IOmark-VDI

IBM

IBM FlashSystem V9000

Test Report: VDI-151205-a

Test Report Date: 5, December 2015

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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.

IOmark-VDI is a benchmark that certifies storage systems for VDI results. The measurement criteria are storage performance, with the restriction that all storage workloads must be supported by the tested system. Although there are CPU and memory considerations, these aspects are not tested by IOmark-VDI workload.

This document is the official benchmark report for the tested configuration using IBM V9000 FlashSystem appliance. The result of the benchmark showed the tested solution supported 4,096 simultaneous, virtual desktop instances at a cost of $183.59 per VDI instance, meeting the storage response time requirements. The system also supported 3,072 VDI fully provisioned instances while meeting the storage performance requirements.

A full description of the configuration tested along with pricing information are provided in the following document, with application workload details in Appendix A.

The criteria and performance requirements are as follows:

- For all application workloads:
    - All workloads must reside entirely on the tested system
    - 70% of response times for I/O's must not exceed 30ms
    - The replay time must complete within 1 hour and 5 minutes for each 1 hour workload

Vendor Product Description

IBM FlashSystem V9000

IBM FlashSystem® V9000 is a comprehensive all-flash enterprise storage solution. FlashSystem V9000 delivers the full capabilities of IBM FlashCore™ technology plus a rich set of storage virtualization features. FlashSystem V9000 delivers industry-leading value to enterprises along three dimensions: Performance, Economics, and Integration. The V9000 FlashSystem is production-ready within 15 minutes and can be used for any virtualization project where simplicity is key. The IBM V9000 FlashSystem features the following:

- Three dimensions of value: Scalable Performance, Enduring Economics, Agile Integration
- Accelerate time to value with agile, easy-to-implement, fully-integrated systems
- Data protection with a full suite of DR tools including snapshots, clones and replication
- Provides advanced virtualization, provisioning and performance management with IBM Virtual Storage Center

IOmark-VDI Test Summary

For the tested configuration, the following data is provided

Item	Value
Testing Identifier:	VDI-151205-a
Product:	IBM FlashSystem V9000
Test Sponsor:	IBM Corporation
Auditor:	Evaluator Group Inc.

Table 1: Test Identifier Information

Item	Value
IOmark-VDI Version:	IOmark-VDI 3.8
Testing Completed:	November 2015
Equipment Availability:	December 2014
Audit Certification Date:	1, December 2015
Report Date:	5, December 2015

Table 2: Test Revision and Dates

IOmark-VDI Results

Shown below are the IOmark-VDI results for the system under test. The definition and workload characteristics of the benchmark are provided in Appendix A.

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

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

- Fully Provisioned (No clones - Requires at least 14 GB of thinly provisioned capacity / VDI user before compression)
- Linked Clones (Hypervisor based clones - Requires 4 GB of thin capacity / VDI user)

For each configuration run, the results are reported. Tables 3 and 4 below show the number of users supported (as defined in Appendix A).

VDI Mode	IOmark-VDI Standard Worker	Tested Logical Capacity	Total Price	Price / User
Linked Clone	4,096	18.25 TB	$752,000.00	$183.59
Fully Provisioned	2,816	26.0 TB	$752,000.00	$267.05

Table 3: IOmark-VDI Summary for Standard Worker

The Standard Worker" workload is measured during a steady-state period during the VDI workload. The measurement period discards the startup and end portions of the workload and measures a 30-minute window during the middle of a 60-minute workload. The response time summary is shown below in Table 4, with further details shown in Figures 3 and 4.

VDI Mode	Test RAID Level	Average Read Resp. Time	Average Write Resp. Time	Average Response Time / VDI User
Linked Clone	RAID 5	2.11 ms	1.59 ms	1.82 ms
Fully Provisioned	RAID 5	1.97 ms	2.75 ms	2.34 ms

Table 4: IOmark-VDI Workload Results for Standard Worker

As shown above in Table 4, the 4,096 Linked Clone users had an average response time of 1.82 ms, and the 2,816 Fully Provisioned users had an average response time of 2.34 ms. both of which were lower (better) than the required response time.

