed? Which data block size is the slowest to be processed causing bottlenecks?
- What is the current port state and health of each target port? How well read/write operations are performed through each target port? Which target port is the slowest in performing read/write and I/O operations?
- What is the current state of each X-Brick? How many SSDs and Battery Backup Units are present in each X-Brick?
- How well read/write operations were performed on each volume? Which volume is handling the maximum amount of I/O?
- How well the space of each volume is utilized?
- How well read/write operations were performed on each volume folder? Which volume folder is handling the maximum amount of data?
- How well read/write operations were performed through each initiator? Which initiator is taking too long to perform the I/O operations?
- How well read/write operations were performed on each initiator group? Which initiator group is handling the maximum I/O operations?
- How well read/write operations were performed on each initiator group folder? Which folder is handling the maximum I/O operations?

- How well read/write operations were performed on each snapshot? Which snapshot is experiencing a processing bottleneck?

1.1 How does eG Enterprise Monitor the EMC XtremIO Storage Array?

eG Enterprise employs an *agentless* approach to monitor the EMC XtremIO storage array. This approach requires that the eG agent be deployed on a remote Windows host in the environment. To collect the metrics of interest from the EMC XtremIO storage array, this agent uses the *RESTful APIs*.

The pre-requisites that need to be fulfilled to use these command line interfaces have been detailed in the next section.

1.2 Pre-requisites for Monitoring EMC XtremIO Storage Array

To enable the eG agent to monitor the EMC XtremIO storage array, the following pre-requisites should be fulfilled:

The user who is authorized to access the EMC XtremIO should be vested with *read-only* privileges i.e., the user should be capable of executing the *HTTP GET* commands of the Restful APIs. The eG agent communicates with this user to collect the necessary metrics.

Once the aforesaid requirement is fulfilled, the eG agent will report a plethora of useful metrics revealing the health of the EMC XtremIO storage array and present these performance statistics in the eG monitoring model using the hierarchical layer model representation of Figure 1.

The chapter that follows will discuss each layer of Figure 1 in great detail.

2

The EMC XTREMIO Monitoring Model

This chapter deep dives into every layer of the *EMC XtremIO* monitoring model, the tests mapped to each layer, and the measures every test reports.

2.1 The XtremIO System Layer

The tests mapped to this layer report the health state of each SSD, space utilization of each SSD, CPU utilization and state of each X-Env, bandwidth utilization for read/write operations in each Data Protection Group etc.

Figure 2: The tests mapped to the XtremIO System layer

2.1.1 XIO Data Protection Groups Test

The XtremIO Storage Array is an all-flash system, based on a scale-out architecture. The system uses building blocks, called X-Bricks, which can be clustered together to grow performance and capacity as required. An X-Brick is the basic building block of an XtremIO array. An X-Brick comprises of 25 SSDs. A data protection group is a set of SSDs that form a redundancy group. Each data protection group has a name, health state, and defined usable SSD space. Each X-Brick contains one data protection group, which is created during the initial configuration. The data protection group cannot be removed. Whenever multiple SSDs fail, administrators are required to assign a new SSD in the data protection group so that the space within the data protection group is maintained and the data loss is kept to a minimum. To achieve superior data protection, enhanced performance of the XtremIO storage array along with a minimal data loss due to SSD failure, it is necessary to continuously monitor the bandwidth utilization and IOPS of the data protection group. The **XIO Data Protection Group** test helps administrators in this regard!

This test auto-discovers the Data Protection Group of an X-Brick and reports the bandwidth utilization for read/write operations, the rate at which read/write operations are performed and the percentage of free space within the SSDs of the Data Protection Group.

Purpose	Auto-discovers the Data Protection Group of an X-Brick and reports the bandwidth utilization for read/write operations, the rate at which read/write operations are performed and the percentage of free space within the SSDs of the Data Protection Group

<table>
<tr><td>Target of the test</td><td colspan="3">An EMC XtremIO Storage array</td></tr>
<tr><td>Agent deploying the test</td><td colspan="3">A remote agent</td></tr>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each Data Protection Group on the EMC XtremIO Storage array that is to be monitored</td></tr>
<tr><td rowspan="3">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Read bandwidth:
Indicates the rate at which data is read from this data protection group.</td><td>MB/Sec</td><td rowspan="2">Comparing the value of these measures across the data protection groups will clearly indicate which data protection group is the slowest in I/O processing, and when exactly the slowdown occurred – when reading data? or when writing data?</td></tr>
<tr><td>Write bandwidth:
Indicates the rate at which data is written to this data protection group.</td><td>MB/Sec</td></tr>
<tr><td></td><td>Bandwidth:
Indicates the amount of data handled while performing I/O operations per second on this data protection group.</td><td>MB/Sec</td><td>Compare the value of this measure across the data protection groups to identify the group that is consuming the maximum bandwidth.</td></tr>
</table>

	Read IOPS: Indicates the rate at which read operations were performed on this data protection group.	IOPS	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential reading bottleneck.
	Write IOPS: Indicates the rate at which write operations were performed on this data protection group.	IOPS	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck.
	IOPS: Indicates the rate at which I/O operations were performed on this data protection group.	IOPS	A high value is desired for this measure. Compare the value of this measure across the data protection groups to identify the group that is handling the maximum number of I/O operations.
	User data SSD free space: Indicates the percentage of free space available for use in the SSDs of this data protection group.	Percent	A high value is desired for this measure. When an SSD in a data protection group fails, the cluster rebuilds it to restore redundancy. A rebuild reconstructs the data from the failed SSD onto the remaining SSDs in the data protection group, thus restoring redundancy and protection level. A rebuild requires sufficient available space in the remaining SSDs to handle the data protection group's demands. If sufficient free space is not available, a rebuild cannot be performed and the data protection group's performance and resiliency may be degraded.

2.1.2 XIO SSDs Test

This test reports the current health and enabled state of each SSD in an EMC XtremIO, monitors the space utilization of each SSD, and enables administrators to accurately identify which SSD is experiencing space crunch currently. In addition, this test monitors the level of traffic on each SSD, and helps isolate irregularities in load balancing across the SSDs. In the process, the test also helps identify which SSD is experiencing processing bottlenecks (if any).

