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# IOmark-VDI

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NIMBUS DATA

BROCADE 

**Nimbus Data**

**Gemini**

Test Report: VDI- 130906-c

Test Report Date: 26, September 2013

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## Executive Summary

IOmark is a storage specific workload and benchmark designed to test storage systems performance using a variety of real world, application centric workloads. The IOmark-VDI benchmark is a specific workload that measures Virtual Desktop Infrastructure (VDI) workloads against storage systems. Results are published after audit and certified approval by IOmark authorized auditors.

This document is the official benchmark report for the tested configuration using Brocade's 16 Gb Fibre Channel infrastructure and Nimbus Data's Gemini storage system. The result of the benchmark showed the tested solution supported 4,032 simultaneous virtual desktop instances at a cost of \$39.68 per VDI instance, meeting the read and write response time averages required. (See tables 3, 4 and 7 for performance and pricing information).

The criteria and performance requirements are as follows, with a full description of the benchmark and workloads available in Appendix A:

- For all application workloads:
  - 70% of response times for I/O's must not exceed 30ms
  - All storage must reside on the storage system under test
  - The replay time must complete within 1 hour and 15 seconds for each 1 hour workload

The remainder of this report provides details on the product tested, configuration and results

## Vendor Product Description

### Brocade Gen 5 Fibre Channel

Brocade Gen 5 Fibre Channel is the purpose-built networking solution for flash storage, enabling breakthrough application performance, scalability, and availability. Implementing the right network architecture ensures the improvements from the implementation of flash memory at the storage layer do not drive new bottlenecks within the network layer. Brocade ensures flash storage speed is delivered fast, by doubling transfer rates with its cut-through network architecture. Gen 5 Fibre Channel combines low latency and unmatched IOPS to maximize application performance with flash storage. Extreme performance enables the deployment of more virtual desktops without sacrificing reliability in the virtualized data center.

Brocade's new 5<sup>th</sup> generation Fibre Channel product line includes the 6510 Fibre Channel switch and the 1860 card, which provides both 10 Gb Ethernet as well as 16 Gb Fibre Channel connectivity. The Brocade 1860 HBA's utilized 16 Gb FC SCP+ connectors to provide high-speed and low latency storage connectivity to the Fibre Channel SAN. Each physical host in the configuration utilized two, dual port cards, providing a total of eight ports of 16 Gb Fibre Channel connectivity. The Brocade 6510 is a 48-port, high-performance, enterprise-class switch that meets the demands of highly virtualized storage environments by delivering market-leading Gen 5 Fibre Channel technology.

- Low latency switching eliminates I/O bottlenecks and unleashes the full performance of flash storage.
- Shatters application IOPS performance barriers with 420 million frames per second speed
- Unprecedented performance for bandwidth-intensive applications across 16 Gbps links

- Delivers six nines availability for non-stop operations
- Innovative diagnostic, monitoring, and management capabilities delivers availability and serviceability.
- Massive scalability to support consolidation, while reducing complexity and costs.

High-speed connectivity and flash storage also requires a networking infrastructure that is highly resilient, scales easily, and is simple to manage. Brocade Gen 5 Fibre Channel addresses these requirements through breakthrough innovations, including Fabric Vision technology.

### Nimbus Data Gemini

Server and desktop virtualization, databases, big data analytics, cloud computing, and next-generation technical applications demand high-performance, ultra-efficient storage systems. Unlike hybrid or tiered systems, Nimbus Data's Gemini all-flash arrays deliver **consistent low-latency, superior reliability, unmatched throughput, and dramatically lower data center costs**. With the patent-pending Parallel Memory Architecture and novel distributed caching design, Gemini arrays outperform commodity server-based storage systems by up to **5x in IOPS, 40x in latency, 6x in bandwidth, and 10x in rack density**.