Tested Configuration Details

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

Hypervisor Configuration for IOmark-VDI Workload

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

Storage System Parameter	Value
Hypervisor	VMware ESXi vSphere
Number of interfaces to the storage system:	4 @ 16 Gb FC / Controller (8 total)
Host Connectivity to the storage system:	4 @ 16Gb FC
Hypervisor storage protocol used:	FCP (SCSI over FC)
Hypervisor version:	VMware ESXi 5.5 U2
Thin provisioning:	Not utilized in VMFS
Hypervisor Storage Access:	VMFS datastore
Datastore Filesystem:	VMFS 5.6 – 1 MB block size
VAAI:	VAAI supported
SATP:	VMW_SATP_ALUA
PSP:	VMW_PSP_RR (Round Robin)
Total capacity of system allocated to IOmark-VDI:	26.0 TB (Actual used w/ thin provisioning)

Table 5: Hypervisor Configuration Parameters

Storage Configuration for IOmark-VDI Workload

- A total of 64 SCSI logical units (LUNs) were utilized on the IBM FlashSystem V9000
- VMFS datastore type, with "VMFS 5" chosen
- Each virtual machine was allocated using "thin provisioning" as VMware datastore type

Storage System Parameter	Value
Storage System firmware	IBM V9000 firmware version 7.5.1
High Availability Access to all LUNs	Yes (active / active)
Total <u>raw</u> capacity of system under test (SUT)	34.8 TB
Total <u>usable</u> capacity of system under test (SUT)	26.0 TB
Thin provisioning:	Yes
RAID Level(s)	V9000 default - RAID 5 (multi-level chip R5)
Total Cache Capacity:	128 GB (dual V9000 controllers R/W cache)
Read Cache:	Dynamic Read Ahead
Write Cache:	Dynamic Write Back
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 - All flash storage media
Deduplication or compression of data:	No
Storage system clones / writeable snapshots:	No
Type of storage system clone:	No
Storage Media Utilized:	-
- SSD's	12 x 2.9 TB flash module = 34.8 TB
- 15K RPM	NA
- 10K RPM	NA
- 7.2K RPM	NA

Table 6: Storage System Configuration Parameters

Configuration Diagram

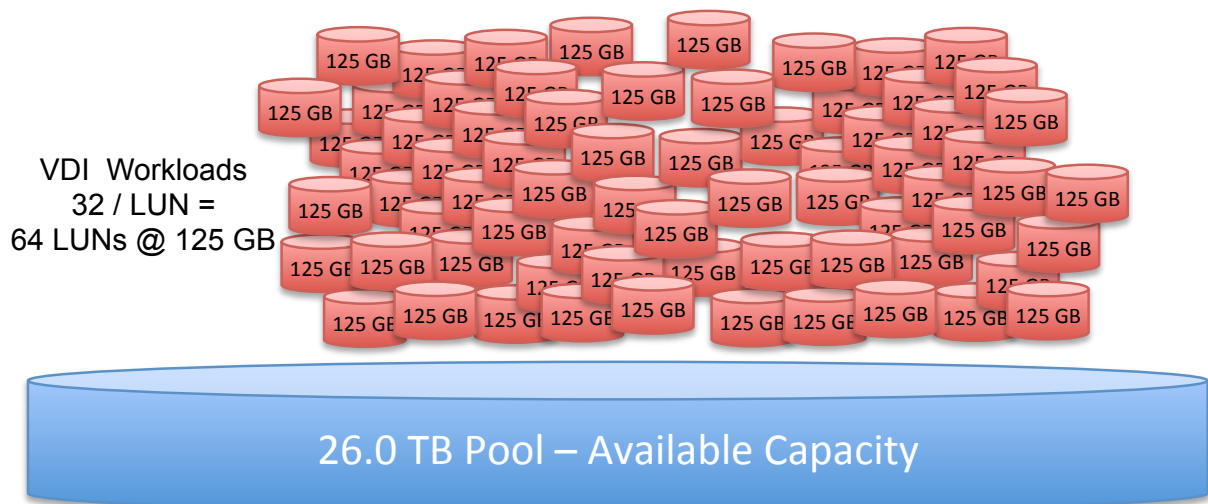The logical data layout of the test configuration is shown below in Figure 1.