Purpose	Reports the current health and enabled state of each SSD in an EMC XtremIO, monitors the space utilization of each SSD, and enables administrators to accurately identify which SSD is experiencing space crunch currently. In addition, this test monitors the level of traffic on each SSD, and helps isolate irregularities in load balancing across the SSDs
Target of the test	An EMC XtremIO Storage array
Agent deploying the test	A remote agent

<table>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each Data Protection Group:SSD in the target EMC XtremIO Storage array that is being monitored</td></tr>
<tr><td rowspan="2">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>SSD health state:
Indicates the current health of this SSD.</td><td></td><td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Healthy</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the current health of this SSD. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td></tr>
</table>

<table>
<tr>
<td></td>
<td>SSD enabled state:
Indicates whether/not this SSD is enabled.</td>
<td></td>
<td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Enabled</td><td>0</td></tr><tr><td>Disabled</td><td>1</td></tr><tr><td>Unknown</td><td>2</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate whether/not this SSD is enabled. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
<tr>
<td></td>
<td>SSD RG state:
Indicates whether/not this SSD is within a Raid Group.</td>
<td></td>
<td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>In RG</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate whether/not this SSD is within a Raid Group. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
<tr>
<td></td>
<td>SSD size:
Indicates the total size of this SSD.</td>
<td>GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSD space in use:
Indicates the amount of space that is currently utilized by this SSD.</td>
<td>GB</td>
<td>If the value of this measure is close to that of the SSD size measure, it indicates potential space crunch in the SSD. Administrators are therefore required to increase the size of the SSD.</td>
</tr>
<tr>
<td></td>
<td>SSD free space:
Indicates the percentage of space that is available for use in this SSD.</td>
<td>Percent</td>
<td>A high value is desired for this measure.</td>
</tr>
</table>

	SSD space used: Indicates the percentage of space that is currently in use in this SSD.	Percent	A low value is desired for this measure. A consistent increase in this value could indicate a gradual, but steady erosion of space in this SSD. A value close to 100% indicates that this SSD is rapidly running out of space.
	Endurance remaining: Indicates the tolerance i.e., withstanding capability of this SSD, expressed in terms of percentage.	Percent	A high value is desired for this measure. A sudden/gradual decrease in the value indicates an impending SSD failure.
	Read bandwidth: Indicates the rate at which data is read from this SSD.	MB/Sec	Comparing the value of these measures across the SSDs will clearly indicate which SSD is the slowest in I/O processing, and when exactly the slowdown occurred – when reading data? or when writing data?
	Write bandwidth: Indicates the rate at which data is written to this SSD.	MB/Sec	
	Bandwidth: Indicates the amount of data handled while performing I/O operations per second on this SSD.	MB/Sec	Compare the value of this measure across the SSDs to identify the SSD that is consuming the maximum bandwidth.
	Read IOPS: Indicates the rate at which read operations were performed on this SSD.	IOPS	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential reading bottleneck.
	Write IOPS: Indicates the rate at which write operations were performed on this SSD.	IOPS	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck.
	IOPS: Indicates the rate at which I/O operations were performed on this SSD.	IOPS	A high value is desired for this measure. Compare the value of this measure across the SSDs to identify the SSD that is handling the maximum number of I/O operations.

2.1.3 XIO XEnvs Test

By default, each X-Brick comprises of two storage controller nodes and each storage controller consists of two CPU sockets. An XIOS instance called the X-ENV runs on each CPU socket. There are 6 software modules that are responsible for various functions such as I/O flow, I/O processing etc in the XTREMIO storage array. The first 3 (R,C,D) are data plane modules and the last 3 (P,M,L) are control plane modules. Each of these modules are explained in detail as follows:

P – Platform Module. This module is responsible for monitoring the hardware of the system. Each node runs a P-module.

M – Management Module. This module is responsible for system wide configurations. It communicates with the XMS management server to perform actions such as volume creation, host LUN masking, etc from the GUI and CLI. There

is one active M-module running on a single node, and the other nodes run a stand-by M-module for HA purposes.

L – Clustering Module. This clustering module is responsible for managing the cluster membership state, joining the cluster, and typical cluster functions. Each node runs an L-module.

R- Routing Module. This module is the SCSI Command parser and translates all host SCSI commands into internal XtremIO commands/addresses. It is responsible for the 2 FC and 2 iSCSI ports on the node and functions as the ingress/egress point for all I/O of the node. It is also responsible for breaking all I/O into 4K chunks and calculating the data hash values via SHA-1. Each node runs an R-Module.

C- Control Module. This module contains the address to hash mapping table (A2H) which is the first layer of indirection that allows much of the "magic" to happen. Many of the advanced data services such as snapshots, de-duplication, thin provisioning, etc are all handled in this module.

D- Data Module. The data module contains the hash to physical (H2P) SSD address mapping. It is also responsible for doing all of the I/O to the SSDs themselves as well as managing the data protection scheme, called XDP (XtremIO Data Protection).

Each storage controller node is configured specifically to run R and C modules on one CPU socket and the D module is run on the other CPU socket. When communication between the RC and D modules happens evenly, then the I/O processing will be smooth and uniform. If for any reason the XIOS instance aka X-ENV is inactive, the corresponding storage controller node may fail leading to performance degradation of the XTREMIO storage array. Also, if the CPU utilization of the X-Env is not maintained optimally, then the I/O processing may not be uniform. In order to maintain uniform I/O processing, it becomes important to continuously monitor the state and CPU utilization of each X-Env. The **XIO XEnvs** test exactly helps you in this regard. This test auto-discovers the X-Envs of the target storage array and reports the current state and CPU utilization of each X-Env.

Purpose	Auto-discovers the X-Envs of the target storage array and reports the current state and CPU utilization of each X-Env		
Target of the test	An EMC XtremIO Storage array		
Agent deploying the test	A remote agent		
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each *X-Env* of the EMC XtremIO Storage array that is being monitored		
Measurements made by the	**Measurement**	**Measurement Unit**	**Interpretation**

<table>
<tr>
<td>test</td>
<td>CPU usage:
Indicates the CPU utilization of this X-Env.</td>
<td>Percent</td>
<td>A high value for this measure indicates continuous I/O processing by the storage array. If the value of this measure is increasing gradually or is high for a prolonged period, then administrators should check if adequate LUNs/Volumes are available for storage purposes, if the disk drive capacity is adequate or if the storage capacity of the snapshots is adequate. To optimize the CPU utilization, administrators may either increase the storage capacity or clear unwanted storage space for a smoother I/O processing.</td>
</tr>
<tr>
<td></td>
<td>XEnv state:
Indicates the current state of this X-Env.</td>
<td></td>
<td>The values reported by this measure and their numeric equivalents are available in the table below:
<table>
<tr><th>Measure Value</th><th>Numeric Value</th></tr>
<tr><td>Active</td><td>0</td></tr>
<tr><td>Unknown</td><td>1</td></tr>
</table>
Note:
This measure reports the Measure Values listed in the table above to indicate the state of this X-Env. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
</table>

2.2 The XtremIO Cluster Layer

This layer monitors the level of I/O activity of each cluster and space usage of each SSD in a cluster of the EMC XtremIO. In addition, this layer helps administrator to keep a check on the I/O processing capability of the cluster based on the data block size so that lag in read/write operations can be detected and precautionary measures can be initiated before any serious damage occurs.

