An Ideal Match:
Optimizing Citrix XenDesktop Performance with EMC XtremIO for 3000 Users

A performance test demonstrating the EMC XtremIO storage system successfully supporting a complex Citrix XenDesktop workload designed to simulate a 3,000-user VDI environment at normal load
Many strategies exist for solving the “storage problem” inherent with virtual desktop infrastructure (VDI). These strategies encompass a range of “work around” solutions that revolve around a core approach of addressing the symptoms instead of the underlying deficiencies. Some companies even go to the extreme of intentionally crippling desktops in a desperate attempt to artificially induce a reduction of I/O requests.

The EMC XtremIO all-flash storage array offers a real solution to the VDI storage problem. XtremIO is built upon a revolutionary architecture that enables agile data centers with the following key elements: linear scale-out, inline all-the-time data services, copy data management, ample data center services, and application-level integrations.

This white paper outlines a performance test that demonstrated the EMC XtremIO storage system successfully supporting a complex Citrix XenDesktop workload designed to simulate a 3,000-user VDI environment at normal load. This paper also discusses additional benefits of the EMC XtremIO all-flash storage platform.

Ultimately, the EMC XtremIO storage system is shown to partner perfectly with Citrix XenDesktop in containing costs and maximizing the potential of VDI.

**Business Challenge**
Virtual desktops have grown in popularity in recent years. As more companies have freed their workers from the figurative shackles of traditional desktops, virtual desktop infrastructures (VDI) such as Citrix XenDesktop have grown as well.

The promise of VDI is clear. Virtualizing and centralizing desktops offers a more secure, more manageable and less costly end-user computing model. Consequently, the increasing availability of scalable server architecture has made virtual desktops more than just technically feasible.

**Present Need for Solution**
Nevertheless, in spite of the massive potential that VDI offers in transforming the modern workplace, adoption has been slow. The most significant barriers to increased adoption of VDI are rooted in storage performance shortfalls and capacity problems.
Common barriers to realizing the full potential of VDI include:

- **Improper Storage Design**: Storage that is capable of properly supporting a VDI must be designed with more than just size requirements in mind.

- **Insufficient Cache**: Insufficient system memory slows server response times to service requests.

- **Neglected VDI Optimization**: Improper or neglected optimization may result in failed VDI deployments.

- **Improperly Managed Boot Storms**: Hundreds or thousands of simultaneous login attempts — a daily occurrence at most organizations — can lead to failed or slowed systems when improperly managed.

- **Lack of Antivirus Optimization**: Improperly deployed antivirus can result in system-wide degradation of virtual desktop performance.

- **Lack of Application Virtualization Strategy**: Failure to implement an appropriate application virtualization strategy can significantly complicate the management of a VDI.

- **Lack of Profile Strategy**: A non-existent or flawed profile strategy impedes the personalization and usability that are so crucial to maximizing user adoption of a VDI.

**Top Features to Consider in a VDI Storage Solution**

Exercising careful consideration in the selection of a VDI storage solution can eliminate the barriers to VDI adoption noted above. It is the key to fully realizing the promise and potential of a VDI installation.

In particular, the following six features are conducive to maximizing the potential of a VDI:

1. **Enhanced User Experience**: It is crucial that the user experience deliver maximum satisfaction regardless of the scale of the VDI — particularly in consideration of the inarguable fact that user satisfaction translates directly into productivity. XtremIO’s massive IO performance assures that each desktop across the system is providing an ideal user experience at all times, at any scale and at any stage of the desktop lifecycle.

2. **IO Storm-Proof Storage**: Storm-proof storage eliminates the delays and system crashes that can commonly result from boot storms. Whether one user is attempting to log in, or thousands of users doing the same simultaneously, it should all be the same from the perspective of the individual user. XtremIO’s consistently low sub-millisecond latencies work to assure that the user experience is never impacted by the occurrence of boot or any other type of IO storms.
3. **Small Storage Capacity Footprint:** Cutting-edge data reduction technology can dramatically reduce the storage capacity footprint required in support of a VDI environment. XtremIO’s always-on, real-time inline data reduction technology substantially shrinks the storage space required for VDIs of any size.

4. **Rapid Desktop Provisioning Capabilities:** Provisioning of a new virtual desktop should be lightning fast. Unlike other arrays, XtremIO doesn’t store duplicate data globally across the cluster; deduplication occurs inline and in-memory. XtremIO’s unique, intelligent, content-based addressing scheme coupled with in-memory metadata results in deduplication happening at the storage control plane level, without ever touching the data plane with SSDs. Accordingly, provisioning tasks are carried out at the speed of RAM.