- 100% flash memory for unrivaled performance
- Industry's best efficiency and lowest operating costs
- High availability with no single-point-of-failure
- FC, iSCSI, NFS, SRP, iSER, RDMA, and SMB protocols
- Patent-pending architecture and flash management
- Ethernet, Fibre Channel and Infiniband connectivity
- Complete data protection and optimization software
- Hot-swap everything with live expansion/upgrade

## IOmark - VDI Result Details

For the tested configuration, the following data is provided

| Item                | Value                                       |
|---------------------|---|
| Testing Identifier: | VDI- 130906-c                               |
| Product:            | Nimbus Data Gemini - & Brocade FC equipment |
| Test Sponsor:       | Nimbus Data, Inc. ; Brocade Inc.            |
| Auditor:            | Evaluator Group Inc.                        |

**Table 1: Test Identifier Information**

| Item                      | Value                               |
|---------------------------|-------------------------------------|
| IOmark-VDI Version:       | Version: IOmark-VDI 3.2.10          |
| Revision Date:            | 2 June 2014 (previous ID: 130906-b) |
| Testing Completed:        | August, 2013                        |
| Equipment Availability:   | March, 2013                         |
| Audit Certification Date: | 26, August 2013                     |
| Original Report Date:     | 6, September 2013                   |

**Table 2: Test Revision and Dates**

## IOmark-VDI Results

The tested configuration utilized Brocade's 16 Gb Fibre Channel infrastructure and Nimbus Data's Gemini storage system. The results of the benchmark are detailed below in tables 3 - 7. The tested solution supported 4,032 simultaneous virtual desktop instances at a cost of \$39.68 per VDI instance, meeting the read and write response time averages required. The workload details and characteristics are provided in Appendix A starting on page 13.

Price information provided below is explained in detail in Table 7 later in this report.

A VDI user may be configured to run in one of three modes:

- Fully Provisioned (No clones - Requires at least 10 GB of thinly provisioned capacity / VDI user)
- Linked Clones (Hypervisor based clones - Requires 3.4 GB of capacity / VDI user)
- Storage Clones (Clones on Storage System - Requires at least 3.4 GB of capacity / VDI user)

For each configuration, results are reported and for those not run results are shown as "Not Run."

| VDI Mode          | VDI-IOmark Users | Tested Useable Capacity | Total Price | Price / User |
|-------------------|------------------|-------------------------|-------------|--------------|
| Fully Provisioned | Not Run          | N/A                     | N/A         | N/A          |
| Linked Clones     | 2,016            | 17.6 TB                 | \$160,000   | \$79.37      |
| Storage Clones    | Not Run          | N/A                     | N/A         | N/A          |

**Table 3: VDI-IOmark Workload Summary for Heavy Worker**

Table 4 below shows the number of "Standard Users" supported (as defined on page 5).

| VDI Mode          | VDI-IOmark Users | Tested Useable Capacity | Total Price | Price / User |
|-------------------|------------------|-------------------------|-------------|--------------|
| Fully Provisioned | Not Run          | N/A                     | N/A         | N/A          |
| Linked Clones     | 4,032            | 17.6 TB                 | \$160,000   | \$39.68      |
| Storage Clones    | Not Run          | N/A                     | N/A         | N/A          |

**Table 4: VDI-IOmark Workload Summary for Standard Worker**

Notes on VDI Mode:

- Fully Provisioned = each VDI instance fully provisioned with 21 GB per instance
- Linked Clones = each VDI instance run in linked clone mode with 3.4 GB per VDI instance
- Storage Clones = each VDI instance run with 3.4 GB per VDI instance

## Tested Configuration Details

Connectivity, configuration and pricing information for the system under test are provided.