Figure 3: The tests mapped to the XtremIO Cluster layer

2.2.1 XIO Cluster Status Test

An XtremIO Storage Array can include a single X-Brick or a cluster of multiple X-Bricks. A cluster of multiple X-Bricks consists of:

- Two or four X-Bricks

- Two InfiniBand Switches

This test auto discovers the clusters of the target storage array and reports the current health, connection state and uptime. In addition, this test monitors the SSD space utilization of the cluster and helps administrators identify potential space crunch, if any. Also, this test helps administrators to figure out the cluster that is busy processing I/O requests along clusters, detect irregularities in the distribution of I/O load across clusters and thus enables administrators to initiate pre-emptive measures.

Purpose	Auto discovers the clusters of the target storage array and reports the current health, connection state and uptime. In addition, this test monitors the SSD space utilization of the cluster and helps administrators identify potential space crunch, if any		
Target of the test	An EMC XtremIO Storage array		
Agent deploying the test	A remote agent		
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each cluster on the EMC XtremIO Storage array being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Cluster uptime since last restart: Indicates the time duration for which this cluster had been up since the last restart.	Hours	

<table>
<tr>
<td></td>
<td>Cluster health state:
Indicates the current health of this cluster.</td>
<td></td>
<td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Healthy</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the health of this cluster. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
<tr>
<td></td>
<td>Cluster manager connection state:
Indicates the current connection state between the XtremIO Management Server (XMS) and this cluster.</td>
<td>MB/Sec</td>
<td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Connected</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the connection state of this cluster. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>Consistency state:
Indicates the detection of data consistency error in this cluster.</td>
<td></td>
<td>This measure will report a value Healthy if the data consistency error is determined as non-existant and Unknown otherwise.
The values reported by this measure and their numeric equivalents are available in the table below:
<table>
<tr><th>Measure Value</th><th>Numeric Value</th></tr>
<tr><td>Healthy</td><td>0</td></tr>
<tr><td>Unknown</td><td>1</td></tr>
</table>
Note:
This measure reports the Measure Values listed in the table above to indicate the detection of data consistency error in this cluster. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td>
</tr>
<tr>
<td></td>
<td>Used user data SSD space:
Indicates the percentage of SSD space utilized by this cluster.</td>
<td>Percent</td>
<td>A value close to 100 indicates that the SSDs in the cluster are running out of space.</td>
</tr>
<tr>
<td></td>
<td>Free user data SSD space:
Indicates the percentage of SSD space that is currently available for use in this cluster.</td>
<td>Percent</td>
<td>A high value is desired for this measure. A sudden/gradual decrease in the value of this measure is an indication for the administrators to either free up space in the SSDs or add additional resources to the cluster.</td>
</tr>
<tr>
<td></td>
<td>Reads:
Indicates the number of reads made on this cluster per second during the last measurement period.</td>
<td>Reads/sec</td>
<td rowspan="2">Comparing the value of these measures across clusters will clearly indicate which cluster is overloaded - it could also shed light on irregularities in load balancing across the clusters.</td>
</tr>
<tr>
<td></td>
<td>Writes:
Indicates the number of writes to this cluster during the last measurement period.</td>
<td>Writes/Sec</td>
</tr>
<tr>
<td></td>
<td>Data reads:
Indicates the rate at which data is read from this cluster during the last measurement period.</td>
<td>MB/Sec</td>
<td>Compare the values of these measures across the clusters to identify the slowest cluster in terms of servicing read and write requests (respectively).</td>
</tr>
</table>

	Data written: Indicates the rate at which data is written to this cluster during the last measurement period.	MB/Sec	
	Average read size: Indicates the average amount of data read from this cluster per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the clusters to identify the slowest cluster in terms of servicing read and write requests (respectively).
	Average write size: Indicates the average amount of data written to this cluster per I/O operation during the last measurement period.	MB/Op	

2.2.2 XIO Cluster Traffic Test

To external applications, XtremIO appears and behaves like a standard block storage array. However, due to its unique architecture, it takes a fundamentally different approach to internal data organization. Instead of using logical addresses, XtremIO uses data blocks internally to store data. According to the block content, XtremIO decides where exactly to place the data blocks.

In a write operation, any data chunks that are larger than the native block size are broken down into standard blocks when they first enter the storage array. The system calculates a unique fingerprint for each of the incoming data blocks, using a special mathematical algorithm. This unique fingerprint is used for two primary purposes:

- To determine where the data block is placed within the array
- Inline Data Reduction

Because of the way the fingerprinting algorithm works, the ID numbers appear completely random and are evenly distributed over the possible range of fingerprint values. This results in an even distribution of data blocks across the entire cluster and all SSDs within the array. In other words, with XtremIO it is neither necessary to check the space utilization levels on different SSDs, nor to actively manage equal data writes to every SSD. XtremIO inherently provides even distribution of data by placing the blocks based on their unique IDs. To achieve peak performance of any storage array, administrators should constantly keep a check on the read/write operations on the clusters, disks, SSDs of the storage array. The shorter the time taken to perform the read/write operations, the better is the performance of the storage array. In order to improve the performance of the storage array and figure out any processing bottlenecks in the storage array, it is necessary for the administrator to carefully monitor the processing capability of each cluster in the EMC XtremIO with respect to the size of the data blocks. The **XIO Cluster Traffic** test helps administrators in this regard!

This test reports the I/O processing capability of each cluster with respect to the data block size. For each data block size, this test reports how well the data block is processed, the time taken to process each data block size etc. Using this test, administrators can identify processing bottlenecks and initiate pre-emptive actions.

Purpose	Reports the I/O processing capability of each cluster with respect to the data block size. For each data block size, this test reports how well the data block is processed, the time taken to process each data block size etc
Target of the	An EMC XtremIO Storage array

<table>
<tr><td>test</td><td colspan="3"></td></tr>
<tr><td>Agent deploying the test</td><td colspan="3">A remote agent</td></tr>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each cluster:data block on the EMC XtremIO Storage array</td></tr>
<tr><td rowspan="5">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Read bandwidth:
Indicates the rate at which data blocks of this size were read from this cluster.</td><td>MB/Sec</td><td></td></tr>
<tr><td>Write bandwidth:
Indicates the rate at which data blocks of this size were written to this cluster.</td><td>MB/Sec</td><td></td></tr>
<tr><td>Read latency:
Indicates the time taken to read data blocks of this size.</td><td>msecs</td><td rowspan="2">Ideally, this value should be low. A high value could indicate that read/write operations are slowing down for some reason.</td></tr>
<tr><td>Write latency:
Indicates the time taken to write data blocks of this size.</td><td>msecs</td></tr>
<tr><td></td><td>Average latency:
Indicates the average time taken to read/write data blocks of this size.</td><td>msecs</td><td>A value close to 100 indicates that the SSDs in the cluster are running out of space.</td></tr>
</table>

	Read IOPS: Indicates the rate of read I/.O operations measured for the data blocks of this size during the last measurement period.	IOPS	
	Write IOPS: Indicates the rate of write I/O operations measured for the data blocks of this size during the last measurement period.	IOPS	

2.3 The XtremIO Target Layer

Using the tests mapped to this layer, administrators can focus on the overall operational state and operational efficiency of their storage ports i.e., target ports. This way, they can proactively detect a potential overload condition and/or an I/O processing bottleneck with the target ports, and initiate measures to resolve these issues. In addition, the layer also throws light on the current state of each X-Brick and the number of SSDs and BBUs in each X-Brick.