Figure 1: Logical System Configuration

Connectivity

The storage connectivity was 16 Gb Fibre Channel. Each V9000 controller utilized 8 connections to the Brocade FC switch, and the V9000 storage module also used 8 FC connections, for a total of 24 @ 16 Gb FC connections for the storage. Not shown was an additional 4 @ 16 GB FC host connections.
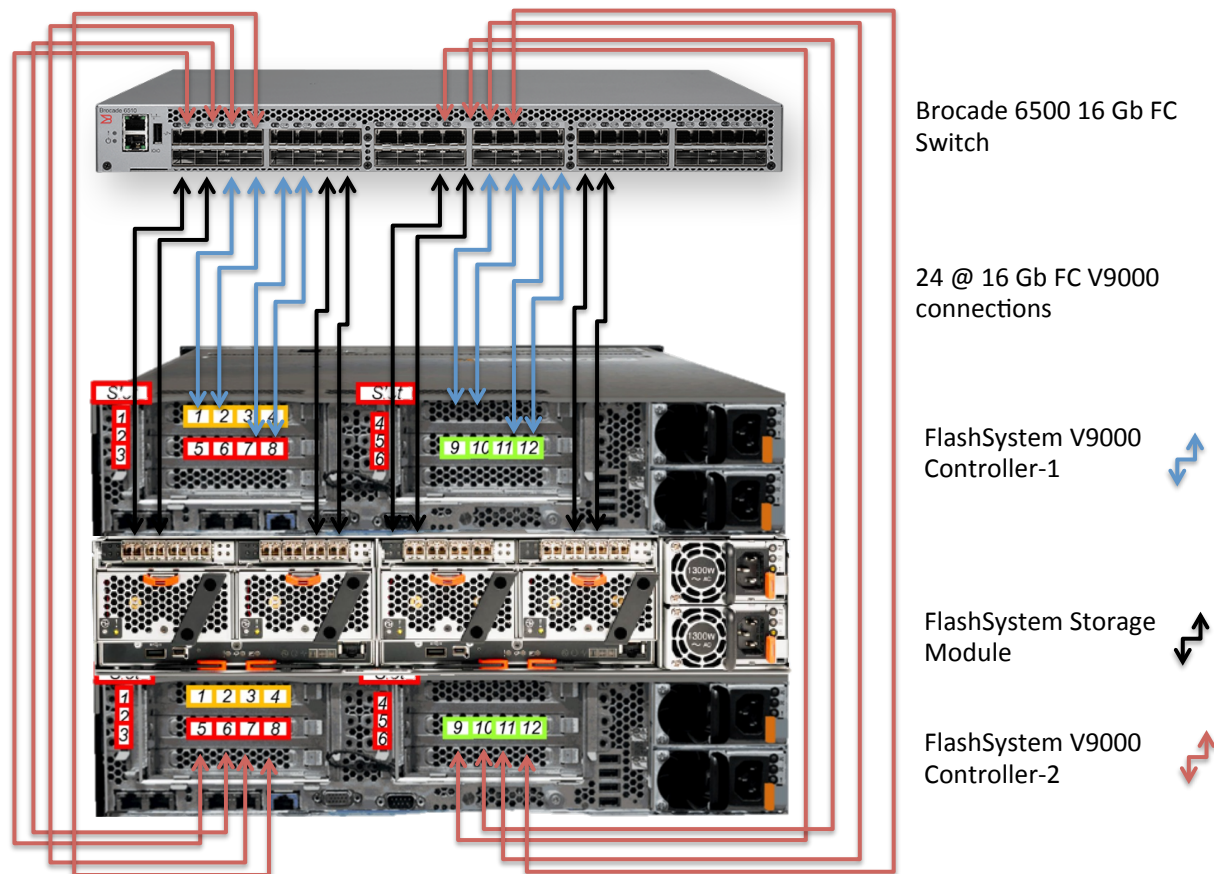
A diagram is shown below in Figure 2.