### Storage Configuration for IOmark-VDI Workload

- Each of 2 controllers configured with exclusive access to 50% of total capacity
- A total of 160 SCSI logical units (LUNs) were created on the Nimbus Data Gemini
- VMFS was the datastore type, with “VMFS 5” chosen
- Storage was presented to physical host via 16 Gb Fibre Channel connectivity
- End-to-end 16 Gb Fibre Channel with Brocade 16 Gb FC HBAs and Brocade 6510 FC Switch
- Each application set was allocated as “thin” provisioned

### Configuration items

Detailed configuration parameters for the system under test, including connectivity are provided below in Table 5.

| Storage System Parameter                          | Value                                  |
|---|--|
| Number of interfaces to the storage system:       | 8 (8 available, 8 utilized)            |
| Connectivity to the storage system:               | 16 Gb FC                               |
| Hypervisor storage protocol used:                 | FCP (SCSI over Fibre Channel Protocol) |
| Hypervisor version:                               | VMware ESXi 5.1                        |
| Thin provisioning:                                | Yes - utilized in VMFS                 |
| Hypervisor Storage Access:                        | VMFS datastore                         |
| Datastore Filesystem:                             | VMFS 5 – 1 MB block size               |
| VAAI:   | VAAI supported                         |
| SATP:   | VMW_SATP_ALUA                          |
| PSP:  | VMW_PSP_MRU                            |
| Total capacity of system allocated to IOmark-VDI: | 17.6 TB                                |

**Table 5: VMware Configuration Parameters**

Detailed configuration parameters for the system under test, including connectivity are provided below in Table 6.

| Storage System Parameter                      | Value  |
|---|--|
| Storage System firmware                       | Halo - Version 8.5   |
| High Availability Access to all LUNs          | No (each controller configured independently)                            |
| Total raw capacity of system under test (SUT) | 24 TB  |
| Thin provisioning:                            | Yes - utilized on Nimbus Data  |
| RAID Level(s)                                 | RAID 5 - 2 groups 11+1 (stripe size of 128 KB)<br>24 Disks @ 1,000GB SSD |
| Total Cache Capacity:                         | 128 GB (64 GB / controller)  |
| Read Cache                                    | Adaptive Read Ahead  |
| Write Cache:                                  | Write through  |
| VAAI Features Enabled:                        | Yes  |
| - Block Zero                                  | Yes  |
| - Full Copy                                   | Yes  |
| - HW Locking                                  | Yes  |
| - NAS Clone                                   | N/A  |
| - NAS Reserve                                 | N/A  |
| Automated tiering within the storage system:  | No   |
| Deduplication or compression of data:         | No (Available feature, not utilized)                                     |
| Storage system clones / writeable snapshots:  | Not utilized   |
| Type of storage system clone:                 | N/A  |
| Storage Media Utilized:                       | -  |
| - SSD's – 1,000GB                             | 24   |
| - 15K RPM                                     | 0  |
| - 10K RPM                                     | 0  |
| - 7.2K RPM                                    | 0  |

**Table 6: Storage System Configuration Parameters**



## Configuration Diagram

The logical data layout of the test configuration is shown below in Figure 2.

The system was configured to use two controllers in non HA mode. Each controller managed a pool of 8.8 TB of RAID 5, based on 12 SSD's for each pool. Failover was not possible in this configuration.