Figure 4: The tests mapped to the XtremIO Target layer

2.3.1 XIO Targets Test

A target is a physical port located on the storage controller of the XtremIO Storage Array.

The XtremIO Storage Array supports the following target types:

- iSCSI - a 10GbE NIC port for connecting to iSCSI networks. There are two iSCSI targets per Storage Controller.
- FC - an FC HBA port for connecting to fiber optic cable networks. There are two FC targets per Storage Controller.

The cluster targets form the XtremIO Storage Array's front-end to which application servers connect for receiving storage services. The I/O requests from the host/server are primarily received through these targets, and the responses from the storage array are communicated to the host/server through these targets. The targets are the primary handlers of the I/O request processing in the storage array. By periodically checking the target port status and measuring the I/O load on the ports, you can identify overloaded ports, and thus proactively detect potential/existing load-balancing irregularities and/or processing bottlenecks with the storage controller. The **XIO Targets** test facilitates this port check. For every target port configured on the storage controller, this test reports the port state, the I/O load on the ports, the processing ability of the ports, and the errors encountered by each target port. In the process, the test not only points administrators to overloaded ports, but also puts a finger on ports that are slow when processing I/O requests and the ports that are erroneous.

Purpose	For every target port configured on the storage controller, this test reports the port state, the I/O

<table>
<tr><td></td><td colspan="3">load on the ports, the processing ability of the ports, and the errors encountered by each target port. In the process, the test not only points administrators to overloaded ports, but also puts a finger on ports that are slow when processing I/O requests and the ports that are erroneous.</td></tr>
<tr><td>Target of the test</td><td colspan="3">An EMC XtremIO Storage array</td></tr>
<tr><td>Agent deploying the test</td><td colspan="3">A remote agent</td></tr>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each X-Brick:Storage Controller:target port of the target EMC XtremIO being monitored</td></tr>
<tr><td>Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td></td><td>Port state:
Indicates the current state of this target port.</td><td></td><td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Up</td><td>0</td></tr><tr><td>Down</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the current state of this target. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td></tr>
</table>

<table>
<tr><td></td><td>Target health:
Indicates the current health of this target port.</td><td></td><td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Level 1 clear</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the health of this target. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td></tr>
<tr><td></td><td>Bandwidth:
Indicates the amount of data utilized for performing I/O operations per second through this target port.</td><td>MB/sec</td><td></td></tr>
<tr><td></td><td>Read bandwidth:
Indicates the amount of data utilized for performing read I/O operations per second through this target port.</td><td>MB/Sec</td><td rowspan="2">By comparing the values of these measures across the target ports, you can isolate those target ports that consume bandwidth excessively, and also understand where exactly was too much of bandwidth consumed - while reading? or writing?</td></tr>
<tr><td></td><td>Write bandwidth:
Indicates the amount of data utilized for performing write I/O operations were performed per second through this target port.</td><td>MB/Sec</td></tr>
<tr><td></td><td>IOPS:
Indicates the total number of reads and writes through this target port per second.</td><td>IOPS</td><td>Compare the value of this measure across the target ports to know the target port that handled the maximum number of I/O operations and the port that handled the least. By constantly analyzing these values, administrators can keep a check on the load balancing issues across the target ports.</td></tr>
<tr><td></td><td>Read IOPS:
Indicates the number of read I/O operations performed through this target port per second.</td><td>IOPS</td><td></td></tr>
</table>

	Write IOPS: Indicates the number of write I/O operations performed through this target port per second.	IOPS	
	Reads: Indicates the number of reads per second through this target port during the last measurement period.	Reads/sec	Compare the value of this measure across target ports to identify the port that is handling the maximum number of read requests and the port that is handling the least.
	Writes: Indicates the number of writes handled by this target port per second during the last measurement period.	Writes/sec	Compare the value of this measure across target ports to identify the port that is handling the maximum number of write requests and the port that is handling the least.
	Data reads: Indicates the rate at which data was read through this target port during the last measurement period.	MB/Sec	Compare the value of these measures across the target ports to identify the slowest target port in terms of servicing read and write requests respectively.
	Data written: Indicates the rate at which data was written through this target port during the last measurement period.	MB/Sec	
	Average read size: Indicates the average amount of data read through this target port per I/O operation during the last measurement period.	MB/Op	
	Average write size: Indicates the average amount of data written through this target port per I/O operation during the last measurement period.	MB/Op	

	Loss of signals: Indicates the number of times the signal was lost on this target port during the last measurement period.	Number	Ideally, the value of this measure should be zero. A non-zero value for this measure indicates that the port detected a loss of the electrical or optical signal used to transfer data on the port. This is likely an indicator for a faulty connector or cable. These are also caused when the device connected to the port is restarted, replaced or being serviced when the Fiber Channel cable connected to the port is temporarily disconnected. If the port is in the "loss of signal" state for longer than a specific period, the port will get into the link failure state which could degrade the performance of the Fiber Channel link. **This measure is applicable only when the target port is a FC port.**
	Rate of Signal loss: Indicates number of signals lost on this target port per second during the last measurement period.	Signals/sec	A low value is desired for this measure. **This measure is applicable only when the target port is a FC port.**
	Loss of Syncs: Indicates the number of times this target port failed to synchronize during the last measurement period.	Number	Ideally, the value of this measure should be zero. A non-zero value for this measure indicates that port went into the "loss of synchronization" state, where it encountered continuous Disparity errors. This is likely an indicator for a faulty connector or cable. These are also caused when the device connected to the port is restarted, replaced or being serviced when the Fiber Channel cable connected to the port is temporarily disconnected. If the port is in the "loss of synchronization" state for longer than a specific period, the port will get into the link failure state which could degrade the performance of the Fiber Channel link. **This measure is applicable only when the target port is a FC port.**
	Loss syncs rate: Indicates the number of times this target port failed to synchronize per second during the last measurement period.	Sync/sec	Ideally, the value of this measure should be zero. **This measure is applicable only when the target port is a FC port.**