Brocade 6500 16 Gb FC Switch

24 @ 16 Gb FC V9000 connections

FlashSystem V9000 Controller-1

FlashSystem Storage Module

FlashSystem V9000 Controller-2

Figure 2: Physical System Connectivity

Tested Configuration Pricing

Item	Description	Qty.	List Price
1	IBM V9000, w/ 26 TB usable capacity	1	$752,000
Total	**List Price HW + 3 year service & support**		**$752,000**

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 3, 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.
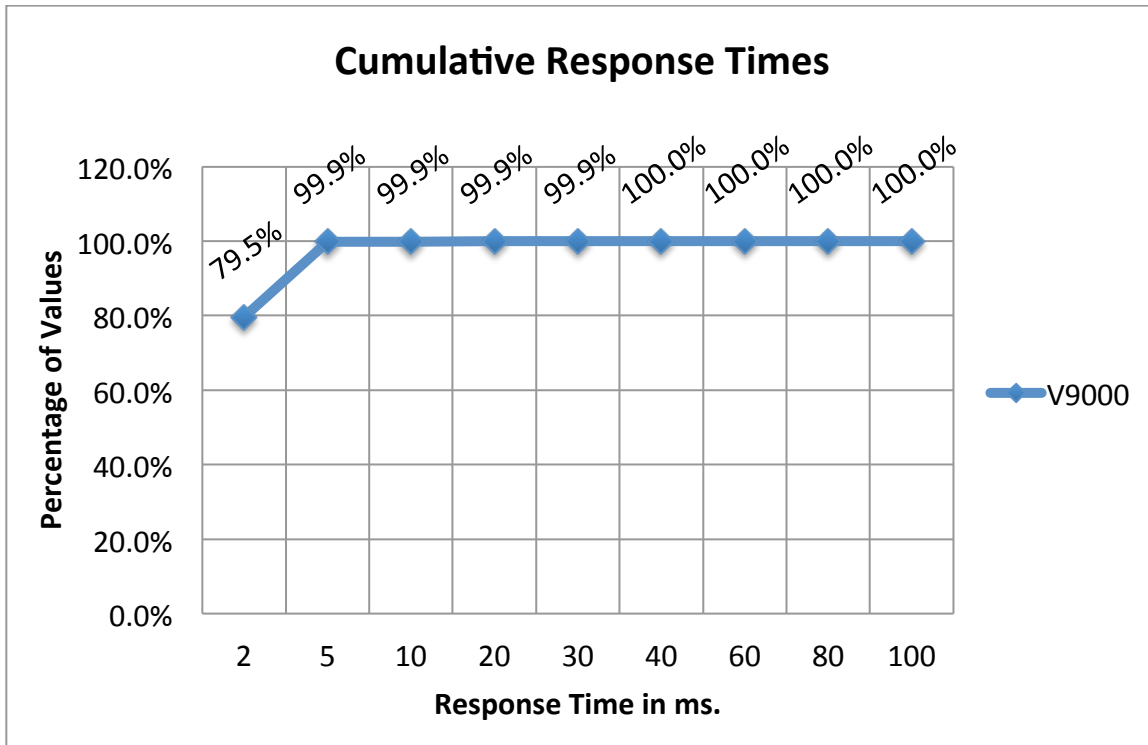
Cumulative Response Times

Figure 3: Response Time Results - V9000 Fully Provisioned

As shown above in Figure 3 for 2,816 fully provisioned standard users, the system performance exceeded the requirements, indicating response times were lower than required (lower times are better). The primary response time of interest is:

- 99.9% of response times were less than 30 ms

Also of interest is the fact that 99.9% of response times were less than 5 ms
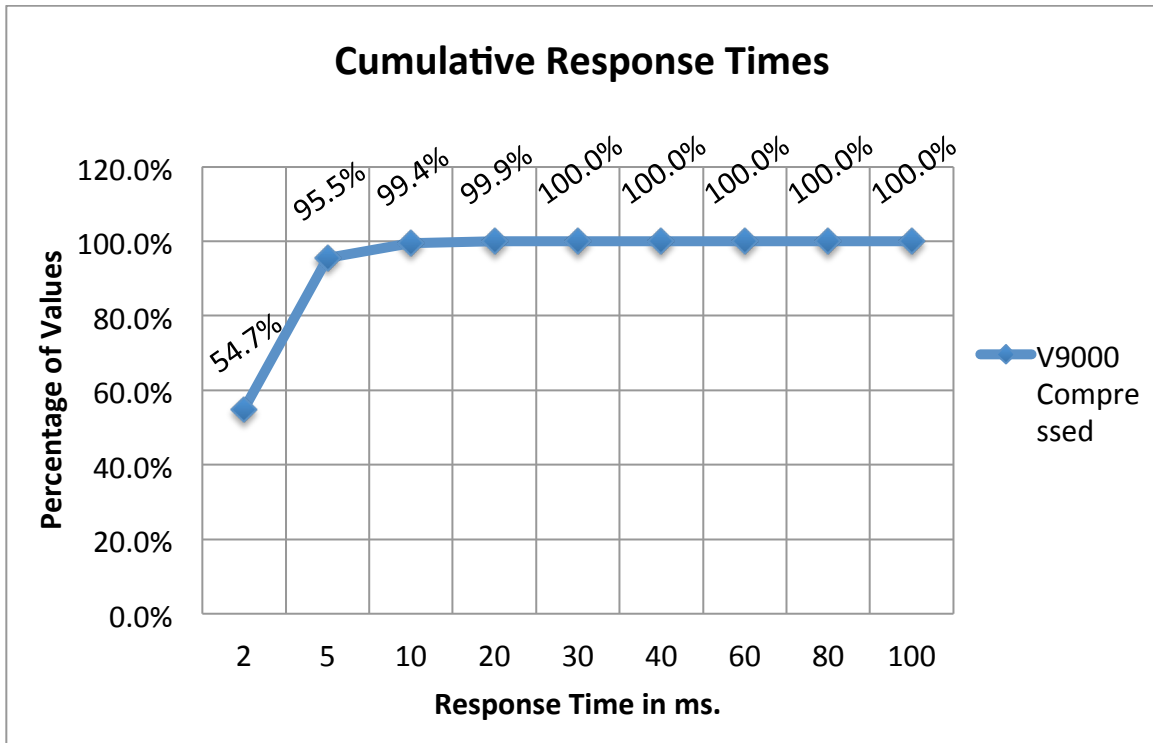
Cumulative Response Times

Figure 4: Response Time Results - V9000 Linked Clone Users

As shown above in Figure 4 for 4,096 linked clone standard users, the system performance exceeded the requirements, indicating response times were lower than required (lower times are better). The primary response time of interest is:

• 99.9% of values were less than 30 ms

Also of interest is the fact that 99.9% of response times were less than 5 ms.

Appendix A - IOmark-VDI Overview

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 limitation to the scale of the test is 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. Heavy 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 based on application capture
  - The size of I/O's is variable, ranging from 512, up to 2 MB transfers based on application
- Standard User Profile:
  - The workload is non synthetic, actual I/O patterns are issued as captured
  - Rates are 50% of "Heavy" user profile
  - The size of I/O's is variable, ranging from 512, up to 2 MB 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)	20 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
Total VDI Guest Environment	Total = 20 GB

Table 8: IOmark-VDI Guest Application Overview

The total capacity required for each set of applications is approximately 20 GB of logical capacity. Each additional workload set requires an additional 20 GB of logical capacity. The capacity required for linked clone users is 4 GB which is the capacity after data reduction, and the capacity required for fully provisioned users is 14 GB without data reduction, or 8 GB with compression.

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:
  - 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.

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