5. **Simple Deployment (with zero tuning):** Though many VDI administrators have experienced otherwise, virtual desktop deployment can and should be a simple, formulaic operation. XtremIO makes deployment a simple 1-2-3 process — no tuning required.

6. **Reduced Cost per Desktop:** Containing costs is a critical component of success for any organization. It is particularly crucial for VDI systems, where even slight per-desktop cost inefficiencies can cause total cost of ownership to soar. XtremIO enables per-desktop cost reductions that offer unmatched TCO.

**Citrix VDI Capacity Program for Storage Partners**

Citrix Ready launched the VDI Capacity Program with many existing storage partners. The goal is to address the storage needs of customers who already have implemented or are considering implementing Citrix XenDesktop. VDI presents multiple types of data — each with its own unique requirements — to the storage infrastructure tier. Storage in turn can cope with these requirements using various hardware- and software-based approaches, some of which can be combined into hybrid solutions. As the number of storage options for VDI has steadily increased over the last several years, confusion has arisen for some customers who are still unsure as to which approach is right for them.

To help address this confusion, Citrix started this program — Citrix Ready VDI Capacity Program for Storage Partners Phase II — with storage partners representing several different VDI workloads with their storage solutions. To participate in the program, the partner was required to set up a test environment with the necessary compute resources needed to generate a 1,500, 3,000, or 5,000 user XenDesktop workload.

As opposed to a traditional “benchmark,” whereby different achievement scores are possible, this “VDI Capacity” program is a simulation of “a day in the life” of a XenDesktop farm supporting a certain number of users. If a partner’s chosen storage solution can successfully support “a day’s” run to the defined user capacity while sustaining required performance metrics, the partner passes and the validation test is concluded.
Test Methodology
The VDI Capacity Program is focused on provisioning the appropriate amount of storage capacity with a cost-effective design, while also assuring adequate VDI performance. A simple, binary pass/fail methodology is employed. In this test iteration, the primary objective was to demonstrate the ability of the XtremIO X-Brick to comfortably support 3,000 Windows 8.1 virtual desktops deployed via XenDesktop 7.6 PVS in a vSphere 6.0 environment.

It may also be noted that this Citrix Ready program stipulates including the user data, typically stored in user file shares, be included as part of this VDI testing. Industry leading EMC VNX® unified storage platform, specifically, a EMC VNX5600 unified storage array, was used for the user data storage requirement component of this testing. In a real VDI deployment, customers often already have user file shares and the underlying storage in place.
Table 1: Hardware Components Summary

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server model</td>
<td>Desktop Cluster: Cisco C260-BASE-2646</td>
<td>20</td>
<td>62 servers</td>
</tr>
<tr>
<td></td>
<td>Desktop Cluster: Cisco B230-BASE-M2</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infrastructure Cluster: Cisco C260-BASE-2646</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Processor(s)</td>
<td>Cisco C260-BASE-2646 @ 2.393 GHz</td>
<td>2</td>
<td>124 Processor Sockets, Total 1240 cores</td>
</tr>
<tr>
<td></td>
<td>Cisco B230-BASE-M2 @ 2.263 GHz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>Cisco C260-BASE-2646</td>
<td></td>
<td>144 GB per server</td>
</tr>
<tr>
<td></td>
<td>Cisco B230-BASE-M2</td>
<td></td>
<td>256 GB per server</td>
</tr>
<tr>
<td>Disk(s)</td>
<td>Cisco C260-BASE-2646: Seagate HDD (not used in test)</td>
<td>1</td>
<td>140 GB per server (not used in test)</td>
</tr>
<tr>
<td></td>
<td>Cisco B230-BASE-M2: Intel SSD SA2BZ10 (not used in test)</td>
<td>1</td>
<td>95 GB per server (not used in test)</td>
</tr>
<tr>
<td>Network Adapter</td>
<td>Cisco VIC Ethernet NIC 10000Mb</td>
<td>2</td>
<td>124 Adapters</td>
</tr>
<tr>
<td>Storage Array Controller</td>
<td>EMC XtremIO X-Brick: Controller 256GB Cache</td>
<td>2</td>
<td>One XtremIO X-Brick with 2 controllers for the VM data of the entire 3000 desktop solution</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: Controller 24GB Cache</td>
<td>2</td>
<td>One VNX5600 with 2 controllers for the user data of the entire 3000 desktop solution</td>
</tr>
<tr>
<td>Other component (if applicable) Storage Array Disks</td>
<td>EMC XtremIO X-Brick: 400 GB SSDs</td>
<td>25</td>
<td>10 TB (Raw)</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: 200 GB SSD</td>
<td>10</td>
<td>130 TB (Raw)</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600: 2 TB NL-SAS 7200 RPM</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