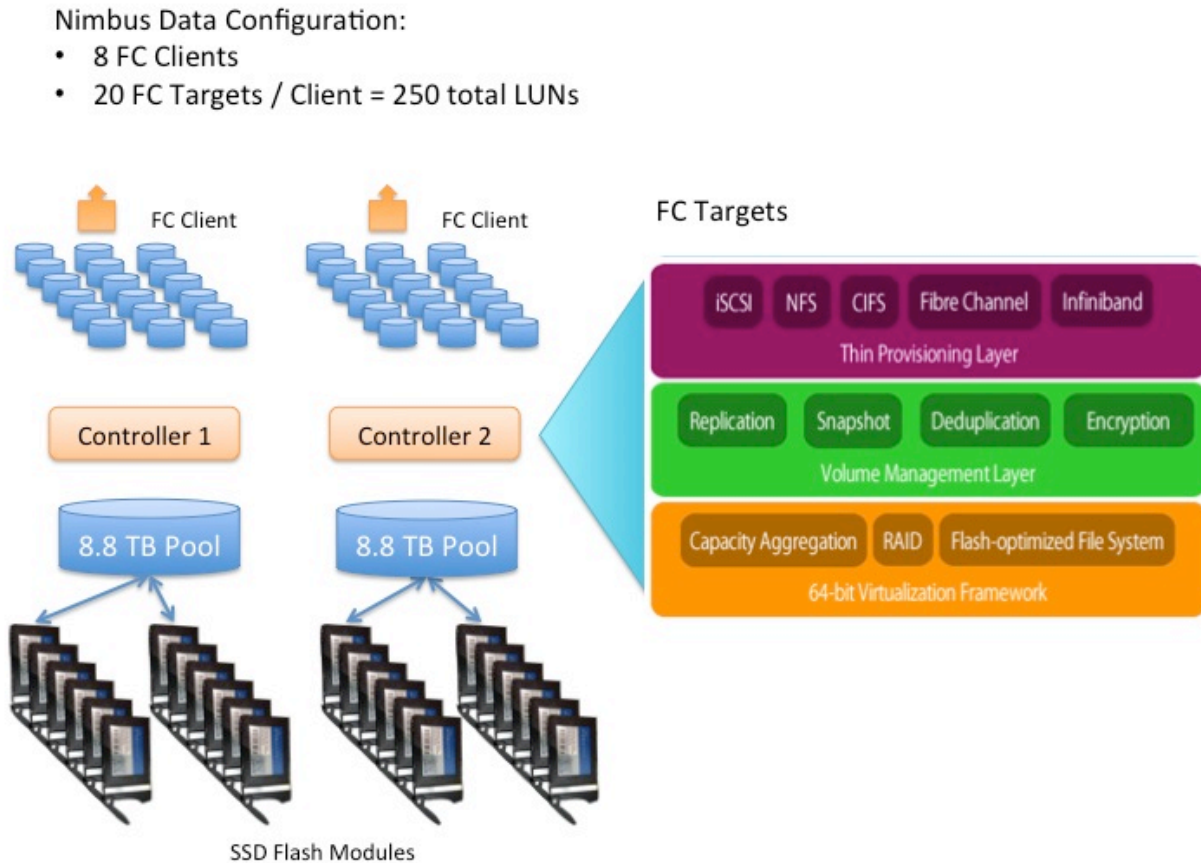