	Invalid CRCs: Indicates the number of invalid CRCs that occurred on this target port during the last measurement period.	Number	This refers to the number of frames handled by this target that contains checksum errors. Ideally, the value of this measure should be zero. These are usually recoverable errors and will not degrade system performance unless their occurrence is sustained when the data cannot be relayed after retransmissions. **This measure is applicable only when the target port is a FC port.**
	Rate of invalid CRCs: Indicates the rate at which invalid CRCs occurred on this target port during the last measurement period.	CRC/sec	Ideally, the value of this measure should be low. A high value for this measure indicates poor health of the target port. **This measure is applicable only when the target port is a FC port.**
	Primitive sequence protocol errors: Indicates the number of Primitive Sequence protocol errors that occurred on this target port during the last measurement period.	Number	Ideally, the value of this measure should be zero. **This measure is applicable only when the target port is a FC port.**
	Rate of PSP errors: Indicates the number of Primitive Sequence protocol errors occurred per second on this target port during the last measurement period.	Errors/sec	Ideally, the value of this measure should be zero. **This measure is applicable only when the target port is a FC port.**
	Link failures: Indicates the number of link failures experienced by this target during the last measurement period.	Number	Ideally, the value of this measure should be zero. A non-zero value indicates that Fiber Channel connectivity with this target was "broken" that many times. This is likely an indicator for a faulty connector or cable. These are also caused when the device connected to this target is restarted, replaced or being serviced when the Fiber Channel cable connected to this target is temporarily disconnected. **These measures are applicable only when the target port is a FC port.**
	Rate of link failures: Indicates the number of link failures experienced per second by this target during the last measurement period.	Failures/sec	

	Dumped frames: Indicates the number of frames dumped by this target port due to lack of buffer credit during the last measurement period.	Percent	**Buffer credits**, also called buffer-to-buffer credits (BBC) are used as a flow control method by Fiber Channel technology and represent the number of frames a port can store. Each time a port transmits a frame that port's BB Credit is decremented by one; for each R_RDY received, that port's BB Credit is incremented by one. Transmission of an R_RDY indicates that the port has processed a frame, freed a receive buffer, and is ready for one more. If the BB Credit is zero, the corresponding node cannot transmit until an R_RDY is received back. A high value for this measure therefore indicates that an R_RDY was not received by the FC port for a long time. This is a cause for concern, as until the R_RDY is received, the FC port will not resume communication. The solution for this problem is to allocate optimal buffer credits to the FC port. The optimal number of buffer credits is determined by the distance (frame delivery time), the processing time at the receiving port, the link signaling rate, and the size of the frames being transmitted. As the link speed increases, the frame delivery time is reduced and the number of buffer credits must be increased to obtain full link utilization, even in a short-distance environment. Smaller frame sizes need more buffer credits. **This measure is applicable only when the target port is a FC port.**

2.3.2 XIO X-Bricks Test

An X-Brick is the basic building block of an XtremIO array. Each X-Brick is comprised of:

- One 2U Disk Array Enclosure (DAE), containing:
  - 25 eMLC SSDs (standard X-Brick) or 13 eMLC SSDs (10TB Starter X-Brick [5TB])
  - Two redundant power supply units (PSUs)
  - Two redundant SAS interconnect modules
- One Battery Backup Unit
- Two 1U Storage Controllers (redundant storage processors) which includes,
  - Two redundant power supply units (PSUs)
  - Two 8Gb/s Fiber Channel (FC) ports
  - Two 10GbE iSCSI ports

- Two 40Gb/s InfiniBand ports
- One 1Gb/s management/IPMI port

This test monitors the current state of each X-Brick and also reports the number of SSDs and BBUs available in each X-Brick.

<table>
<tr><td>Purpose</td><td colspan="3">Monitors the current state of each X-Brick and also reports the number of SSDs and BBUs available in each X-Brick</td></tr>
<tr><td>Target of the test</td><td colspan="3">An EMC XtremIO Storage array</td></tr>
<tr><td>Agent deploying the test</td><td colspan="3">A remote agent</td></tr>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each X-Brick of the target EMC XtremIO being monitored</td></tr>
<tr><td rowspan="2">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>X-Brick state:
Indicates the current state of this X-Brick.</td><td></td><td>The values reported by this measure and their numeric equivalents are available in the table below:
<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>In sys</td><td>0</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the state of this X-Brick. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td></tr>
</table>

	Number of SSDs: Indicates the total number of SSDs in this X-Brick.	Number	
	Number of BBUs: Indicates the number of Battery Backup units in this X-Brick.	Number	If the value of this measure is 1 then this X-Brick is a stand-alone X-Brick. If the value of this measure is 2 then this X-Brick is a single X-Brick cluster.

2.4 The XtremIO Service Layer

The tests mapped to this layer helps administrators to monitor the level of I/O activity on each initiator, initiator group, volume, snapshot volume folder etc. Using these tests, administrators can analyze the I/O activity on each of the volumes, volume folders, snapshots etc, and easily identify the volumes, volume folders and snapshots that are busy in I/O processing.

Figure 5: The tests mapped to the XtremIO Service layer

2.4.1 XIO Volumes Test

One of the primary capabilities of the XtremIO Storage Array is to provision volumes (LUNs) to the connected servers. Each volume is a defined quantity of disk space which is provisioned to the servers so that you can enable the servers to treat the volume as a SCSI device. Once the volumes are provisioned, you can create instantaneous copy images of volume data called snapshots so as to ensure availability of the original copy of the volume data without interruption. In an EMC XtremIO cluster, you can define various quantities of disk space as volumes. For an administrator to efficiently utilize the volumes, it is essential to provision the volumes prudently and monitor the processing ability of the volumes round the clock. If a sudden decrease in the I/O processing is noticed, administrators need to analyze what exactly has brought down the I/O processing capability of the volumes. To address the needs of the administrators and keep an eye on the volumes, eG Enterprise suite provides you with the **XIO Volumes** test.

This test auto discovers the volumes of the target storage array and helps administrators to figure out the volume that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the volumes, analyze the space utilization of each volume and thus enables administrators to initiate pre-emptive measures when I/O processing capability decreases gradually.

Purpose	Auto discovers the volumes of the target storage array and helps administrators to figure out the volume that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the volumes, analyze the space utilization of each volume and thus enables administrators to initiate pre-emptive measures when I/O processing capability decreases gradually		
Target of the test	An EMC XtremIO Storage array		
Agent deploying the test	A remote agent		
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each volume of the target EMC XtremIO being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**

	Bandwidth: Indicates the amount of data handled while performing I/O operations per second on this volume.	MB/Sec	
	Read bandwidth: Indicates the amount of data utilized for read I/O operations per second on this volume.	MB/Sec	
	Write bandwidth: Indicates the amount of data utilized for write I/O operations per second on this volume.	MB/Sec	
	IOPS: Indicates the rate at which I/O operations were performed on this volume during the last measurement period.	IOPS	Compare the value of this measure across the volumes to know which volume handles the maximum number of I/O operations
	Read IOPS: Indicates the rate at which read operations were performed on this volume.	IOPS	
	Write IOPS: Indicates the rate at which write operations were performed on this volume.	IOPS	
	Read latency: Indicates the time taken to perform read operations on this volume.	msec	
	Write latency: Indicates the time taken to perform write operations on this volume.	msec	
	Average latency: Indicates the average time taken to perform I/O operations on this volume.	msec	