The XtremIO X-Brick was connected to the VMware vCenter cluster via iSCSI block protocol over a 10 gigabyte Ethernet. In practice, an eight gigabyte FC network could also be used with no change in function. Windows 8.1 desktops were provisioned via Citrix XenDesktop 7.6 PVS, placing operating system virtual disks on the XtremIO array and user data and profiles on low-cost, high-capacity, near-line Serial Attached SCSI (NL-SAS) drives on an EMC VNX5600 array.

Desktops were hosted on two different server types due to equipment availability. In practice, any similar combination of servers providing the same number and type of processor cores along with the same amount of memory per core should be acceptable in implementing the solution.

Infrastructure services (domain controller, SQL Server, XenDesktop controllers, PVS servers, and so on) were configured on virtual machines hosted on a single Cisco UCS C260 server hosted by the VNX used in the solution. These services can be hosted on existing hardware, or existing services can be used for the solution. In either scenario, it is imperative that product-sizing best practices are observed.
Login Virtual Session Indexer (Login VSI) is the industry-standard tool for VDI performance and capacity testing. This tool was used to generate VDI workloads and to measure performance. For this test, the test load was targeted to two vCPUs per virtual desktop, and was designed to simulate typical daily knowledge-worker tasks such as web browsing, viewing videos, sending and receiving emails, and managing documents via tools such as Microsoft Office 2013. The binary result of pass/fail was determined by observing whether the storage system successfully met the storage demands placed upon it without reaching a latency limit known as VSImax.

**Overview of EMC**
EMC is a global leader in enabling businesses and service providers to transform their operations and deliver information technology as a service (ITaaS). Fundamental to this transformation is cloud computing. EMC accelerates the journey to cloud computing, helping IT departments to store, manage, protect and analyze their most valuable asset — information — in a more agile, trusted and cost-efficient manner.

XtremIO all-flash array ranks very high among EMC’s most popular and important product offerings. XtremIO synergistically maximizes the value realized by customers of Citrix XenDesktop by enabling true N-way, active-active scale-out storage, a content-aware in-memory metadata engine, and inline, all-the-time data reduction technologies.

In sum, XtremIO delivers an incredibly cost-effective, agile VDI Storage platform. Whether deployed for small- or large-scale rollouts of 100 or 100,000 desktops, whether users are call-center employees or sophisticated CAD designers, whether an organization operates in a classic 9-to-5 environment or in a never-down 24/7 environment — XtremIO always, reliably delivers an amazingly consistent user experience.

**EMC XtremIO Unique Offerings**
XtremIO offers a number of innovative and unique features comprising a comprehensive package that is simply not available with any competing product. Offerings that are unique to XtremIO include:

- **Completely Stormproof VDI Environment:** XtremIO’s consistently low latencies enable high performance even during peak workloads and very high utilization spikes.

- **Dramatically Reduced VDI Storage Capacity Requirements:** The amount of storage capacity required to support VDI environments is radically reduced as a result of XtremIO’s always-on, inline all the time data reduction technology. Accordingly, thousands of virtual desktops can be supported with only a few terabytes of flash storage.
• **Rapid Virtual Desktop Provisioning**: Uniquely, XtremIO performs VM cloning and desktop provisioning tasks at the speed of RAM.

• **Radically Simple Admin Experience**: Configuration, deployment, and tuning can be performed in three simple steps:
  1. Create the volumes (any number of sizes)
  2. Create the initiator groups for all the hosts and their applications
  3. Map the volumes to those initiator groups

• **Reduced Planning Complexity**: Start small and grow incrementally — without service disruptions — to any scale desired.

• **Industry-Leading Integration with VDI Platforms and Hypervisors**: Leading VDI platforms such as Citrix XenDesktop can be deployed within seconds with the EMC Virtual Storage Integrator.

• **Turnkey VI Solution Options with Converged Infrastructure and Federation EUC**: XtremIO offers a complete, turnkey, plug-and-play VDI solution.

• **Low TCO and Cost-per-Desktop**: XtremIO provides an unparalleled user experience and unprecedented simplicity, all at an amazingly low cost. The result is unmatched TCOs and exceptionally low per-desktop costs.