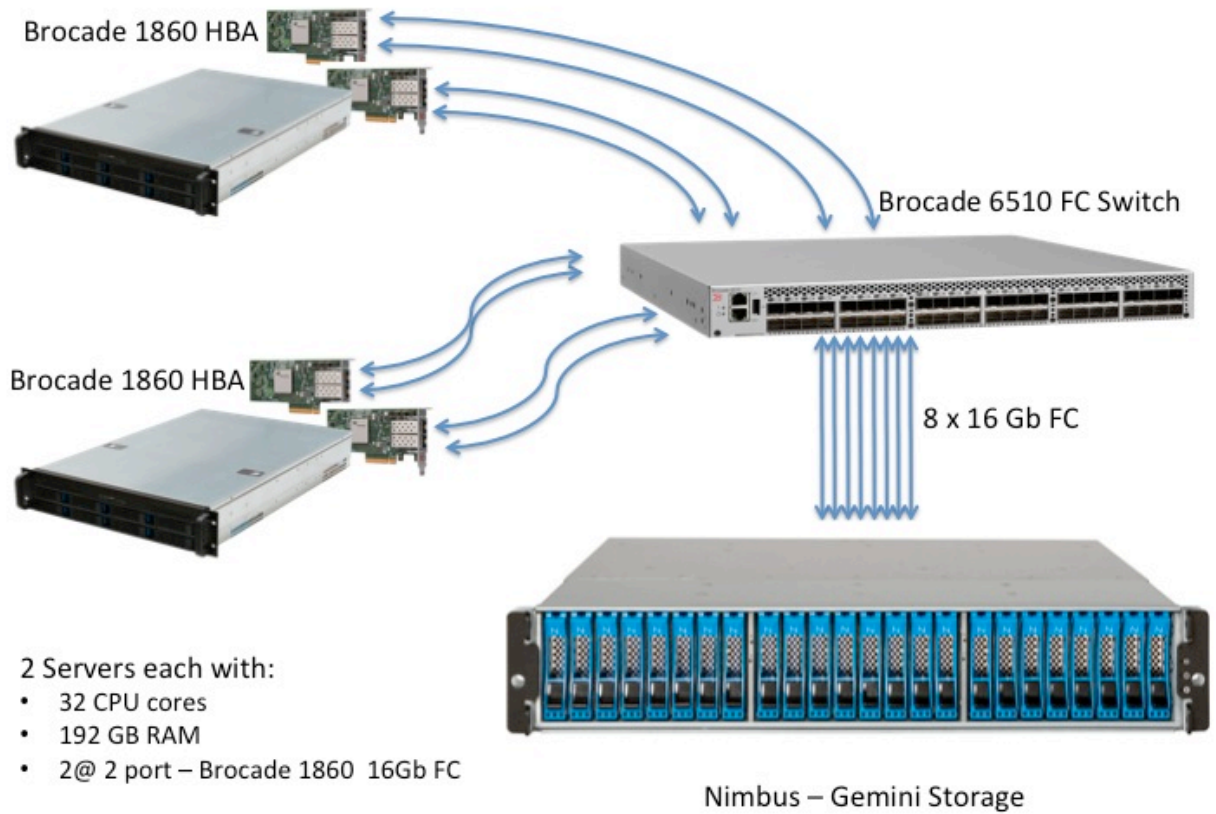