	Reads: Indicates the number of reads performed on this volume per second during the last measurement period.	Reads/sec	Compare the values of this measure across the volumes to know which volume handles the maximum number of read requests.
	Data written: Indicates the amount of data written to this volume during the last measurement period.	MB/sec	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck. By comparing the value of this measure across the volumes, you can quickly identify the volume that is the slowest to process write requests.
	Number of LUN mappings: Indicates the number of LUN mappings defined on this volume.	Number	
	Number of destination snaps: Indicates the number of snapshots that were snapshotted from this volume.	Number	By default, volumes are snapshotted at equal intervals and these snapshots are distributed to various clients whereas the original volume is maintained as the source copy. If the value of this measure is high, then administrators may be required to correlate this value with that of the *Bandwidth* measure. The higher the value of this measure, the greater is the bandwidth utilized. Therefore, for the bandwidth to be maintained in an optimal range, the value of this measure should be maintained within the permissible limits. If too many snapshots are created within a short period of time, then the optimization of the storage array may fail leading to severe processing bottlenecks.
	Used volume size: Indicates the total amount of space utilized for writing data to this volume before deduplication process.	GB	
	Free volume size: Indicates the amount of space that is available for use in this volume.	GB	A high value is desired for this measure. A gradual/sudden decrease in the value of this measure indicates that the volume is running out of space.
	Used volume: Indicates the percentage of space that is already utilized in this volume.	Percent	A value close to 100% indicates that the volume is running out of space.

	Free volume: Indicates the percentage of space that is available for use in this volume.	Percent	A high value is desired for this measure.

2.4.2 XIO Volume folders Test

In an EMC XtremIO cluster, you can define various quantities of disk space as volumes. In large environments, multiple EMC XtremIO clusters may be deployed with too many volumes. If too many volumes are available in the cluster, then, monitoring the I/O processing and the I/O load on each individual volume is difficult for the administrators. Therefore, it is necessary to group the volumes and place those volumes in a volume folder. By analyzing the I/O processing and I/O load of each volume folder, administrators can figure out the processing ability of the volumes within the volume folder. If a volume folder is experiencing minimum activity, then administrators can resize a volume and allocate the available disk space to a volume that is currently experiencing space crunch or a volume that is constantly handling high I/O rate, thereby evenly distributing the load across the volume folders. To achieve the above, administrators can use the **XIO Volume folders** test.

This test auto discovers the volume folders of the target storage array and helps administrators to figure out the volume folder that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the volume folders and thus enables administrators to identify the volume folder whose I/O processing rate is the maximum and the minimum. Using this test, administrators can easily load balance the volumes and utilize the volumes more efficiently.

Purpose	Auto discovers the volume folders of the target storage array and helps administrators to figure out the volume folder that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the volume folders
Target of the test	An EMC XtremIO Storage array
Agent deploying the test	A remote agent
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.
Outputs of the test	One set of results for each volume folder of the target EMC XtremIO being monitored

Measurements made by the test	Measurement	Measurement Unit	Interpretation
	Bandwidth: Indicates the amount of data utilized for I/O operations per second on this volume folder.	MB/Sec	
	Read bandwidth: Indicates the amount of data utilized for read I/O operations per second on this volume folder.	MB/Sec	
	Write bandwidth: Indicates the amount of data utilized for write I/O operations per second on this volume folder.	MB/Sec	
	IOPS: Indicates the rate at which I/O operations were performed on this volume folder during the last measurement period.	IOPS	Compare the value of this measure across the volumes to know which volume handles the maximum number of I/O operations
	Read IOPS: Indicates the rate at which read operations were performed on this volume folder.	IOPS	
	Write IOPS: Indicates the rate at which write operations were performed on this volume folder.	IOPS	
	Reads: Indicates the number of reads performed on this volume folder per second during the last measurement period.	Reads/sec	Compare the values of this measure across the volumes to know which volume folder handles the maximum number of read requests.
	Writes: Indicates the number of writes performed on this volume folder per second during the last measurement period.	Writes/sec	

	Data reads: Indicates the rate at which data was read from this volume folder during the last measurement period.	MB/Sec	
	Data written: Indicates the rate at which data was written to this volume folder during the last measurement period.	MB/Sec	
	Average read size: Indicates the amount of data read from this volume folder per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the volume folders to identify the volume folder that is the slowest in terms of servicing read and write requests (respectively).
	Average write size: Indicates the amount of data written to this volume folder per I/O operation during the last measurement period.	MB/Op	

2.4.3 XIO Initiators Test

The XtremIO Storage Array uses the term "Initiators" to refer to ports which can access a volume. Initiators can be managed by assigning them to an Initiator Group. The Initiators within an Initiator Group share access to one or more of the cluster's volumes. This test auto discovers the initiators of the target storage array and reports the current connection state. In addition, this test helps administrators to figure out the initiator that is busy processing I/O requests along initiators, detect irregularities in the distribution of I/O load across the initiators and thus enables administrators to initiate pre-emptive measures.

Purpose	Auto discovers the initiators of the target storage array and reports the current connection state. In addition, this test helps administrators to figure out the initiator that is busy processing I/O requests along initiators, detect irregularities in the distribution of I/O load across the initiators and thus enables administrators to initiate pre-emptive measures.
Target of the test	An EMC XtremIO Storage array
Agent deploying the test	A remote agent

<table>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD – How often should the test be executed
2. HOST – The IP address of the storage array
3. PORT - The port number at which the storage array listens. The default is NULL.
4. XTREMIO USER and XTREMIO PASSWORD - Provide the credentials of a user who has read only privileges to access the XtremIO storage array in the XTREMIO USER and XTREMIO PASSWORD text boxes.
5. CONFIRM PASSWORD - Confirm the password by retyping it here.
6. SSL -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the SSL flag is set to Yes by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the SSL flag to No.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for each initiator of the target EMC XtremIO being monitored</td></tr>
<tr><td rowspan="3">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Initiator connection state:
Indicates the connection state of this initiator to the XtremIO storage array via at least one target port.</td><td></td><td>The values reported by this measure and their numeric equivalents are available in the table below:<table><tr><th>Measure Value</th><th>Numeric Value</th></tr><tr><td>Connected</td><td>0</td></tr><tr><td>Disconnected</td><td>1</td></tr><tr><td>Unknown</td><td>1</td></tr></table>Note:
This measure reports the Measure Values listed in the table above to indicate the connection state of this initiator. However, in the graph, this measure is indicated using the Numeric Values listed in the above table.</td></tr>
<tr><td>Bandwidth:
Indicates the amount of data utilized for performing I/O operations per second through this initiator.</td><td>MB/Sec</td><td></td></tr>
<tr><td></td><td>Read bandwidth:
Indicates the amount of data utilized for performing read I/O operations per second through this initiator.</td><td>MB/Sec</td><td></td></tr>
</table>