• **Single-Platform Enablement**: XtremIO is uniquely capable of supporting a mixed-workload storage consolidation, enabling the realization of unprecedented infrastructure and application agility.

The scale-out, flash-optimized, global data reduction architecture of XtremIO provides for a number of multiplying effects across many aspects of the array, which in turn leads to a number of key benefits. These benefits include extending the effective capacity of the array, as well as minimizing the required writes to media. This serves to improve XtremIO hosted application performance, and increases the usable lifespan of the purchased flash.

The XtremIO data reduction architecture comprises the following components:

• **Content Addressable Data Engine**: Enhances data reduction, balances data, augments efficiency and increases performance.
• **Global Scale-Out Metadata Engine**: Delivers consistently high performance across all array services for all applications.

• **Always-On Inline Data Services**: Provides data services that never stop working and never require disablement, including thin provisioning, data deduplication, compression, and space-efficient, writable snapshots.

• **XtremIO Data Protection (XDP)**: Provides flash-specific data protection with no legacy from disk-based RAID, which is faster than RAID 10. XDP provides better protection than RAID 6, and requires less overhead than RAID 5.

• **XtremIO Virtual Copies (XVC)**: Augments data reduction by enabling multiple writable copies of application datasets that consume zero physical data.

EMC XtremIO has been validated by Citrix as a Citrix Ready product. To date, more than 27,000 products have been validated as Citrix-compatible.
Overview of Test Results and Data

The purpose of this test was to verify that EMC XtremIO complied with all interoperability requirements of the VDI Capacity Program.

Table 2: Results Summary

<table>
<thead>
<tr>
<th>Time taken to Launch VMs</th>
<th>115 per minute</th>
</tr>
</thead>
</table>
| Login VSI max and Average User Response Time | Login VSI max: 1.71 sec  
Login Average: 1.32 sec |
| Total IOPS in Storage Solution | The boot storm generated 58,108 IOPS at the peak. LoginVSI Knowledge Worker Workload tests generated 61,033 IOPS at the peak.  
XtremIO X-Brick can deliver 150K mixed IOPS and 250K read IOPS. |

Note: The same XtremIO X-Brick is capable of supporting many times the IOPS this VDI workload created. “Total IOPS in Storage Solution” really indicates the IOPS generated by the workload, not the maximum IOPS capability of the storage array itself.

| Storage Cost / Infrastructure Cost per User | Storage Cost per user (inclusive of storage for user data/user file shares): $76  
Note: The cost of the solution is of the systems as tested and from the time of Citrix Ready VDI Capacity Program testing results submission (December 2015). |

The basic hardware building block for the XtremIO array is the X-Brick. Each XtremIO X-Brick is comprised of two active-active controller nodes and a disk array enclosure packaged together, presenting no single point of failure. An X-Brick is a high-availability, high-performance SAN appliance available in five terabyte, 10 terabyte, 20 terabyte, and 40 terabyte capacity configurations. It is capable of driving incredible database loads, handling thousands of virtual machines, and supporting thousands of virtual desktops.
The total I/O requirements of 3,000 concurrent knowledge worker desktops never exceeded a small fraction of the total I/O capability of the X-Brick. As a result, the user experience was excellent throughout the test, and never reached the Login VSI VSImax figure for the number of desktops tested. Additionally, the average storage response times were below two milliseconds, and no I/O bottlenecks were observed throughout the testing.

Administrators configured the XtremIO array using three simple steps and then left the array running. During normal desktop operations, most I/O access to XtremIO consisted of random writes, but no cache sizing or tuning was required at any time. And a data reduction ratio of 4.9:1 was achieved by the XtremIO array’s inline data reduction technology, clearly demonstrating XtremIO’s excellent dollar-per-desktop value.

Notable test highlights included the following:

1. **Boot Storm Performance**: XtremIO’s ability to weather a boot storm was tested by the simulation of booting 3,000 desktops over a period of 28 minutes. Latency array peaked during the boot storm at just over 1.7 milliseconds. CPU utilization during the boot storm peaked at approximately 80 percent. The data reduction ratio achieved during the boot storm was 5.2:1.