Figure 2: Logical System Configuration

## Connectivity

The host to storage connectivity used during testing was Fibre Channel, utilizing 4, 16 Gb Fibre Channel connections between the switch and each controller, and a total of 8 ports @ 16 Gb Fibre Channel between the hosts and the switch. A diagram is shown below in Figure 3.



**Figure 3: Physical System Connectivity**

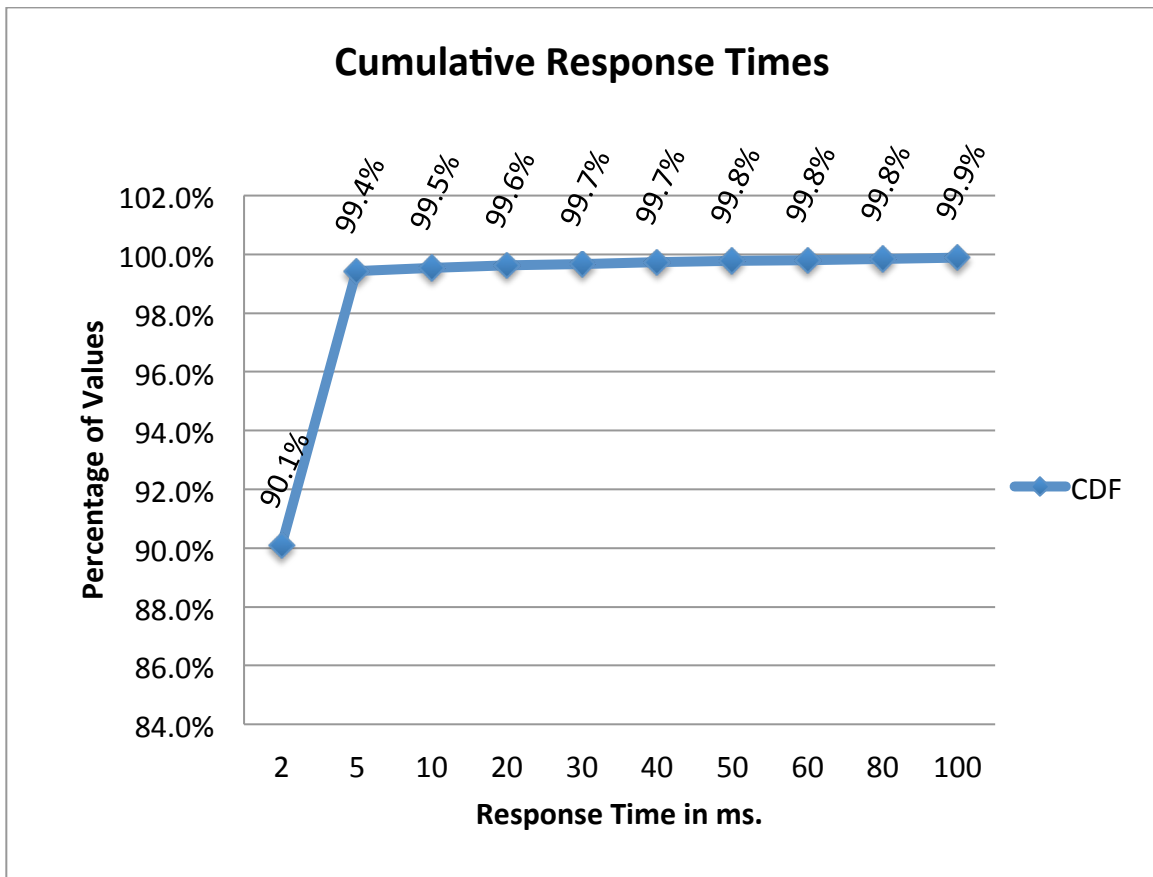
### Tested Configuration Pricing

| Item  | Description                                    | Qty | Price        |
|-------|--|-----|--------------|
| 1     | Nimbus Data Gemini Base System w/ dual cntrlr. | 1   | \$40,000.00  |
| 2     | Nimbus 1 TB SSD                                | 24  | \$120,000    |
| 3     | Feature Licenses                               | 1   | N/A (incl.)  |
|       |  |     |              |
| Total | List Price                                     |     | \$160,000.00 |

**Table 7: IOmark-VDI Price Information**

## Detailed Results

IOmark-VDI performance results are measured against all VDI system workloads. The average storage response times for all VDI applications are shown below in Figure 4, plotted as a Cumulative Distribution Function (CDF) for results. The CDF is a measure of statistical probability, and indicates the probability that a response time is less than a specific value.



**Figure 4: Response Time Results**

As shown above in Figure 4, results exceeded the requirements (indicating response times were lower than required). (lower times are better) The response times of interest are:

- 99.7 % of response times were less than 30ms
- 99.4 % of values were less than 5ms
- 90.1% of response times were less than 2ms

# Appendix A - IOmark-VDI Overview

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The ability to recreate a known workload is important for comparing a system against potential alternatives. Establishing a reference or benchmark workload enables system vendors as well as resellers and IT users to compare several systems utilizing a known workload.

Specifically, the IOmark-VDI benchmark recreates a storage workload that typically occurs in virtual desktop infrastructure environments. The workload is non-synthetic and recreates several applications that are commonly found in virtualized server environments.

## Why the Need for IOmark-VDI

Currently, several application generators have been developed that are able to generate VDI workloads. However, there is no standard reference configuration, with the primary focus is on the server infrastructure. There are no existing benchmark workloads focusing on storage and storage system performance while running VDI applications.

By establishing a set of standard applications and capturing their I/O streams, it is possible to recreate application based storage workloads for these complex environments. IOmark-VDI is designed utilizing these concepts, and as such is the first benchmark designed to accurately generate application workloads for storage systems, enabling direct comparison of storage system configurations and their ability to support a specific number of applications.

## How IOmark-VDI Operates

IOmark-VDI uses the concept of workload replay. I/O streams are captured from actual running applications and then “replayed” so that the exact sequence and I/O commands are issued. This allows the creation of a workload that is indistinguishable from an actual workload to the system under test, while being reproducible and requiring fewer resources. Additionally, the test environment is less expensive, easier and faster to create since actual applications are not required. Because CPU and memory are not consumed running applications, a much higher I/O workload may be generated with a set of server resources than is possible using native applications. This ratio is typically 10: 1, but may vary.