	Write bandwidth: Indicates the amount of data utilized for performing write I/O operations per second through this initiator.	MB/Sec	
	IOPS: Indicates the rate at which I/O operations were performed through this initiator during the last measurement period.	IOPS	Compare the value of this measure across the initiators to know which initiator handled the maximum number of I/O operations and which handled the least. If the gap between the two is very high, then it indicates serious irregularities in I/O operations across the initiators.
	Read IOPS: Indicates the number of read operations performed through this initiator per second.	IOPS	
	Write IOPS: Indicates the number of the write operations performed through this initiator per second.	IOPS	
	Read latency: Indicates the time taken to perform read operations through this initiator.	msec	A low value is desired for this measure. A high value indicates that the read and write operations take too long to execute which directly affects the performance of the XtremIO Storage Array.
	Write latency: Indicates the time taken to perform write operations through this initiator.	msec	
	Average latency: Indicates the average time taken to perform I/O operations through this initiator.	msec	
	Reads: Indicates the rate at which the read operations were performed through this initiator during the last measurement period.	Reads/sec	Compare the value of this measure across initiators to know which initiator handled the maximum number of read requests and which handled the least.

	Writes: Indicates the rate at which the write operations were performed through this initiator during the last measurement period.	Writes/sec	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck. By comparing the value of this measure across the initiators, you can quickly identify the initiator which is the slowest in processing write requests.
	Data reads: Indicates the rate at which data was read through this initiator during the last measurement period.	MB/Sec	Compare the values of these measures across the initiators to identify the slowest initiator in terms of servicing read and write requests (respectively).
	Data written: Indicates the rate at which data was written through this initiator during the last measurement period.	MB/Sec	
	Average read size: Indicates the amount of data read through this initiator per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the initiators to identify the slowest initiator in terms of servicing read and write requests (respectively).
	Average write size: Indicates the amount of data written through this initiator per I/O operation during the last measurement period.	MB/Op	

2.4.4 XIO Initiator Groups Test

Initiators can be managed by assigning them to an Initiator Group. If too many initiators are available in an EMC XtremIO cluster, then individual monitoring of each initiator becomes difficult for the administrators. To avoid such inconvenience but at the same time monitor the I/O processing of the initiators without any lag, administrators can use the **XIO Initiator Groups** test. This test auto discovers the initiator groups of the target storage array and helps administrators to figure out the initiator group that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the initiator groups and thus enables administrators to initiate pre-emptive measures.

Purpose	Auto discovers the initiator groups of the target storage array and helps administrators to figure out the initiator group that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the initiator groups and thus enables administrators to initiate pre-emptive measures
Target of the test	An EMC XtremIO Storage array
Agent deploying the test	A remote agent

Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each initiator group of the target EMC XtremIO being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Bandwidth: Indicates the total amount of data utilized for performing I/O operations per second on this initiator group.	MB/Sec	
	Read bandwidth Indicates the amount of data utilized for performing read I/O operations per second on this initiator group.	MB/Sec	High values for these measures indicate high bandwidth usage by this initiator group folder. By comparing the values of these measures across the initiator group, you can isolate those initiator group that consume bandwidth excessively, and also understand which operation consumed too much of bandwidth – is it reading? or writing?
	Write bandwidth: Indicates the amount of data utilized for performing write I/O operations per second on this initiator group.	MB/Sec	
	IOPS: Indicates the rate at which I/O operations were performed on this initiator group.	IOPS	Compare the value of this measure across the initiator group to know which initiator group is handling the maximum number of I/O operations.

	Read IOPS: Indicates the rate at which read operations were performed on this initiator group.	IOPS	
	Write IOPS: Indicates the rate at which write operations were performed on this initiator group.	IOPS	A high value is desired for this measure. A low value for this measure may indicate a poor throughput thus resulting in a decrease in the free space of the initiator group and the overall performance.
	Reads: Indicates the number of read operations performed on this initiator group per second during the last measurement period.	Reads/Sec	Compare the value of this measure across initiator groups to know which initiator group is handling the maximum number of read requests.
	Writes: Indicates the number of write operations performed on this initiator group per second during the last measurement period.	Writes/Sec	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck. By comparing the value of this measure across the initiator group folders, you can quickly identify the initiator group folder which is the slowest in processing write requests.
	Data reads: Indicates the rate at which data was read from this initiator group during the last measurement period.	MB/Sec	Compare the values of these measures across the initiator groups to identify the slowest initiator group in terms of servicing read and write requests (respectively).
	Data written: Indicates the rate at which data was written to this initiator group during the last measurement period.	MB/Sec	
	Average read size: Indicates the amount of data read from this initiator group per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the initiator groups to identify the slowest initiator group in terms of servicing read and write requests (respectively).
	Average write size: Indicates the amount of data written to this initiator group per I/O operation during the last measurement period.	MB/Op	

2.4.5 XIO Initiator Group Folders Test

An initiator group folder comprises of multiple initiator groups. This test auto-discovers the initiator group folders of the target storage array and helps administrators to figure out the initiator group folder that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the initiator group folders and thus enables administrators to initiate pre-emptive measures.

Purpose	Auto-discovers the initiator group folders of the target storage array and helps administrators to figure out the initiator group folder that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the initiator group folders and thus enables administrators to initiate pre-emptive measures.		
Target of the test	An EMC XtremIO Storage array		
Agent deploying the test	A remote agent		
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each initiator group folder of the EMC XtremeIO being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Number of sub folders: Indicates the number for sub-folders that were created from this initiator group folder.	Number	
	Bandwidth: Indicates the amount of data utilized for performing I/O operations per second on this initiator group folder.	MB/Sec	

	Read bandwidth Indicates the amount of data utilized for performing read I/O operations per second on this initiator group folder.	MB/Sec	High values for these measures indicate high bandwidth usage by this initiator group folder. By comparing the values of these measures across the initiator group folders, you can isolate those initiator group folders that consume bandwidth excessively, and also understand which operation consumed too much of bandwidth – is it reading? or writing?
	Write bandwidth: Indicates the amount of data utilized for performing write I/O operations per second on this initiator group folder.	MB/Sec	
	IOPS: Indicates the rate at which I/O operations were performed on this initiator group folder.	IOPS	Compare the value of this measure across the initiator group folders to know which initiator group folder id handling the maximum number of I/O operations.
	Read IOPS: Indicates the rate at which read operations were performed on this initiator group folder.	IOPS	
	Write IOPS: Indicates the rate at which write operations were performed on this initiator group folder.	IOPS	A high value is desired for this measure. A low value for this measure may indicate a poor throughput thus resulting in a decrease in the free space of the initiator group folder and the overall performance.
	Reads: Indicates the number of read operations performed on this initiator group folder per second during the last measurement period.	Reads/Sec	Compare the value of this measure across initiator group folders to know which initiator group folder is handling the maximum number of read requests.
	Writes: Indicates the number of write operations performed on this initiator group folder per second during the last measurement period.	Writes/Sec	Ideally, the value of this measure should be high. A steady dip in this measure value could indicate a potential writing bottleneck. By comparing the value of this measure across the initiator group folders, you can quickly identify the initiator group folder which is the slowest in processing write requests.