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**Figure 2: Boot storm IOPS**

![Boot storm IOPS graph](image-url)
Figure 3: Boot Storm Latency

XtremIO Latency - Boot Storm

Figure 4: Boot storm CPU utilization

XtremIO CPU Utilization - Boot Storm
2. **Login Storm:** A total of 3,120 desktop sessions were launched to assure that the number of active desks never fell below the threshold of 3,000 active desktops. As the test progressed, new users were logged in at the average rate of one login every 1.92 seconds. The simulation of a knowledge worker’s typical workload was initiated immediately upon the completion of each login. LoginVSI VSimax was never reached. The array latency averaged less than two milliseconds throughout the testing, and peaked briefly at approximately 2.5 milliseconds. CPU utilization during the login storm peaked at approximately 87 percent, and the data reduction ratio achieved during the boot storm was 4.9:1.
Figure 6: VSImax–3,000 desktops

Figure 7: Login Srm IOPS
Figure 8: Login Storm Latency

Figure 9: Login Storm CPU Utilization
The test conclusively demonstrated that a single XtremIO X-Brick was easily up to the task of hosting 3,000 Citrix XenDesktops. In sum, the test case generated 58,108 IOPS. The XtremIO array proved fully capable of handling these loads while continuing to offer plenty of remaining headroom at every point of the test.

Test Results Prove a Perfect Symbiosis
Citrix XenDesktop delivers full Windows VDI capabilities in addition to virtual apps, meeting the demands of any use case. XenDesktop enables users to access their apps, desktops and data without the limitations of a traditional solution. On the unified FlexCast Management Architecture (FMA) platform, XenDesktop is the only solution that is FIPS-compliant and Common Criteria certified to meet the highest security standards of regulated industries. End users will enjoy the simple virtual desktop interface, while IT will appreciate the superior performance of HDX technology, even when deployed over challenging, high-latency networks.
A Citrix XenDesktop environment, when backed by the EMC XtremIO all-flash storage array for desktop storage and the EMC VNX unified storage platform for user data, provides a high performance desktop experience complemented with an easy-to-use storage environment. The combination of the XtremIO array and the VNX platform delivers the perfect storage environment for fully meeting the complex storage needs of a virtual desktop environment.

As demonstrated with Login VSI test results, XtremIO clearly exceeds the benchmark set for the Citrix VDI Capacity Program. The test also confirmed that all-flash shared storage provides extremely high performance and capacity savings when deployed with XenDesktop virtual desktop VMs.

It should be noted, however, that Login VSI only tests a small subset of the factors that are key to a successful VDI deployment. Two primary influential factors are end-user experience and administrative/management complexity. Any VDI solution that improves end-user experience while reducing operational overhead will result in a superior deployment, and will bolster enhanced user and administrator acceptance. A by-product of the Citrix VDI Capacity Program benchmark test was a clear demonstration of XtremIO’s simplified management requirements and the delivery of an unparalleled user experience.

As conclusively shown by the results of the Citrix VDI Capacity Program benchmark test, EMC XtremIO all-flash storage array serves as a perfect symbiotic partner for Citrix XenDesktop, handily meeting or exceeding all the requirements of the Citrix Ready Program.

For more information about EMC XtremIO all-flash storage, contact EMC.

For more information about XenDesktop, contact Citrix.
Appendix
For more information about the Citrix Ready Program, visit: https://www.citrix.com/partner-programs/citrix-ready.html

For a thorough documentation of the test architecture, hardware and software configurations, and results, please visit: http://www.emc.com/collateral/white-papers/h14747-citrix-xtremio-3000-wp.pdf.

To learn more about how EMC improves XenDesktop deployments, please visit: https://www.citrix.com/global-partners/emc/overview.html.

To learn more about flash storage for VDI, contact Citrix and EMC.

About Citrix Ready
Citrix Ready identifies recommended solutions that are trusted to enhance the Citrix Delivery Center infrastructure. All products featured in Citrix Ready have completed verification testing, thereby providing confidence in joint solution compatibility. Leveraging its industry leading alliances and partner eco-system, Citrix Ready showcases select trusted solutions designed to meet a variety of business needs. Through the online catalog and Citrix Ready branding program, you can easily find and build a trusted infrastructure. Citrix Ready not only demonstrates current mutual product compatibility, but through continued industry relationships also ensures future interoperability. Learn more at www.citrixready.citrix.com.

About EMC
EMC Corporation is a global leader in enabling businesses and service providers to transform their operations and deliver IT as a service. Fundamental to this transformation is cloud computing. Through innovative products and services, EMC accelerates the journey to cloud computing, helping IT departments to store, manage, protect and analyze their most valuable asset — information — in a more agile, trusted and cost-efficient way. Additional information about EMC can be found at www.EMC.com.

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