In order to scale up the workload on a storage system, additional VDI workloads may be added to the same, or to other physical hosts. The only limitations to the scale of the test are the physical infrastructure supporting the workload. Sufficient, CPU, memory and I/O capabilities must be available to run additional workload sets.

Unlike artificial workload generation tools, IOmark-VDI recreates accurate read vs. write and random vs. sequential I/O requests. Another benefit of IOmark-VDI is the fact that it creates accurate access patterns, thus enabling storage cache algorithms to work properly.

Finally, IOmark-VDI maintains an accurate ratio of performance to capacity as workloads are scaled, ensuring that storage performance is measured with respect to storage capacity accurately. As a result, IOmark-VDI maintains an accurate ratio of I/O to capacity, producing results applicable to IT users.

## Benchmark Application Workload Set

### VDI Workload

1. View steady state operation
  - a. Knowledge Worker Profile – Average / VDI User
    - i. 12.52 IOPS / User
    - ii. 1.06 MBps / User
  - b. Standard Worker Profile – Average / VDI User
    - i. 6.26 IOPS / User
    - ii. 0.53 MBps / User
2. Benchmark Criteria:
  - 70% of I/O response times must not exceed 30ms
  - All storage utilized must reside on/within the storage system under test

### VDI Benchmark Parameters

- Operating System disk size is 20 GB (thinly provisioned)
- All user sessions were running Windows 7 as their guest OS
- No user data disk utilized
- VMware Linked clones may be utilized (as noted)
- Storage linked clones may be utilized (as noted)
- Heavy Profile:
  - The workload is non synthetic, actual I/O patterns are issued as captured
  - The size of I/O's is variable, ranging from 512, up to 2 MB transfers
  - The most common I/O size is 4 KB, accounting for approximately 50% of the transfers
- Standard User Profile:
  - The workload is non synthetic, actual I/O patterns are issued as captured
  - Rates are 50% of Knowledge Worker profile
  - The size of I/O's is variable, ranging from 512, up to 2 MB transfers
  - The most common I/O size is 4 KB, accounting for approximately 50% of the transfers

### VDI Workload Generation

The workload generator used to generate the VDI workload was VMware View Planner. This application workload generator controlled running the 8 listed applications above, in a Windows 7 64 bit OS environment, running as a guest vm in a hypervisor environment.

## VDI Workload Details

The specific applications comprising a VDI workload set are detailed below in Table 7.

| Application                                     | Storage Capacity / Instance |
|---|-----------------------------|
| Guest OS (Microsoft Win 7 64bit)                | 21 GB                       |
| MS Office (Word, Excel, PowerPoint and Outlook) | N/A                         |
| MS Internet Explorer                            | N/A                         |
| Adobe Acrobat Reader                            | N/A                         |
| Windows Media Server                            | N/A                         |
| Windows 7 zip                                   | N/A                         |
| <b>Total VDI Guest Environment</b>              | <b>Total = 21 GB</b>        |

**Table 8: IOmark-VDI Guest Application Overview**

The total capacity required for each set of applications is approximately 20 GB of capacity. Each additional workload set requires an additional 20 GB of capacity.

## Understanding Results

IOmark-VDI produces results indicating the response time of a storage system given a particular workload. Based on established criteria, these results indicate how many VDI sessions are supported by a specific storage configuration with a maximum allowed response time. The report is audited for accuracy and issued by Evaluator Group, Inc., an independent storage analyst firm.

## Benchmark Criteria

IOmark has established the benchmark criteria for the IOmark-VDI workload. The performance requirements are established as follows:

- For all application workloads:
  - Workloads are scaled in sets of 8 workloads
  - 70% of response times for I/O's must not exceed 30ms
  - All storage must reside on the storage system under test
  - The replay time must complete within 1 hour and 15 seconds for each 1 hour workload

### More Information about IOmark-VDI

For more information about the IOmark benchmark, a theory of operations guide, published results and more, visit the official website at <http://www.iomark.org> . Some content is restricted to registered users, so please register on the site to obtain all available information and the latest results.

### About Evaluator Group

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