	Data reads: Indicates the rate at which data was read from this initiator group folder during the last measurement period.	MB/Sec	Compare the values of these measures across the initiator group folders to identify the slowest initiator group folder in terms of servicing read and write requests (respectively).
	Data written: Indicates the rate at which data was written to this initiator group folder during the last measurement period.	MB/Sec	
	Average read size: Indicates the amount of data read from this initiator group folder per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the initiator group folders to identify the slowest initiator group folder in terms of servicing read and write requests (respectively).
	Average write size: Indicates the amount of data written to this initiator group folder per I/O operation during the last measurement period.	MB/Op	

2.4.6 XIO Snapshots Test

Snapshots are instantaneous copy images of volume data with the state of the data captured exactly as it appeared at the specific point in time that the snapshot was created, enabling users to save the volume data state and then access the specific volume data whenever needed, including after the source volume has changed.

Creating snapshots, which can be done at any time, does not affect system performance, and a snapshot can be taken either directly from a source volume or from other snapshots within a source volume's group (Volume Snapshot Group).

The original copy of the data remains available without interruption, while the snapshot can be used to perform other functions on the data. Changes made to the snapshot's source do not change or impact on the snapshot data.

XtremIO snapshots are read-write. Users can choose to mount the snapshot in read-only (host side or from the host) in order to maintain its immutability.

XtremIO's snapshot technology is implemented by leveraging the content-aware capabilities of the system (Inline Data Reduction), optimized for SSD media, with a unique metadata tree structure that directs I/O to the right timestamp of the data. This allows efficient snapshotting that can sustain high performance, while maximizing the media endurance, both in terms of the ability to create multiple snapshots and the amount of I/O that a snapshot can support. To analyze the performance of snapshots, administrators can use the **XIO Snapshots** test.

This test auto-discovers the snapshots of the target storage array and helps administrators to figure out the snapshot that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the snapshots. In addition, using this test, administrators can analyze the space utilization of each snapshot and thus figure out remedial measures to keep a check on the irregularities detected.

Purpose	Auto-discovers the snapshots of the target storage array and helps administrators to figure out

	the snapshot that is busy processing I/O requests, detect irregularities in the distribution of I/O load across the snapshots. In addition, using this test, administrators can analyze the space utilization of each snapshot and thus figure out remedial measures to keep a check on the irregularities detected		
Target of the test	An EMC XtremIO Storage array		
Agent deploying the test	A remote agent		
Configurable parameters for the test	1. **TEST PERIOD** – How often should the test be executed 2. **HOST** – The IP address of the storage array 3. **PORT** - The port number at which the storage array listens. The default is NULL. 4. **XTREMIO USER** and **XTREMIO PASSWORD** - Provide the credentials of a user who has *read only* privileges to access the XtremIO storage array in the **XTREMIO USER** and **XTREMIO PASSWORD** text boxes. 5. **CONFIRM PASSWORD** - Confirm the password by retyping it here. 6. **SSL** -. The eG agent collects performance metrics by invoking Restful APIs on the target Storage array. Typically, the Restful APIs can be invoked through the HTTP or the HTTPS mode. By default, the eG agent invokes the Restful APIs using the HTTPS mode. This is why, the **SSL** flag is set to **Yes** by default. If the target storage array is not SSL-enabled, then the Restful APIs can be accessed through the HTTP mode only. In this case, set the **SSL** flag to **No**.		
Outputs of the test	One set of results for each snapshot available in the target EMC XtremIO being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Bandwidth: Indicates the amount of data utilized for performing I/O operations per second on this snapshot.	MB/Sec	
	Read bandwidth: Indicates the amount of data utilized for performing read I/O operations per second on this snapshot.	MB/Sec	
	Write bandwidth: Indicates the amount of data utilized for performing write I/O operations per second on this snapshot.	MB/Sec	

	IOPS: Indicates the rate at which I/O operations were performed on this snapshot during the last measurement period.	IOPS	Compare the value of this measure across the snapshots to know which snapshot handles the maximum number of I/O operations
	Read IOPS: Indicates the rate at which read operations were performed on this snapshot.	IOPS	
	Write IOPS: Indicates the rate at which write operations were performed on this snapshot.	IOPS	
	Reads: Indicates the number of reads performed on this snapshot per second during the last measurement period.	Reads/sec	Compare the value of this measure across the snapshots to know which snapshot handles the maximum number of read requests.
	Writes: Indicates the number of writes performed on this snapshot per second during the last measurement period.	Writes/sec	
	Data reads: Indicates the rate at which data was read from this snapshot during the last measurement period.	MB/Sec	
	Data written: Indicates the rate at which data was written to this snapshot during the last measurement period.	MB/Sec	
	Average read size: Indicates the amount of data read from this snapshot per I/O operation during the last measurement period.	MB/Op	Compare the values of these measures across the snapshots to identify the snapshot that is the slowest in terms of servicing read and write requests (respectively).

	Average write size: Indicates the amount of data written to this snapshot per I/O operation during the last measurement period.	MB/Op	
	Read latency: Indicates the time taken to perform read operations on this snapshot.	msecs	
	Write latency: Indicates the time taken to perform write operations on this snapshot.	msecs	
	Average latency: Indicates the average time taken to perform I/O operations on this snapshot.	msecs	
	Number of destination snaps: Indicates the number of volumes that were generated from this snapshot.	Number	By default, volumes are snapshotted at equal intervals and these snapshots are distributed to various clients whereas the original volume is maintained as the source copy. If the value of this measure is high, then administrators may be required to correlate this value with that of the *Bandwidth* measure. The higher the value of this measure, the greater is the bandwidth utilized. Therefore, for the bandwidth to be maintained in an optimal range, the value of this measure should be maintained within the permissible limits. If too many snapshots are created within a short period of time, then the optimization of the storage array may fail leading to severe processing bottlenecks.
	Free snap size: Indicates the amount of space allocated for this snapshot.	GB	
	Used snap size: Indicates the amount of space utilized by this snapshot.	GB	
	Free snap size Percent: Indicates the percentage of space allocated for this snapshot.	Percent	

	Used snap size Percent: Indicates the percentage of space utilized by this snapshot.	Percent	A value close to 100 indicates that the snapshot is running out of space.

3

Conclusion

This document has clearly explained how eG Enterprise monitors the **EMC XtremIO**. We can thus conclude that eG Enterprise, with its ability to provide in-depth insight into the performance of SAN storage infrastructures, is the ideal solution for monitoring such environments. For more information on eG Enterprise, please visit our web site at www.eginnovations.com or write to us at sales@eginnovations.com.